Database for Storing Screening Evaluation Worksheets for Seismic PRA Walkdowns

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Abstract: The development of seismic probabilistic risk assessment (SPRA) for a nuclear power plant (NPP) involves performing plant walkdown to estimate the seismic capacities of risk-significant systems, structures, and components (SSCs). These walkdowns require a large number of screening evaluation worksheets (SEWS) to be filled. This paper describes development of a database for storing information of SSCs in the seismic equipment list (SEL) and generating electronic SEWSs for the plant walkdown. The walkdown forms are based on the templates recommended by the Electric Power Research Institute (EPRI) and the technical implementation of the database is carried out in Microsoft Access software.

1. INTRODUCTION

Seismic walkdowns are used in the development of seismic probabilistic risk assessment (SPRA) to assess seismic failure modes and capacities, and to identify potential systems interactions, such as falling structures or objects or seismic-induced fires or flooding. The walkdowns are used to screen systems, structures, and components with high seismic capacity out of further analysis. Screening evaluation worksheets (SEWS) are used in the walkdowns to guide this task.

The seismic equipment list (SEL) includes the systems, structures, and components (SSCs) that are considered in the SPRA. This list usually contain hundreds of items, that can result in thousands of pages when printed. This paper describes the development of a database for storing the SEL for seismic walkdowns and generating electronic SEWS. A touchscreen tablet device could then be used to fill out the SEWS during walkdowns. The database is referred as seismic walkdown database (SWDB).

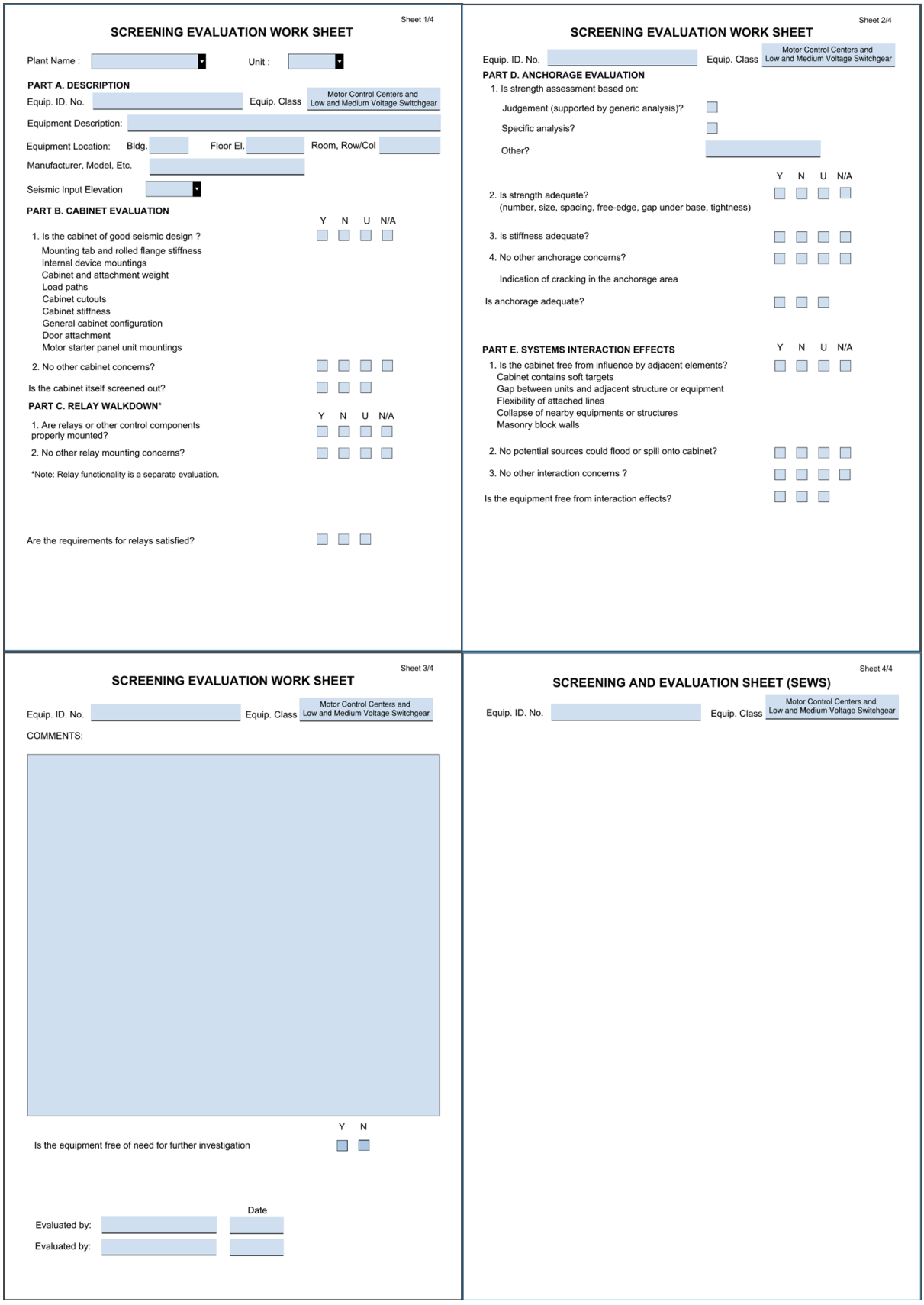
The remainder of this paper is organized as follows. Section 2 describes the structure and contents of the screening evaluation worksheets. Section 3 describes the development of the database. Section 4 describes a pilot test, where the walkdown database was utilized in planning of a seismic walkdown of a nuclear power plant. Section 5 concludes.

