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Using HABIT to Establish the Chemicals Analysis Methodology for Maanshan Nuclear Power Plant

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Abstract**—**In this research, the HABIT analysis methodology was established for Maanshan nuclear power plant (NPP). The Final Safety Analysis Report (FSAR), reports, and other data were used in this study. To evaluate the control room habitability under the CO_2 storage burst, the HABIT methodology was used to perform this analysis. The HABIT result was below the R.G. 1.78 failure criteria. This indicates that Maanshan NPP habitability can be maintained. Additionally, the sensitivity study of the parameters (wind speed, atmospheric stability classification, air temperature, and control room intake flow rate) was also performed in this research.

Keywords**—**PWR, HABIT, habitability, Maanshan.

I. Introduction

MAANSHAN NPP is a PWR plant. Maanshan NPP locates in Hengchun Town, Pingtung County, Taiwan. Additionally, the reactor and systems such as Reactor Coolant System (RCS), feedwater control system, and pressure control systems were designed and manufactured by Westinghouse.

NPPs safety analysis is an important work. After Japan Fukushima Daiichi NPP disaster occurred, NPPs safety requirements are going up. Hence, Taiwan follows the world trend and pays more attention to NPPs safety. RAMP (Radiological protection computer code Analysis and Maintenance Program) international cooperation program is led by U.S. NRC. RAMP main research area is the control room habitability, radiation dose assessment, NPPs decommission, atmospheric dispersion factor and so on. HABIT is one of the codes developed in the RAMP program. HABIT can evaluate control room habitability for toxic chemicals leakage [1]. Our group (Tsing-Hua University) joined RAMP in 2016 and started to use RAMP codes. Hence, we use HABIT code with the FSAR [2], reports [1], [3], R.G. 1.78 [4], and R.G. 1.23 [5] to establish Maanshan NPP analysis methodology. And it was applied to evaluate the control room habitability under the CO_2 storage burst. In addition, the parameters (wind speed, atmospheric stability classification, air temperature, and control room intake flow rate) sensitivity study was also performed in this research.

II. Methodology

The HABIT version 2.0 was used in this study. The HABIT operation screen is shown in Fig. 1. HABIT can be divided into two sub-modules (EXTRAN and CHEM). HABIT in the operation will first perform EXTRAN. After EXTRAN calculation is completed, HABIT will perform the CHEM. EXTRAN calculates the concentration at the location of the air intake of the control room (shown in Fig. 2). CHEM uses the EXTRAN results with data (e.g. flow rate) to calculate the concentration of the control room (see Fig. 3). The HABIT output data are shown in Figs. 4 and 5.

The flow chart of the methodology is shown in Fig. 6. First, the Maanshan NPP data such as the chemical species, quantity, positions, and meteorological data are collected. This study used the data from FSAR [2], reports [1], [3], R.G. 1.78 [4], and R.G. 1.23 [5]. Then, these chemicals will be screened according to R.G. 1.78 [4]. R.G. 1.78 screening rules are based on the chemicals locations, distance, stock, etc. When a chemical is screened out, the control room habitability is not evaluated. When a chemical is not screened out, HABIT will perform the analysis.

The stock of CO_2 is 45,000 kg and its distance is less than 0.5 km (0.3 miles). According to R.G. 1.78, it cannot be screened out. Hence, HABIT performed this analysis. Table I lists the HABIT input parameters and values [3].

TABLE I
MAANSHAN HABIT INPUT PARAMETERS

Parameters	Values
CO_2 initial mass (kg)	45000
CO_2 storage temperature (℃)	-16.67
Wind speed (m/s)	3.11
Atmospheric stability classification	F
Air temperature (℃)	37.2
Control room volume (ft^3)	73169
Control room intake flow rate (ft^3/min)	1000

III. Results

The result of the HABIT analysis is shown in Table II. The maximum concentration is 3.166 g/m^3 and occurred at 1.25 minutes after the CO_2 storage burst. According to R.G. 1.78 [4], the failure criterion is 7.36 g/m^3. The HABIT result is below this criterion. This indicates that the control room habitability can be maintained. In addition, the sensitivity analysis was performed in this study. The parameters were air temperature, wind speed, atmospheric stability classification, and control room intake flow rate.

