EDAC 117-258.03

GENERAL ELECTRIC TEST REACTOR RESPONSE TO ADDITIONAL INFORMATION REQUEST REGARDING SEISMIC SCRAM SYSTEM

Prepared for
General Electric Company
Pleasanton, California
15 September 1980

EDAC
ENGINEERING DECISION ANALYSIS COMPANY, INC.
480 CALIFORNIA AVE., SUITE 301
PALO ALTO, CALIF. 94306
BURNITZSTRASSE 34
6 FRANKFURT 70, W. GERMANY

TABLE OF CONTENTS

	Page
PREFACE	1
RESPONSES	12
Request #1	12
Request #2	13
Request #3	14
Request #4	15
Request #5	17
Request #6	18
Request #7	19
REFERENCES	
APPENDIX A - Description of Triaxial Sensor	

PREFACE

This document presents the responses to the requests for additional information regarding the seismic scram system at the General Electric Test Reactor. These requests were received on 28 August 1980, and were in relation to Item 2 of the 14 August 1980 GE submittal to the USNRC (Reference 1).

Further examination of records from historical earthquakes indicated that it would be more conservative to utilize three-component triggers (two horizontal and one vertical), rather than the current two component (two horizontal) triggers. Therefore, the information provided in this document is based on the premise that three-component triggers will be used. The type of trigger currently contemplated is described in Appendix A.

Table 1 of Reference 1 has been revised to reflect the use of three-component triggers, and the revised version is presented in this document. Table 2 lists the sources of the digitized records used in Table 1. The information shown in Revised Table 1 is represented graphically in Figures 1 and 2. These two figures show the envelopes of the absolute values of the acceleration time histories for the first one second after detecting 0.01g. The envelopes include all records listed in Revised Table 1.

Also note that the seismograph stations from which the records in Table 1 were obtained employed only two-component horizontal triggers, except for the Imperial Valley and Coyote Lake stations, which employed three-component triggers. If the two-component stations had employed three-component triggers, it is possible that they would have been tripped earlier upon detection of vertical motions. If so, the acceleration values shown in Table 1 are conservative for the two-component stations, and actual accelerations were likely less than shown for the intervals after detecting 0.01g.

Recall that the times of key events in the scram system operation are as follows (Ref. 1):

Action	Incremental Time, sec	Total Elapsed Time, sec
Closure of Switches at 0.01-0.03g	0	0
Disengagement of Control Rods	0.18	0.18
Begin Opening Emergency	0.19	0.19
Cooling Valves		
Control Rods at or below 12.2. inch withdrawal position	0.30	0.48
Full Insertion of Control Rods	0.50	0.68
Full Opening of Emergency Cooling Valves and Completion of Scram	0.80	0.99

Examination of the data in Revised Table 1 and Figures 1 and 2 shows that the scram action, which requires a maximum of slightly under one second, will be completed before consequential horizontal or vertical accelerations occur.

TABLE 1 (REVISED)

MAXIMUM INSTRUMENTAL ACCELERATIONS AFTER RECORDING 0.01g

No.	Earthquake and Recording Station	Component	Maximum Acceleration (g) in Interval 0.25 sec.	0.50 sec.	1.0 sec.
1	Imperial Valley 5-18-40	Horizontal	0.020	0.025	0.066
		Vertical	0.075	0.140	0.210
2	Eureka Fed. Bldg. 12-21-54	Horizontal	0.023	0.027	0.032
		Vertical	0.083	0.083	0.083
3	Helena, Montana College, 10-31-35	Horizontal	0.022	0.028	0.042
		Vertical	0.012	0.038	0.047
4	Golden Gate, S.F. 3-22-57	Horizontal	0.017	0.017	0.026
		Vertical	0.010	0.014	0.021
5	Holister City Hall 4-8-61	Horizontal	0.033	0.045	0.112
		Vertical	0.011	0.024	0.024
6	Parkfield 6-27-66	Horizontal	0.010	0.010	0.018
		Vertical	0.029	0.038	0.078
7	San Fernando (Pacoima) 2-9-71	Horizontal	0.053	0.077	0.131
		Vertical	0.086	0.138	0.243
8	San Fernando (646 So. Olive Ave.) 2-9-71	Horizontal	0.013	0.014	0.014
		Vertical	0.018	0.018	0.024
9	San Fernando (3047 Sixth St.) 2-9-71	Horizontal	0.021	0.021	0.021
		Vertical	0.087	0.087	0.103
10	San Fernando (633 E. Broadway) 2-9-71	Horizontal	0.037	0.037	0.037
		Vertical	0.043	0.043	0.096
11	San Fernando (Castalic Old Ridge) 2-9-71	Horizontal	0.063	0.063	0.063
		Vertical	0.037	0.046	0.069
12	Imperial Valley Array 7 10-15-79	Horizontal	0.005	0.006	0.007
		Vertical	0.024	0.047	0.047