2. SCREENING EVALUATION WORKSHEETS

Screening evaluation worksheets are used to assist in collection of information of the seismic capacities during the seismic walkdown. SEWS are presented as checklists, that guide the analyst to assess, for example, the seismic design and anchorage of the equipment, and possibility for seismic-induced interactions. An example SEWS is presented in Figure 1.

The EPRI report 3002012994 [1] includes recommended SEWS for 23 different equipment classes. These classes are (1) Motor Control Centers and Low and Medium Voltage Switchgear, (2) Batteries and Racks, (3) Battery Chargers and Inverters, (4) Transformers, (5) Control and Instrumentation Panels, (6) Instrument Racks, (7) Distribution Panels, (8) Local Instruments and Sensors, (9) Engine Generators, (10) Motor Generators, (11) Horizontal Pumps, (12) Vertical Pumps, (13) Air- or Fluid-Operated Valves or Dampers, (14) Motor-Operated Valves or Dampers, (15) Solenoid-Operated Valves, (16) Air Compressors, (17) Fans and Air Handlers, (18) Chillers, (19) Vertical Tanks or Heat Exchangers, (20) Horizontal Tanks or Heat Exchangers, (21) Traveling Screens and Sluice Gates, (22) Manual Valves or Dampers, and (23) Generic Components.

Figure 1: Example four-page SEWS from [1]. Equipment class (1) Motor Control Centers and Low and Medium Voltage Switchgear.



Sheet 1/4

SCREENING EVALUATION WORK SHEET

Plant Name : Unit :

PART A. DESCRIPTION

Equip. ID. No. Equip. Class Motor Control Centers and Low and Medium Voltage Switchgear

Equipment Description:

Equipment Location: Bldg. Floor El. Room, Row/Col

Manufacturer, Model, Etc.

Seismic Input Elevation

PART B. CABINET EVALUATION

	Y	N	U	N/A
1. Is the cabinet of good seismic design ?	☐	☐	☐	☐
Mounting tab and rolled flange stiffness				
Internal device mountings				
Cabinet and attachment weight				
Load paths				
Cabinet cutouts				
Cabinet stiffness				
General cabinet configuration				
Door attachment				
Motor starter panel unit mountings				
2. No other cabinet concerns?	☐	☐	☐	☐
Is the cabinet itself screened out?	☐	☐	☐	

PART C. RELAY WALKDOWN*

	Y	N	U	N/A
1. Are relays or other control components properly mounted?	☐	☐	☐	☐
2. No other relay mounting concerns?	☐	☐	☐	☐

*Note: Relay functionality is a separate evaluation.