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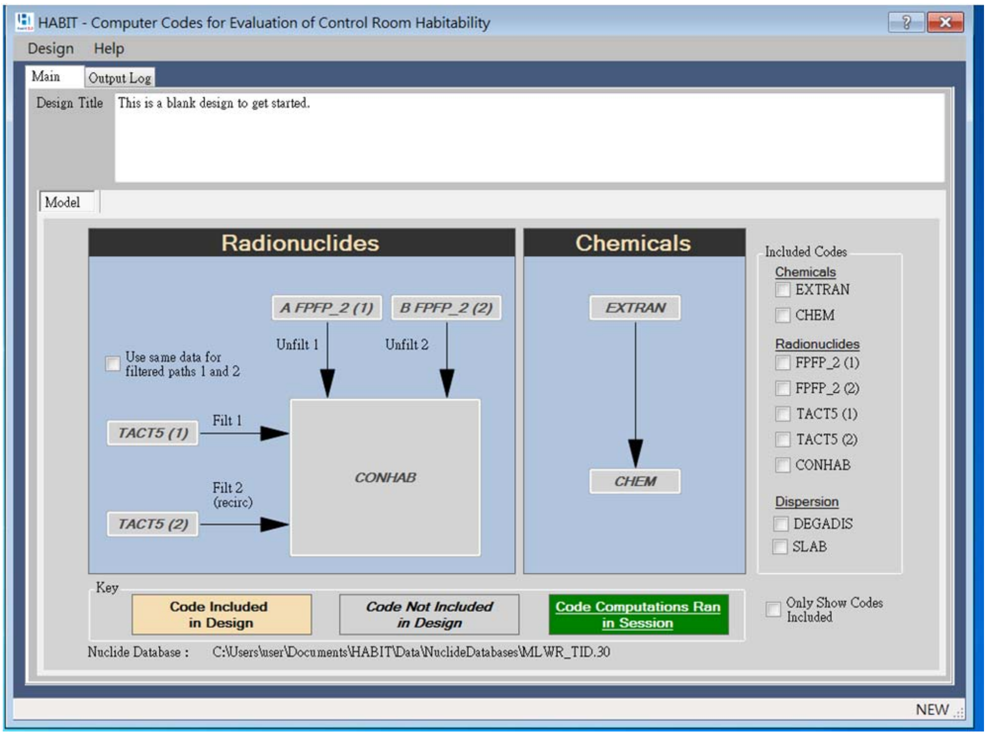