TABLE 1 (REVISED)
-Continued-

MAXIMUM INSTRUMENTAL ACCELERATIONS
AFTER RECORDING 0.01g

No.	Earthquake and Recording Station	Component	Maximum Acceleration (g) in Interval 0.025 sec.	0.50 sec.	1.0 sec.
13	Imperial Valley Array 8 10-15-79	Horizontal	0.003	0.004	0.006
		Vertical	0.029	0.128	0.133
14	Imperial Valley Array 5 10-15-79	Horizontal	0.006	0.009	0.009
		Vertical	0.016	0.016	0.016
15	Imperial Valley Diff. Array 10-15-79	Horizontal	0.007	0.008	0.009
		Vertical	0.028	0.028	0.037
16	Imperial Valley Array 10 10-15-79	Horizontal	0.004	0.005	0.006
		Vertical	0.025	0.025	0.034
17	Imperial Valley Array 6 10-15-79	Horizontal	0.005	0.005	0.008
		Vertical	0.038	0.038	0.081
18	Imperial Valley Array 4 10-15-79	Horizontal	0.010	0.011	0.023
		Vertical	0.022	0.023	0.028
19	Imperial Valley Municipal Airport 10-15-79	Horizontal	0.003	0.003	0.004
		Vertical	0.020	0.020	0.026
20	Imperial Valley Calexico Fire Station 10-15-79	Horizontal	0.003	0.003	0.004
		Vertical	0.039	0.048	0.048
21	Imperial Valley Holtville Post Office 10-15-79	Horizontal	0.002	0.004	0.005
		Vertical	0.019	0.025	0.042

TABLE 1 (REVISED)
-Continued-

MAXIMUM INSTRUMENTAL ACCELERATIONS
AFTER RECORDING 0.01g

No.	Earthquake and Recording Station	Component	Maximum Acceleration (g) in Interval 0.25 sec.	0.50 sec.	1.0 sec.
22	Coyote Lake Array 1 8-6-79	Horizontal Vertical	0.023 0.033	0.023 0.043	0.048 0.051
23	Coyote Lake Array 2 8-6-79	Horizontal Vertical	0.020 0.120	0.021 0.126	0.058 0.150
24	Coyote Lake Array 4 8-6-79	Horizontal Vertical	0.011 0.094	0.017 0.194	0.029 0.194
25	Coyote Lake Array 3 8-6-79	Horizontal Vertical	0.016 0.121	0.026 0.121	0.048 0.122
26	Coyote Lake Array 6 8-6-79	Horizontal Vertical	0.018 0.038	0.035 0.083	0.062 0.083
27	Coyote Lake Coyote Creek 8-6-79	Horizontal Vertical	0.014 0.030	0.021 0.034	0.028 0.038
28	Gazli 5-17-76	Horizontal Vertical	0.015 0.010	0.023 0.010	0.033 0.121
29	Santa Barbara UCSB, Goleta 8-13-78	Horizontal Vertical	0.003 0.026	0.006 0.026	0.009 0.026

TABLE 2

SOURCE OF EARTHQUAKE RECORDS

Records	Source
1. Imperial Valley 5/18/1940	Strong Motion Earthquake Accelerograms, Digitized and Plotted Data, Volume II, Earthquake Engineering Research Laboratory, California Institute of Technology, March, 1973.
2. Eureka Federal Building 12/21/1950	"
3. Helena, Montana College 10/31/1971	"
4. Golden Gate, San Francisco 3/22/1957	"
5. Holister City Hall 4/8/1961	"
6. Parkfield	"
7. San Fernando (Pacoima) 2/9/1971	"
8. San Fernando 646 South Olive Ave. 2/9/1971	"
9. San Fernando 3047 Sixth Street 2/9/1971	"
10. San Fernando 633 E. Broadway 2/9/1971	"
11. San Fernando Castalic Old Ridge 2/9/1971	"