Are the requirements for relays satisfied? ☐ ☐ ☐

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SCREENING EVALUATION WORK SHEET

Equip. ID. No. Equip. Class Motor Control Centers and Low and Medium Voltage Switchgear

PART D. ANCHORAGE EVALUATION

1. Is strength assessment based on:

Judgement (supported by generic analysis)? ☐

Specific analysis? ☐

Other?

	Y	N	U	N/A
2. Is strength adequate? (number, size, spacing, free-edge, gap under base, tightness)	☐	☐	☐	☐
3. Is stiffness adequate?	☐	☐	☐	☐
4. No other anchorage concerns?	☐	☐	☐	☐
Indication of cracking in the anchorage area				
Is anchorage adequate?	☐	☐	☐	

PART E. SYSTEMS INTERACTION EFFECTS

	Y	N	U	N/A
1. Is the cabinet free from influence by adjacent elements?	☐	☐	☐	☐
Cabinet contains soft targets				
Gap between units and adjacent structure or equipment				
Flexibility of attached lines				
Collapse of nearby equipments or structures				
Masonry block walls				
2. No potential sources could flood or spill onto cabinet?	☐	☐	☐	☐
3. No other interaction concerns ?	☐	☐	☐	☐
Is the equipment free from interaction effects?	☐	☐	☐	

Sheet 3/4

SCREENING EVALUATION WORK SHEET

Equip. ID. No. Equip. Class Motor Control Centers and Low and Medium Voltage Switchgear

COMMENTS:

	Y	N
Is the equipment free of need for further investigation	☐	☐

Date

Evaluated by:

Evaluated by:

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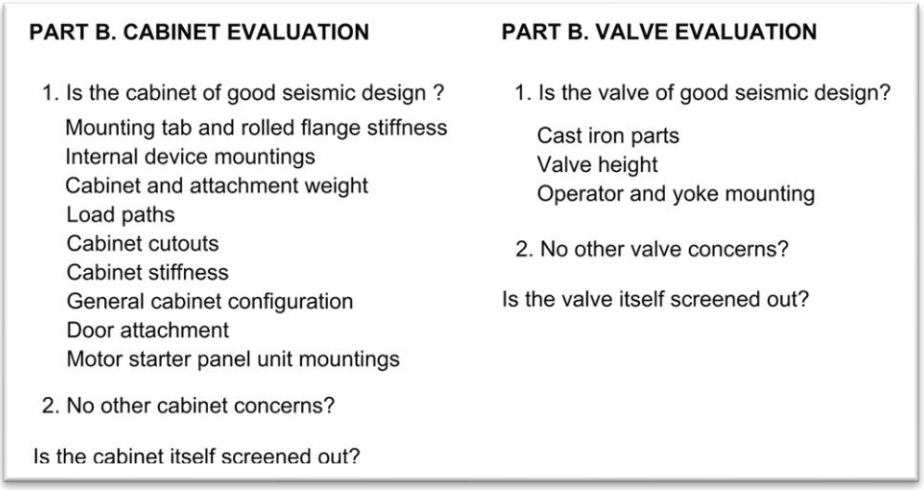
SCREENING AND EVALUATION SHEET (SEWS)

Equip. ID. No. Equip. Class Motor Control Centers and Low and Medium Voltage Switchgear

All the recommended SEWS from the EPRI report [1] are 3 or 4 pages long with the last page being empty for additional hand-written comments. The SEWS begin with “Part A. Description”, which includes the equipment identifier, equipment class, description, location information, and additional information of manufacturer, model, etc., as well as the seismic input elevation. After Part A, there are 2 to 6 additional sections (Part B to Part G) that include the actual evaluation questions. Part A of the SEWS is same for all equipment classes, but the number and contents of the additional sections depend on the equipment class. Lastly, the SEWS includes a field for comments, evaluation if the equipment is free of need for further investigation, and fields for evaluator name and evaluation date.

