# Seismic Adequacy Verification of Safe Shutdown Equipment in Wolsong Unit 1

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## 1. Introduction

Wolsong unit 1 is a nuclear power plant designed and qualified by codes and standards set before the establishment of seismic qualification technology in 1975 [1], and as such has inherently some seismic issues. The U.S. has defined similar nuclear power plants to Wolsong unit 1 as USI (Unresolved Safety Issue) A-46 plants and has resolved the seismic issues of the plants according to the Generic Implementation Procedure (GIP) developed by the Seismic Qualification Utility Group (SQUG) for the seismic adequacy verification of safe shutdown equipment in the plants. Wolsong unit 1 also needed to verify the seismic adequacy of safe shutdown equipment for continued operation. The aim of this paper is to present the verification process of the seismic adequacy of Wolsong unit 1 through the application of the SQUG GIP methodology and the performance of seismic walkdown as a CANDU (CANadian Deuterium Uranium)-type reactor for the first time in Korea. After all, it is to ensure the seismic safety until the next periodic safety review after the designed lifetime [2].

## 2. Methods and Results

### *2.1 Scope*

To prepare a list of equipment subject to seismic adequacy verification in Wolsong unit 1, the safe shutdown equipment list was derived by selecting system and equipment on the safe shutdown path guaranteeing the following four essential safe shutdown functions with the SQUG GIP guide.

a. Reactor Reactivity Control
b. Reactor Coolant Pressure Control
c. Reactor Coolant Inventory Control
d. Decay Heat Removal

### *2.2 Criteria*

This verification has confirmed applicable the codes to Wolsong unit 1 according to the Atomic Energy Law article 23.3 'Periodic safety review', and the Enforcement decree of the above law article 42.3 'Factors of periodic safety review' and has applied these laws and codes as the verification criteria.

a. Bulletin No. 2008-7 by Ministry of Education, Science and Technology, 'Criteria related to location of nuclear power plant facilities'.
b. Bulletin No. 2008-13 by Ministry of Education, Science and Technology, 'Regulations on safety classification and grade of nuclear power plant facilities'.
c. Seismic Qualification Utility Group, Generic Implementation Procedure for Seismic Verification of Nuclear Power Plants Equipment, Revision 3A, December 2001.

### *2.3 Methods*

To check the physical installation status and the functionality of the equipment on the safety shutdown path in Wolsong unit 1, the walkdown was carried out about whether the equipment had seismic adequacy according to the screening walkdown plan requested in appendix F of SQUG GIP.

The number of equipment with safe shutdown functions subject to the walkdown was 396. Screening evaluation work sheets were prepared for individual equipment and the relevant walkdown results were recorded on the sheets to verify the seismic adequacy (refer to Table I).

Table I: Sample of screening evaluation work sheet for Emergency Diesel Generator.

Screening Status: Screened Out — Wolsong NPP — Revision 3A

Unit No. 1 — SCREENING EVALUATION WORK SHEET (SEWS)

Equipment ID No. 5290-DG1 — Equip. Class: 17 - Engine-Generators

Equipment Description: Emergency DG

Location: Bldg. EPS Building — Floor El. 100 — Room, Row/Col B170

Manufacturer: Waukesha Engine Division Dresser Industri — Model: L5670DSIU

SEISMIC CAPACITY VS DEMAND

| | | |
|---|---|---|
| 1. | Elevation where equipment receives seismic input | 100 |
| 2. | Elevation of seismic input below about 40' from grade | Yes |
| 3. | Equipment has fundamental frequency above about 8 Hz | Unknown |
| 4. | Capacity based on: ○ Existing Documentation ○ Bounding Spectrum ◉ 1.5 X Bounding Spectrum ○ GERS | |
| 5. | Demand based on: ○ Ground Response Spectrum ○ 1.5 X Ground Response Spectrum ◉ Conserv. Des. In-Str. Resp. Spec. ○ Realistic M-Ctr. In-Str. Resp. Spec. | |

Does capacity exceed demand? (Indicate at right (*) and in Comments if a special exception to enveloping of seismic demand spectrum is invoked per Sect. 4.2 of the GIP) — Yes*

CAVEATS - BOUNDING SPECTRUM (Identify with an asterisk (*) those caveats which are met by intent without meeting the specific wording of the caveat rule and explain the reason for this conclusion in the COMMENTS section below)

| | | |
|---|---|---|
| 1. | Equipment is included in the earthquake experience equipment class | Yes |
| 2. | Driver and driven equipment connected by a rigid support or common skid | Yes |
| 3. | Base vibration isolators adequate for seismic loads | Yes* |
| 4. | Attached lines (cooling, air, electrical) have adequate flexibility | Yes |
| 5. | Anchorage adequate (See checklist below for details) | Yes |
| 6. | Relays mounted on equipment evaluated | N/A |
| 7. | Have you looked for and found no other adverse concerns? | Yes |

Is the intent of all the caveats met for Bounding Spectrum? — Yes

### *2.4 Results*

According to the walkdown, most equipment were satisfied with all criteria of excitation force for earthquakes, criteria of database for earthquakes, criteria of anchorage for equipment support, and criteria of mutual interference between equipment, and the

seismic adequacy was verified. However, items of 75 equipment were classified as outliers they didn't meet one or more of the evaluation criteria [3, 4].