TABLE 2
-Continued-

SOURCE OF EARTHQUAKE RECORDS

Records	Source
12. Imperial Valley Array 7 10/15/1979	Preliminary Summary of the U.S. Geological Survey, Strong-Motion Records from the October 15, 1979, Imperial Valley Earthquake, Report 79-1654, U.S. Geological Survey, Menlo Park, October, 1979.
13. Imperial Valley Array 8 10/15/1979	"
14. Imperial Valley Array 5 10/15/1979	"
15. Imperial Valley Diff. Array 10/15/1979	"
16. Imperial Valley Array 10 10/15/1979	"
17. Imperial Valley Array 6 10/15/1979	"
18. Imperial Valley Array 4 10/15/1979	"
19. Imperial Valley Municipal Airport 10/15/1979	"

TABLE 2
-Continued-

SOURCE OF EARTHQUAKE RECORDS

Records	Source
20. Imperial Valley Calexico Fire Station 10/15/1979	Preliminary Summary of the U.S. Geological Survey, Strong-Motion Records from the October 15, 1979, Imperial Valley Earthquake, Report 79-1654, U.S. Geological Survey, Menlo Park, October, 1979.
21. Imperial Valley Holtville Post Office 10/15/1979	"
22. Coyote Lake Array 1 8/6/1979	Compilation of Strong-Motion Records from the August 6, 1979 Coyote Lake Earthquake, Report 79-385, U.S. Geological Survey, Menlo Park, October, 1979.
23. Coyote Lake Array 2 8/6/1979	"
24. Coyote Lake Array 4 8/6/1979	"
25. Coyote Lake Array 3 8/6/1979	"
26. Coyote Lake Array 6 8/6/1979	"
27. Coyote Lake Coyote Creek 8/6/1979	"

TABLE 2
-Continued-

SOURCE OF EARTHQUAKE RECORDS

Records	Source
28. Gazli, Soviet Union 5/17/1976	Digitized Accelerogram from the Destructive Gazli Earthquake of 17 May 1977, by V. V. Steinberg et al. Institute of Physics of the Earth, USSR Academy of Science.
29. Santa Barbara UCSB, Goleta 8/13/1978	Processed data from the strong-motion records of the Santa Barbara Earthquake of 13 August 1978. California Division of Mines and Geology, Sacramento, 1979.