The evaluation questions are different for different equipment classes. For example, the first question in Part B of the SEWS for equipment class (1) Motor Control Centers and Low and Medium Voltage Switchgear is “Is the control cabinet of good seismic design?”, but for equipment class (15) Solenoid-Operated Valves it is “Is the valve of good seismic design?” (see Figure 2). However, the number of questions and the evaluation outcome multiple choices always are similar between different equipment classes.

Figure 2: Part B evaluation questions for equipment classes (1) Motor Control Centers and Low and Medium Voltage Switchgear and (15) Solenoid-Operated Valves.



The fact that only the wording of the questions change and the number of questions and evaluation outcome options are always the same allows creating a simple database to store the SEWS. The next section describes the development of this database.

3. DATABASE DEVELOPMENT

3.1. Database tables

The technical implementation of the Seismic Walkdown Database described here was carried out in Microsoft Access software. Microsoft Access was chosen, because it is readily available on many devices and because it allows for information storage on a local hard drive or info on a secure network drive, instead of in a cloud. The SWDB main features are implemented with four tables described below. The aim here is not to present the database implementation in detail, but rather describe the main design characteristics.

Table EquipmentClasses is used to store the 23 equipment classes described in Section 2. The equipment class number is the primary key and the textual representation is stored to be used in the walkdown forms.

Table Equipment is used to store all the equipment in the Seismic Equipment List. Each equipment has a unique equipment identifier, which is used as the primary key, and each equipment must have an

equipment class assigned. Additionally, this table is used to store the information which is included in Part A of the SEWS for all equipment classes.

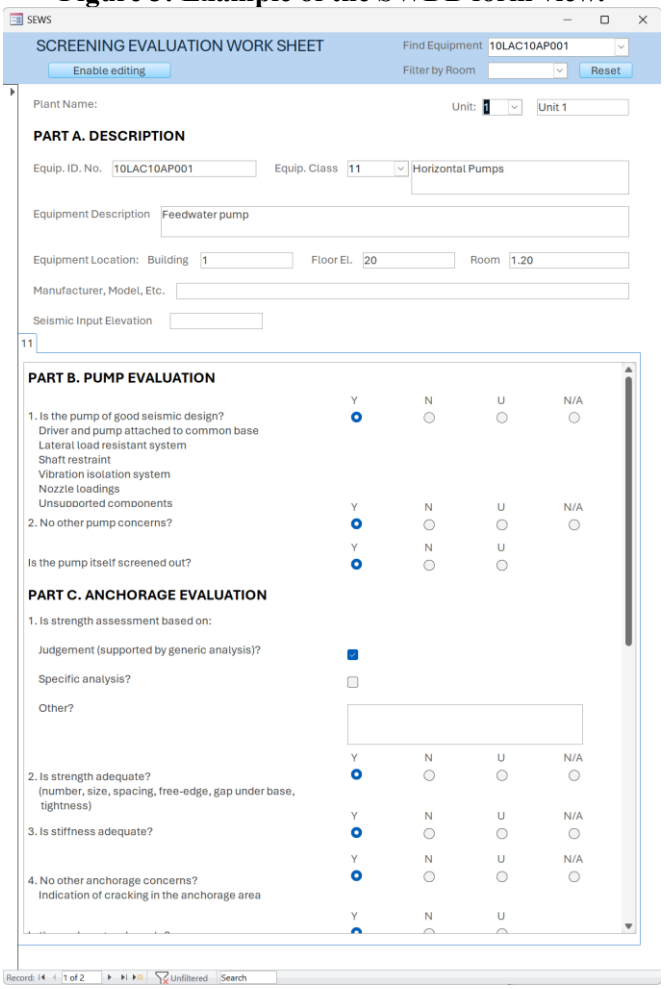
Table SEWSQuestions is used to store the questions presented in the recommended SEWS described in Section 2. These questions are stored as one record for each equipment class, which is used as the primary key. Each field in this table represents one question in the SEWS, and an empty string in the field means that the equipment type does not have that specific question in the SEWS. Additionally, SEWSQuestions is used to store the section headings of the SEWS, because these may differ between equipment classes (see Figure 2).