Fig. 1 The HABIT screen

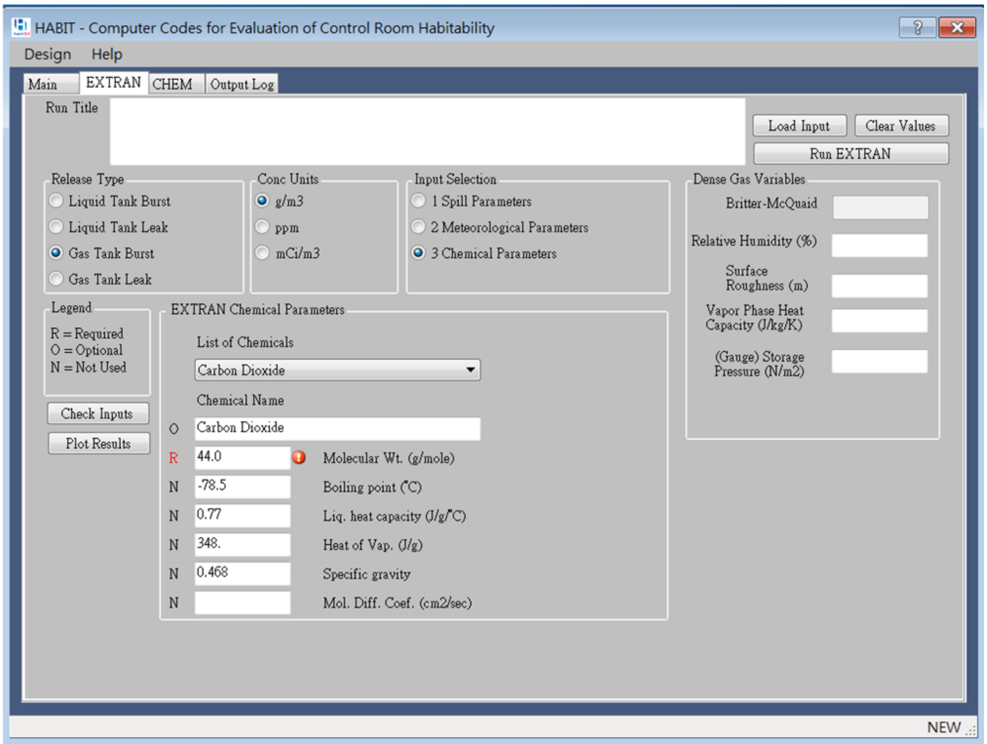


Fig. 2 The EXTRAN screen

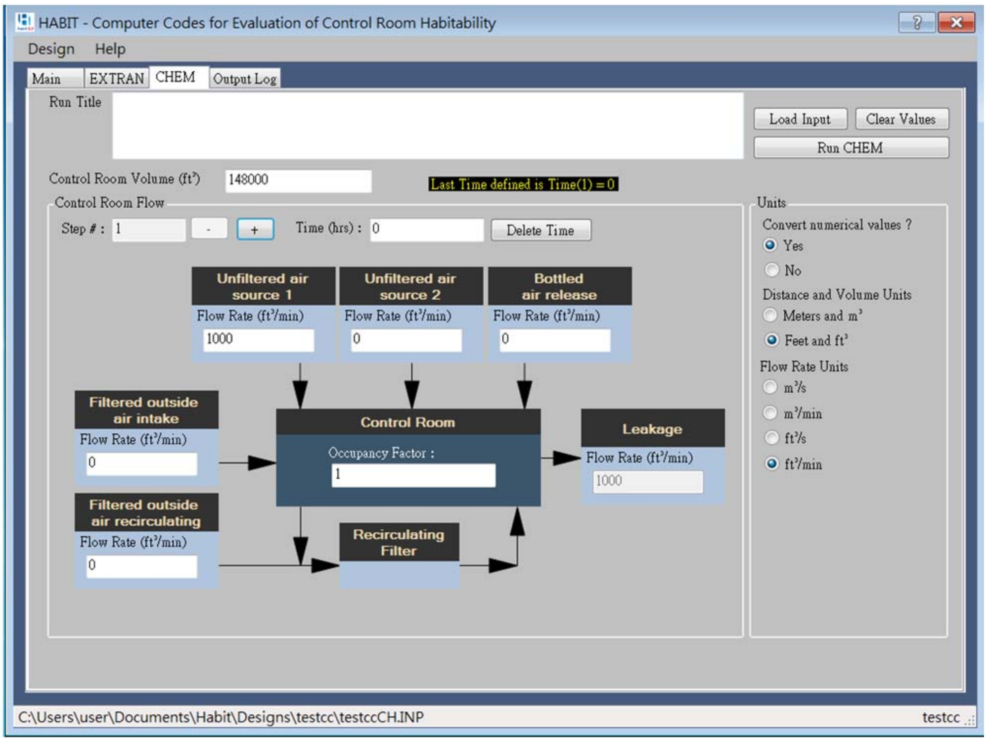


