

Appendix A

3-D Seismic Time History Generation Results

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A.1 Introduction

Purpose of this Appendix A is to generate input load for seismic analysis of new and spent fuel storage rack of the APR1400. Non-linear model requires three-dimensional transient dynamic analysis. For proper response analysis in case of seismic load effect, input load has to convert from seismic load of response spectrum shape to three directions acceleration-time history data.

Therefore, Appendix A is performed to convert response spectrum of Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) specified in Ref. B.2 to acceleration-time history load satisfying requirements of NUREG-0800, SRP 3.7.1 [Ref. A.1].

Acceleration-time history load for new and spent fuel storage racks of the APR1400 was calculated each by input load of floor response spectrum at auxiliary building elevation 137'-6" and 114'-0", respectively.

A.2 Applicable Criteria

Requirements of Ref. A.1 were applied to generate time history data, summarized as follows.

1) Statistical Independence Check

Time history data (two directions horizontal and one direction vertical component) generated respectively should be statistically independent of each other. Evaluation is made by calculating the cross correlation coefficient of time history data between two different events. The cross correlation Coefficient calculated for each three directions component should be smaller than 0.15.

2) Check whether regenerated response spectrum covers target response spectrum

Regenerated response spectrum for generation of time history data should cover target response spectrum specified in the design specification. Evaluation frequency range is shown at section 3.7.1, Table 3.7.1-1 of Ref. A.1 as follows.

| <u>Frequency range (Hz)</u> | <u>Increment (Hz)</u> |
|-----------------------------|-----------------------|
| 0.2 - 3.0 | 0.10 |
| 3.0 - 3.6 | 0.15 |
| 3.6 - 5.0 | 0.20 |
| 5.0 - 8.0 | 0.25 |
| 8.0 - 15.0 | 0.50 |
| 15.0 - 18.0 | 1.0 |
| 18.0 - 22.0 | 2.0 |
| 22.0 - 34.0 | 3.0 |

Generated response spectrum with lower value than target response spectrum value should have less than 10% difference from target value and be 5 point based on frequency range above.

- 3) Average Power Spectral Density (PSD) function by time history data that was generated from rule of Section 3.7.1, Appendix A of Ref. A.1 should exceed the 80% of calculated target PSD, and be applied to range 0.3Hz - 24Hz. Also, when calculating average PSD, width of $\pm 20\%$ from central frequency should be included.

A.3 Assumptions

No assumption was made for the Appendix A of this report.

A.4 Time History Generation

Among Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) response spectrum specified in Ref. B.2, target response spectrums of new and spent fuel storage rack are response spectrum at 137'-6" and 114'-0" respectively.

"ATIGEN" program [Ref. E.2] was used to generate acceleration-time history data and Power Spectral Density (PSD) function of two horizontal direction and vertical component. Time history data is to have a value between 0 to 25 seconds, and damping of 2% and 3% was applied to OBE and SSE load respectively.

Statistical independence of generated seismic history data was identified using "STCOR" program [Ref. E.3].

A.5 Analysis Result

Figure A.1.1 to A.1.12 compares regenerated response spectrum value for generation time history data with design response spectrum specified in design specification. Review result of regenerated response spectrum by applying condition of section A.2.2) shows that it covers the design response spectrum.

Figure A.2.1 to A.2.12 compares PSD with Target PSD of time history data generated in "ATIGEN" program for OBE and SSE condition of New and Spent Fuel Pool. Generated PSD value is higher than 80% of target PSD value that is generated according to Section 3.7.1, Appendix A of Ref. A.1.

Figure A.3.1 to A.3.12 describes acceleration-time history graph for OBE and SSE in which damping ratios of 2% and 3% are applied respectively. Figure A.3.1 to A.3.6 describes time history data about seismic load for 25 seconds at bottom of new fuel pool. Figure A.3.7 to A.3.12 describes time history data about seismic load for 25 seconds at bottom of spent fuel pool. Cross correlation coefficient for respectively generated time history data is calculated as follows. Since it is lower than allowable absolute value 0.15, acceleration-time history data for each direction is statistically independent.