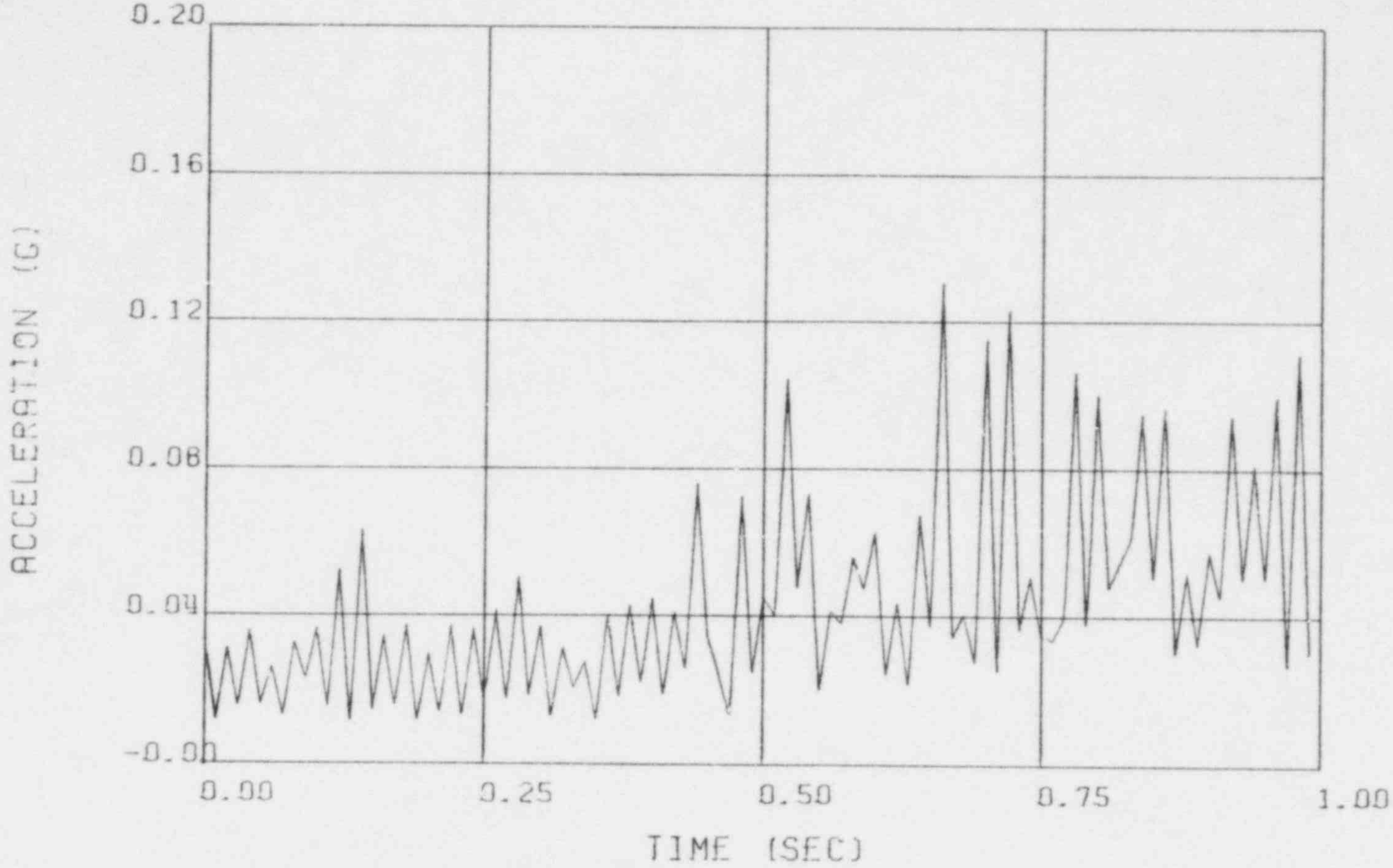

FIGURE 1 ENVELOPE OF MAXIMUM HORIZONTAL ACCELERATIONS AFTER RECORDING 0.01g

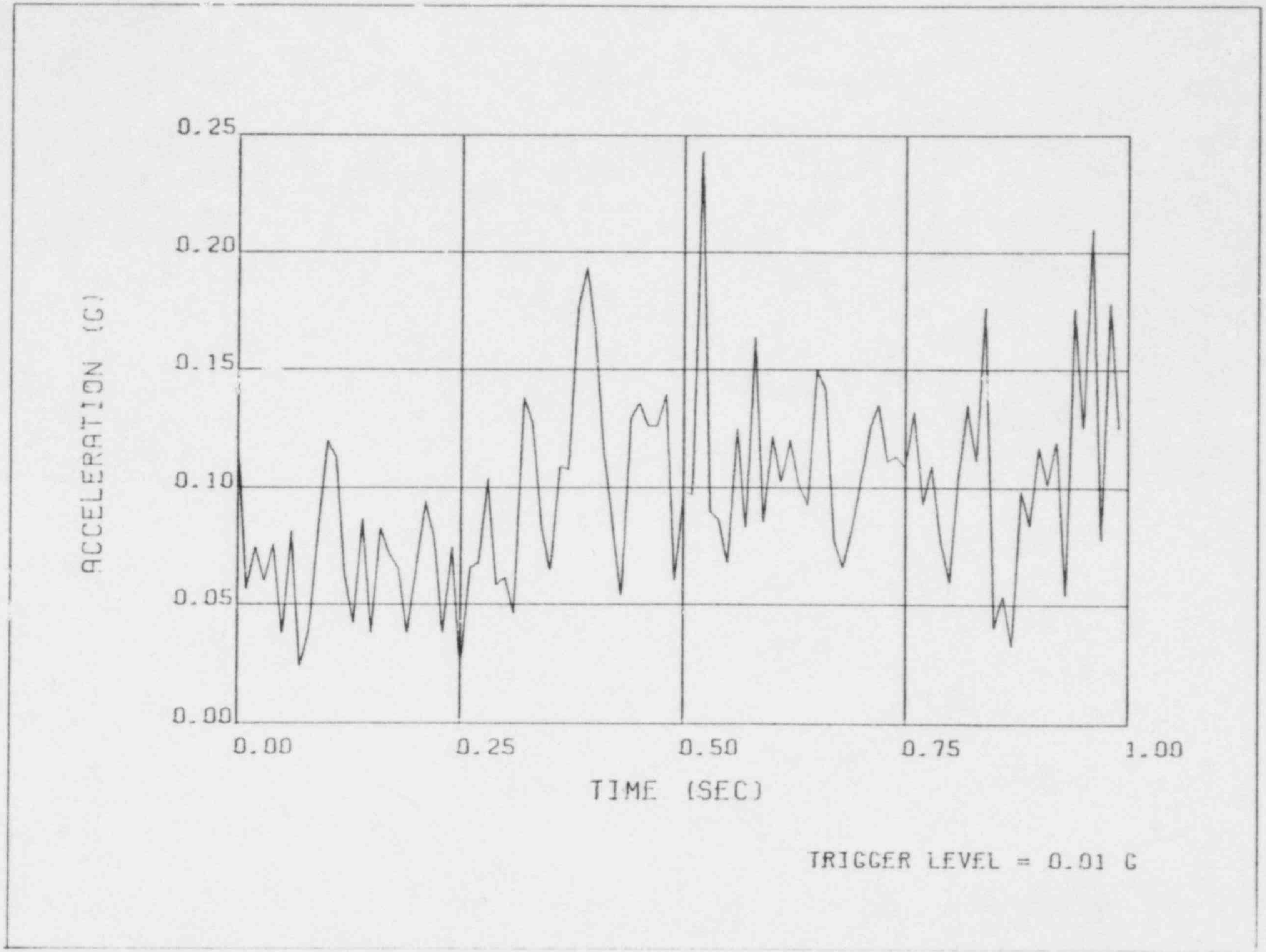

FIGURE 2 ENVELOPE OF MAXIMUM VERTICAL ACCELERATIONS AFTER RECORDING 0.01g

REQUEST #1

"Describe the source of the computerized earthquake records used to determine the maximum instrumental accelerations in Table 1 and provide data plots of the time histories illustrating acceleration levels from seismic scram actuation through the time to complete control rod and valve operation."

RESPONSE

Table 2 provides the source of the computerized (digitized) earthquake records used in Revised Table 1.

Figures 1 and 2 provide envelopes of the absolute values of acceleration time histories as explained in the Preface.

REQUEST #2

"The earthquake threat comes from two main sources: a strike slip event on the Calaveras fault and a thrust event in the immediate vicinity of the plant. The data set presented comes mainly from strike slip events. The strike slip data set should be expanded to include additional records from the 10/15/79 Imperial Valley event, and the August 1979 Coyote Lake event. These include additional records within one kilometer from the fault and more distant records. The cut off distance (5, 10, 20 km) is dependent upon the values of acceleration that are deemed necessary (see Question 4). A data set for thrust type events should be presented. Near-field accelerograms from the 1971 San Fernando, 1978 Santa Barbara, 1976 Gazli, Soviet Union, and 1978 Tabas (Iran) earthquake are examples of records which should be examined."

RESPONSE

The data set has been expanded as suggested (See Table 1). Adequate records of the 1978 Tabas, Iran earthquake record, suitable for digitization, are not presently available.

REQUEST #3

"The vertical component of acceleration is not addressed in your submittal. Demonstrate that significant loadings due to the vertical component will not develop prior to completing rod and valve operation."

RESPONSE