Fig. 3 The CHEM screen

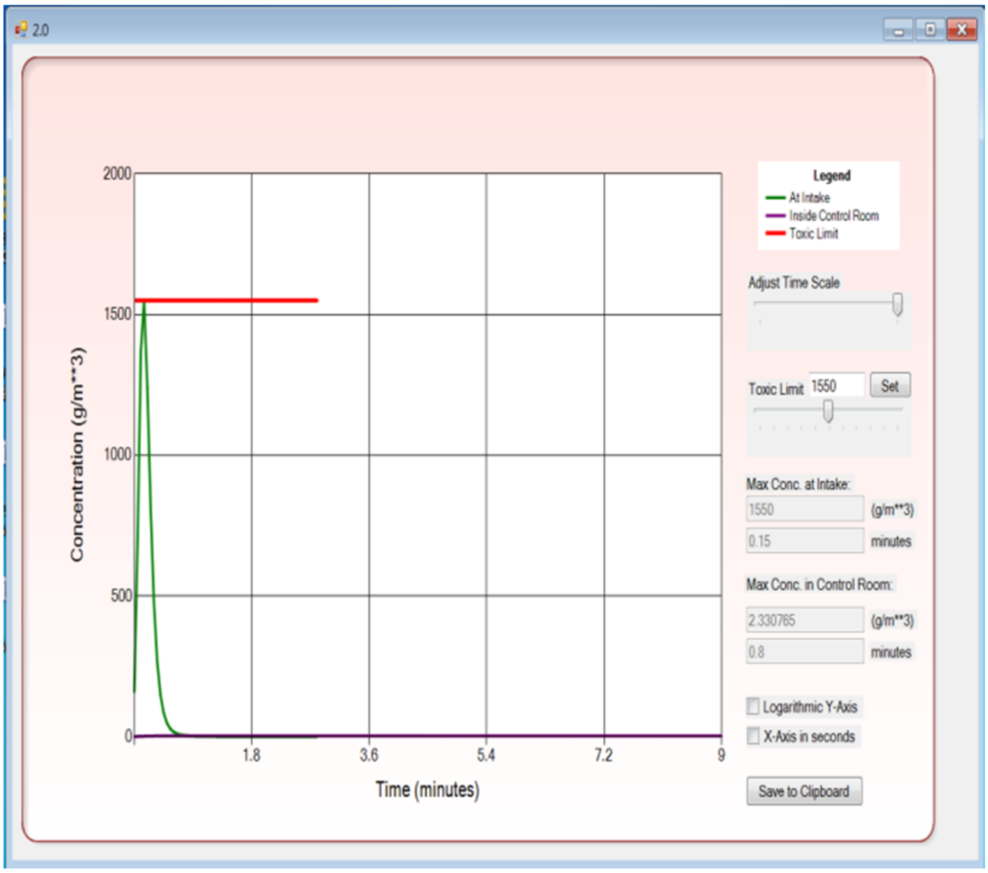
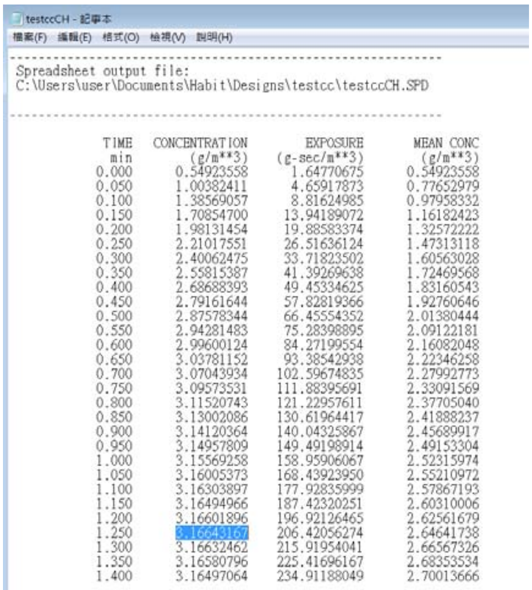