1) Correlation Coefficients for New Fuel Pool

RESULTS OF CORRELATION COEFFICIENT (OBE Condition)

X-Direction TO Y-Direction Acceleration = 6.0699834E-03

X-Direction TO Z-Direction Acceleration = -7.3058070E-03

Y-Direction TO Z-Direction Acceleration = 1.5237166E-02

RESULTS OF CORRELATION COEFFICIENT (SSE Condition)

X-Direction TO Y-Direction Acceleration = 1.3696939E-04

X-Direction TO Z-Direction Acceleration = 1.1627306E-02

Y-Direction TO Z-Direction Acceleration = 3.9900944E-02

2) Correlation Coefficients for Spent Fuel Pool

RESULTS OF CORRELATION COEFFICIENT (OBE Condition)

X-Direction TO Y-Direction Acceleration = -1.1451175E-02

X-Direction TO Z-Direction Acceleration = -1.1122467E-02

Y-Direction TO Z-Direction Acceleration = -8.5602161E-03

RESULTS OF CORRELATION COEFFICIENT (SSE Condition)

X-Direction TO Y-Direction Acceleration = -9.2012743E-03

X-Direction TO Z-Direction Acceleration = -2.1080079E-02

Y-Direction TO Z-Direction Acceleration = -2.6252886E-02

A.6 Conclusions

Acceleration-time history data showed at Figure A.3.1 to A.3.12 is satisfied with application criteria of Section A.2, and was used as input loads for seismic analysis of new and spent fuel storage rack of the APR1400.

Overlay of Target and Generated Spectra
APR1400 DC New Fuel Spectra at Elev. 137'-6"
OBE 2% [E-W Direction]

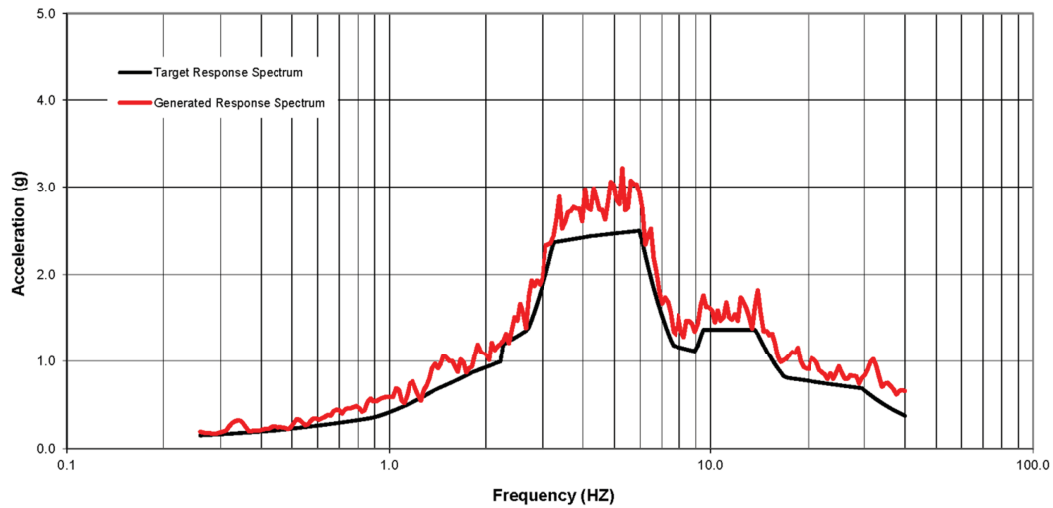


Figure A.1.1 137'-6" OBE Response Spectrum (2% Damping, E-W Direction)

Overlay of Target and Generated Spectra
APR1400 DC New Fuel Spectra at Elev. 137'-6"
OBE 2% [N-S Direction]

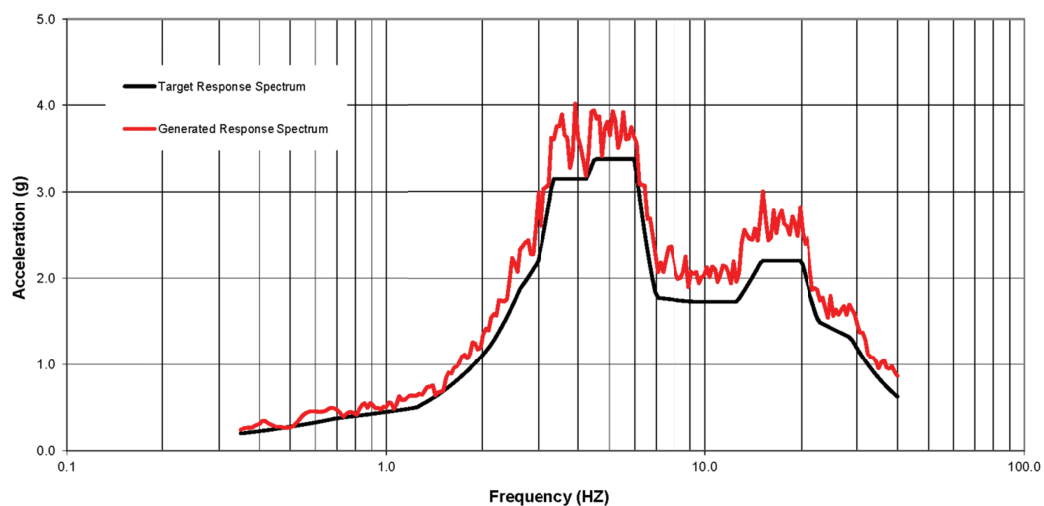


Figure A.1.2 137'-6" OBE Response Spectrum (2% Damping, N-S Direction)