As explained in the Preface to this document, a sensor will be installed which will be triggered by vertical or horizontal motions. The building structure and reactor pressure vessel are essentially rigid in the vertical direction, and there will be no amplification of vertical motions. Therefore, the small vertical accelerations shown in Table 1 will not produce significant loads on the structure or systems, and the rods and valves will operate properly.

REQUEST #4

"Demonstrate that the seismic scram and valve actuation circuitry, the core with control rods in motion and actuated valves while operating will satisfactorily complete their function at the acceleration levels based on your examination. Your response should include the acceleration levels to which this equipment has been demonstrated operable by test and/or analysis. Specific reference to previous submittals may be used."

RESPONSE

The discussion in Reference 1 and the Preface to this document states that all the electrical and electronic scram circuitry operates within 0.18 seconds of the seismic switch closure within 0.01g. The largest horizontal and vertical accelerations in Table 1 at 0.25 second after trip were 0.063g and 0.12g, respectively. These accelerations are clearly very low and non-damaging. The GETR scram and valve actuation circuitry operated properly after horizontal accelerations of about 0.1g (Greenville earthquake, January 1980). Therefore, since the horizontal acceleration levels at 0.2 seconds after trip are within the range of this value,and the small vertical accelerations are non-damaging because of the substantial margin of safety in the design for vertical loads, the scram circuitry will operate satisfactorily to scram the GETR and initiate the required valve operations in a seismic event. Note also that the stresses in the fuel elements are extremely small (on the order of about 10 psi during actuation and about 70 psi for the 0.75g criterion event.); therefore, the fuel element assemblies are not damaged.