Table EvaluationOutcomes is used to store the walkdown analyst's answers to the multiple choice and open field questions in the SEWS. There is one record for each equipment analyzed in the walkdowns and the equipment identifier is used as the primary key. Multiple choice questions answers are encoded as integer values between 1 and 4, one meaning Yes, two meaning No, three meaning Unknown and four meaning Not Applicable. Open field questions and comments field are stored as long text.

3.2. Form view

To ease the use of the database, a form view was created. A screenshot of the form view is shown in Figure 3. The upper part of the form always shows Part A of the SEWS, and a subform with content varying on the equipment class is shown in the lower part of the form. Buttons in the form are used to enable and disable editing of the contents of the form. Navigation buttons can be used to jump between items in the database and drop-down search boxes can be used to jump to a specific record by equipment ID or to filter the equipment by room.

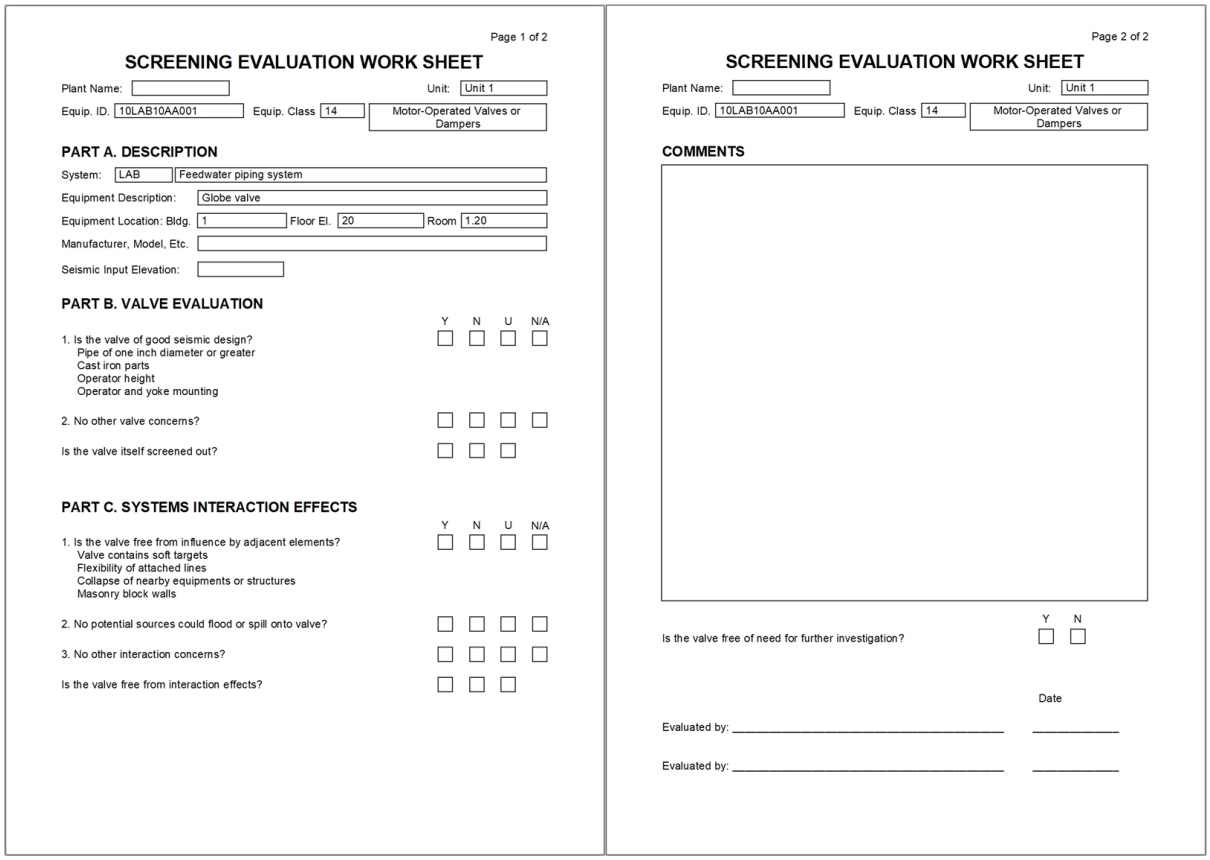
Figure 3: Example of the SWDB form view.