Overlay of Target and Generated Spectra
APR1400 DC New Fuel Spectra at Elev. 137'-6"
OBE 2% [Vertical Direction]

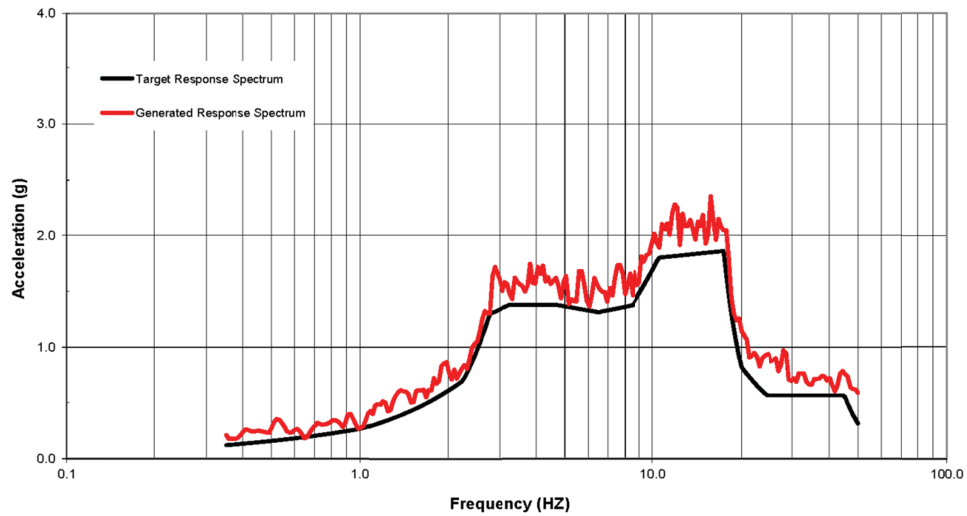


Figure A.1.3 137'-6" OBE Response Spectrum (2% Damping, Vertical Direction)

Overlay of Target and Generated Spectra
APR1400 DC New Fuel Spectra at Elev. 137'-6"
SSE 3% [E-W Direction]

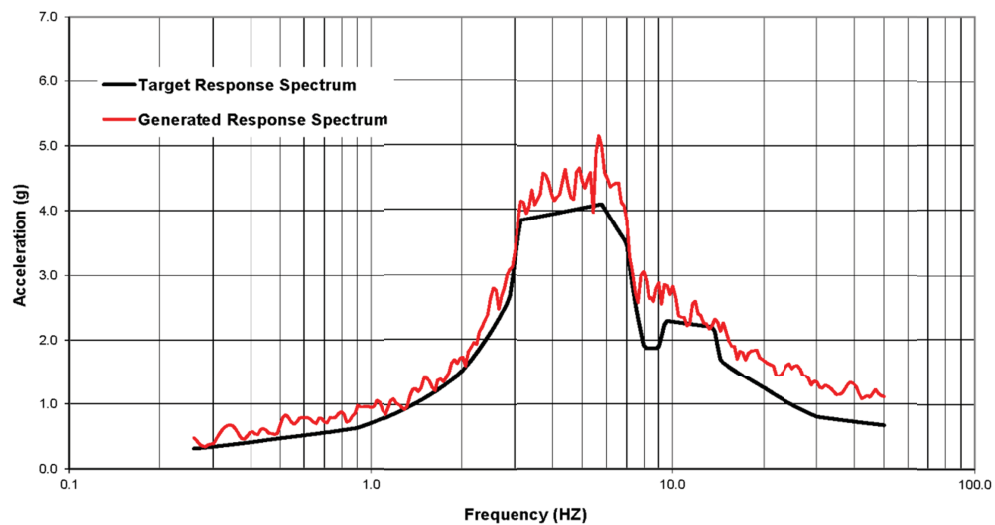


Figure A.1.4 137'-6" SSE Response Spectrum (3% Damping, E-W Direction)