As also discussed in Reference 1 and the Preface to this document, the control rods will be at or below the 12.2 inch withdraw (i.e. shutdown) position within 0.48 seconds after detection of 0.01g. To ensure that the rods would drop, the control rod assemblies were tested for operability with a 1.0g side load imposed statically. The force to move the assembly with this side load was 0.26W where W is the weight of the rod. Gravity and flow forces are clearly greater than this value and, therefore, the control rod will continue to move into the core (within the guide tube of each assembly) with a 1g side load. This latter load is well in excess of

RESPONSE TO REQUEST #4 - continued

the loads which might occur up to 0.48 seconds, the time after the 0.01g trip at which the control rods reach the 12-inch position and the reactor is shut down.

The actuated valves, including those actuated by the seismic scram circuitry (emergency cooling power-operated valves, pressurizer valve and fuel flooding system admission valves), have been proof tested (Ref. 2) and shown to be operable with a conservative envelope of vibratory motion that would be seen by each valve during the maximum postulated seismic event. Therefore, these valves will operate properly at any time during or after the seismic event.

REQUEST #5

"The reactor core, as analyzed for design basis earthquake loads, has control rods fully inserted. Therefore you should verify that the rods will be fully inserted before significant earthquake loading (i.e., acceleration which exceeds that level determined in 4. above)."

RESPONSE

The rods will be inserted before significant earthquake loadings as explained in the response to Request #4.

REQUEST #6

"Please verify that the 'emergency cooling valves' referenced in your submittal include all valves which must operate to mitigate the consequences of a seismic event."

RESPONSE

The valves that must operate to mitigate the consequences of a seismic event were tested with a conservative envelope of vibratory motion that would be seen by each valve during the maximum postulated seismic event (Ref. 2 - Valve Test). Included were proof tests that the valve would perform the required operation (e.g., opening, closing, maintaining pressure integrity, etc.). The emergency cooling power-operated valves, pressurizer valves and fuel flooding system admission valves are the only valves for which initiating action is by seismic trip or scram circuitry. The emergency cooling power-operated valves and the fuel flooding system admission valves begin to open and the pressurizer valve to close within 190 milliseconds after triggering of the scram system. The remainder of the valve operation is complete within a total of one second from scram seismic trip; and, further, the valves have been qualified for operation for in excess of the vibratory motion to which the valve would be submitted for the maximum postulated seismic event.

REQUEST #7

"Since the seismic switches are located within the building your argument regarding the conservatism of using instrumental values of acceleration (last paragraph, Comment 2) is not clear. Please explain."

RESPONSE

The seismic trigger is not located in the free field. Therefore, there is no advantage as described in the referenced paragraph, and the paragraph should be deleted.

REFERENCE

1. General Electric (R. W. Darmitzel) letter to USNRC (D. G. Eisenhut), 14 August 1980. Subject: "Reliability and Response Action Time for the General Electric Test Reactor (GETR) Scram System"

2. Engineering Decision Analysis Company, Inc., "Qualification of Safety Related Valves, General Electric Test Reactor," prepared for General Electric Company, San Jose, California, EDAC-117-217.09, 30 June 1978.

APPENDIX A

DESCRIPTION OF TRIAXIAL SENSOR

APPENDIX A

DESCRIPTION OF THE KINEMETRICS TRIAXIAL SEISMIC TRIP SYSTEM

The Kinemetrics triaxial seismic trip system consists of two major units. These are a Model TS-3 seismic switch and a Model SP-1 seismic switch power supply. The system output is a relay contact change of position when the seismic switch is accelerated either vertically or horizontally to a level greater than the preset level. This relay will be connected into the GETR scram system in the same way as the present seismic switch output.

The seismic switch contains three orthogonal electromagnetic transducers. The transducers are small moving coils that produce a voltage proportional to acceleration. This coil voltage is amplified to energize the output relay. The acceleration trip level is adjusted by changing the sensitivity of the amplifier.

The seismic switch power supply contains a dc power supply and a battery. The dc power supply powers the seismic transducers and serves as a charger for the battery. The battery is connected to float on the power supply output, thus it is a backup power supply. Therefore, the dc power supply and the battery provide redundant power to the triaxial seismic trip system.

The relay provides a contact change of position as a system output that requires a manual reset to return it to normal. A test switch provides a voltage across the transducer coil that simulates an acceleration that would trip the system. It is planned to set the trip points at 0.01g.

The Kinemetrics Company is willing to certify this equipment to operate as designed at acceleration levels up to and including 0.5g and in the environment in which it will be located.