3.3. Report view

In addition to the form view, a report view was also created. There are two main features that can be achieved with the report view: (1) to create a PDF file of the evaluation outcomes in the database to be attached in the walkdown report, and (2) to print empty SEWS for all items in the database prior to the walkdown, if paper walkdown forms are preferred over electronic device. The report view automatically generates the correct SEWS for each item in the database based on the equipment class. The report can be sorted by for example room and equipment ID, or filters can be applied in the database to just include some equipment in the report. An example report is shown in Figure 4.

Figure 4: Example of the SWDB report view.



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SCREENING EVALUATION WORK SHEET

Plant Name: Unit: Unit 1

Equip. ID. 10LAB10AA001 Equip. Class 14 Motor-Operated Valves or Dampers

PART A. DESCRIPTION

System: LAB Feedwater piping system

Equipment Description: Globe valve

Equipment Location: Bldg. 1 Floor El. 20 Room 1.20

Manufacturer, Model, Etc.

Seismic Input Elevation:

PART B. VALVE EVALUATION

	Y	N	U	N/A
1. Is the valve of good seismic design? Pipe of one inch diameter or greater; Cast iron parts; Operator height; Operator and yoke mounting	☐	☐	☐	☐
2. No other valve concerns?	☐	☐	☐	☐
Is the valve itself screened out?	☐	☐	☐	

PART C. SYSTEMS INTERACTION EFFECTS

	Y	N	U	N/A
1. Is the valve free from influence by adjacent elements? Valve contains soft targets; Flexibility of attached lines; Collapse of nearby equipments or structures; Masonry block walls	☐	☐	☐	☐
2. No potential sources could flood or spill onto valve?	☐	☐	☐	☐
3. No other interaction concerns?	☐	☐	☐	☐
Is the valve free from interaction effects?	☐	☐	☐	

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SCREENING EVALUATION WORK SHEET

Plant Name: Unit: Unit 1

Equip. ID. 10LAB10AA001 Equip. Class 14 Motor-Operated Valves or Dampers

COMMENTS

Is the valve free of need for further investigation? Y ☐ N ☐

Date

Evaluated by: _____ _____

Evaluated by: _____ _____

4. PILOT TEST

The seismic walkdown database was utilized in planning of a seismic walkdown performed at a European nuclear power plant as a part of SPRA update project. In this walkdown the plant would not allow using a tablet device in the walkdowns, so the SWDB was used to generate and print the SEWS in advance.

In the walkdown planning, the database was found to be a useful tool. The SEL can be easily copy-pasted from Microsoft Excel spreadsheet software to table Equipment in the database. Then all the SEWS have Part A pre-filled for the walkdowns. Sorting the equipment list by room in the report view when creating the SEWS for printing was found to be useful, because that walkdown plan was created based on which rooms were going to be visited each day of the walkdown.

Another useful addition was the inclusion of system names in the SEWS, as shown in Figure 4. This feature was implemented by creating a table that has the system codes and system names. The system

codes could then be extracted from the unique equipment identifier, and the system name could be fetched from the prementioned table.

5. CONCLUSION

This paper described the development of Seismic Walkdown Database. The SWDB can be used to create and store electronic screening evaluation worksheets for seismic walkdowns.

The SWDB was pilot tested in a seismic walkdown of a nuclear power plant. Even though the walkdown used printed SEWS, the test showed that the database is a useful tool in planning of the walkdowns.

The database presented in this paper could be further developed by implementing a feature to store and display any photographs taken during the walkdown. Another improvement would be automated logging that would track any changes made in the database by the user and timestamp.

References

[1] Electric Power Research Institute. "*Seismic Fragility and Seismic Margin Guidance for Seismic Probabilistic Risk Assessments*", Technical report, 3002012994, (2018).