The walkdown results of the installation status of the equipment and seismic adequacy verification were summarized in screening verification data sheets (refer to Table II).

Table II: Sample of screening verification data sheet.

**Screening Verification Data Sheet (SVDS)**

| Equipment Class | Equipment ID | Equipment Description | BLDG | Floor El (m) | Room, Row/Col | C/D | BS Caveats | Anchor | SI | Screened? |
|---|---|---|---|---|---|---|---|---|---|---|
| 00 - Generic Input Form | 3432-STR1 | ECCS Water Strainer | RB | Basemat | R009 | Yes | NA | Ukn | Yes | No |
| 00 - Generic Input Form | 3432-STR2 | ECCS Water Strainer | RB | Basemat | R009 | Yes | NA | Ukn | Yes | No |
| 00 - Generic Input Form | 5290-Silencer1 | DG Silencer | EPS | 106.4 | ROOF | Yes | NA | Yes | Yes | Yes |
| 00 - Generic Input Form | 5290-Silencer2 | DG Silencer | EPS | 106.4 | ROOF | Yes | NA | Yes | Yes | Yes |
| 01 - Motor Control Centers | 5290-MCC40 | ECCS MOV Control | SCA | 95.43 | S028 | Yes | Yes | Yes | Yes | Yes |
| 01 - Motor Control Centers | 5290-MCC41 | ECCS MOV Control | SCA | 95.43 | S028 | Yes | Yes | Yes | Yes | Yes |
| 01 - Motor Control Centers | 5290-PL89-MCC | 480VAC EPS MCC | SCA | 95.43 | S014 | Yes | N/A | N/A | Yes | Yes |

CERTIFICATION:
All the information contained on this Screening Verification Data Sheet (SVDS) is, to the best of our knowledge and belief, correct and accurate. "All information" includes each entry and conclusion (whether verified to be seismically adequate or not).

Approved: (Signatures of all Seismic Capability Engineers on the Seismic Review Team (SRT) are required; there should be at least two on the SRT. All signatories should agree with all of the entries and conclusions. One signatory should be a licensed professional engineer.

Print or Type Name Signature Date

Print or Type Name Signature Date

CERTIFICATION:
The information provided to the Seismic Capability Engineers regarding systems and operations of the equipment contained on this SVDS is, to the best of our knowledge and belief, correct and accurate.

Approved: (One signature of Systems or Operations Engineer is required if the Seismic Capability Engineers deem it necessary.)

Print or Type Name Signature Date

Print or Type Name Signature Date

The detailed review was performed regarding inappropriate equipment classified as outliers according to the walkdown and evaluation. Seismic demand reduction was realized through detailed reanalyses of individual equipment. Reinforced design of anchorages of individual equipment was applied to resolve the issues and examples showing such reinforcement are presented in Figures 1 and 2.

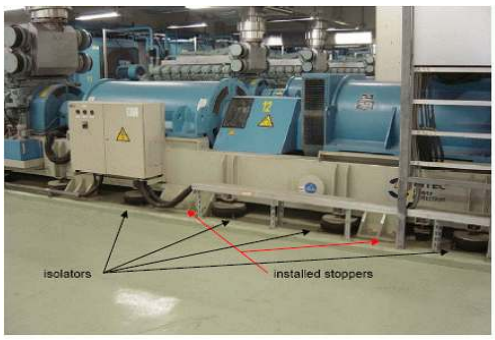


Fig. 1. Example of reinforced emergency diesel generator supports.

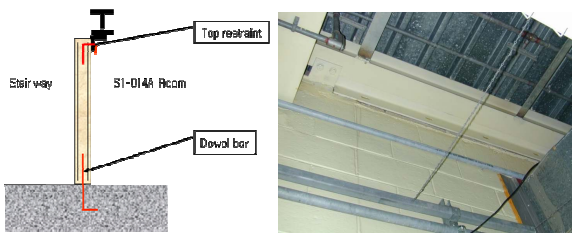


Fig. 2. Example of reinforced masonry wall.

## 3. Conclusions

This paper presented the verification process of the seismic adequacy of the safe shutdown equipment in Wolsong unit 1 and then the seismic issues of the plant were resolved through SQUG GIP to satisfy the legal requirements required by the Atomic Energy Law as a CANDU-type reactor for the first time in Korea.

Now some follow-up measures are being conducted on equipment requiring reinforcement as a result of this seismic adequacy verification at the plant. When the follow-up measures are completed by the end of 2010, the seismic adequacy will be guaranteed enough more than at the moment for all the equipment in Wolsong unit 1.

## REFERENCES

[1] IEEE Standard 344, IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations, 1971.
[2] Seismic Qualification Utility Group, Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Power Plants Equipment, Revision 3A, December 2001.
[3] CSA CAN3-N289.4-M86, Testing Procedures for Seismic Qualification of CANDU Nuclear Power Plants.
[4] Gleason, J.F., EPRI NP-5024, Seismic Ruggedness of Aged Electrical Components, EPRI, January 1987.