Fig. 4 The figure output screen



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Spreadsheet output file:
C:\Users\user\Documents\Habit\Designs\testcc\testccCH.SPD
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TIME min	CONCENTRATION (g/m**3)	EXPOSURE (g-sec/m**3)	MEAN CONC (g/m**3)
0.000	0.54923558	1.64770675	0.54923558
0.050	1.00382411	4.65917873	0.77652979
0.100	1.38569057	8.81624985	0.97958332
0.150	1.70854700	13.94189072	1.16182423
0.200	1.98131454	19.88583374	1.32572222
0.250	2.21017551	26.51636124	1.47313118
0.300	2.40062475	33.71823502	1.60563028
0.350	2.55815387	41.39269638	1.72469568
0.400	2.68688393	49.45334625	1.83160543
0.450	2.79161644	57.82819366	1.92760646
0.500	2.87578344	66.45554352	2.01380444
0.550	2.94281483	75.28398895	2.09122181
0.600	2.99600124	84.27199554	2.16082048
0.650	3.03781152	93.38542938	2.22346258
0.700	3.07043934	102.59674835	2.27992773
0.750	3.09573531	111.88395691	2.33091569
0.800	3.11520743	121.22957611	2.37705040
0.850	3.13002086	130.61964417	2.41888237
0.900	3.14120364	140.04325867	2.45689917
0.950	3.14957809	149.49198914	2.49153304
1.000	3.15569258	158.95906067	2.52315974
1.050	3.16005373	168.43923950	2.55210972
1.100	3.16303897	177.92835999	2.57867193
1.150	3.16494966	187.42320251	2.60310006
1.200	3.16601896	196.92126465	2.62561679
1.250	3.16643167	206.42056274	2.64641738
1.300	3.16632462	215.91954041	2.66567326
1.350	3.16580796	225.41696167	2.68353534
1.400	3.16497064	234.91188049	2.70013666

Fig. 5 The results output screen

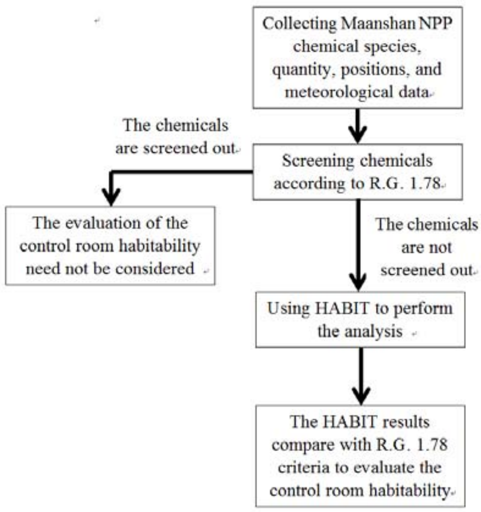

Fig. 6 The methodology flow chart

Table III presents the results for wind speed cases. When the wind speed increased, the maximum concentration decreased. In addition, the time point of the maximum concentration occurred earlier when the wind speed increased. The atmospheric stability classification can be divided into A ~ G level (see Table VII). These levels are from R.G. 1.23 [5]. "A level" is extremely unstable and "G level" is extremely stable. Table IV shows the results for atmospheric stability classification cases. When the atmospheric stability went down, the maximum concentration decreased. Additionally, the time point of the maximum concentration occurred later when the atmospheric stability went down. Table V lists the results for air temperature cases. The air temperature has no effect on the concentration. Table VI shows the results for the cases of the control room intake flow rate. When the intake flow rate went up, the maximum concentration increased. Additionally, the time point of the maximum concentration occurred earlier when the intake flow rate increased.

The above results present that the wind speed, atmospheric stability classification, and the control room intake flow rate have more effect on the concentration.

TABLE II
THE HABIT RESULTS

	Time (min)	Concentration (g/m^3)
HABIT	1.25	3.166
RG 1.78 failure criteria	-----	7.36

TABLE III
THE SENSITIVITY STUDY- WIND SPEED

Wind speed (m/s)	Time (min)	Concentration (g/m^3)
3.11	1.25	3.166
1.0	4	3.35
5.0	0.8	2.834

TABLE IV
THE SENSITIVITY STUDY- ATMOSPHERIC STABILITY CLASSIFICATION

Atmospheric stability classification	Time (min)	Concentration (g/m^3)
F	1.25	3.166
B	1.467	1.226
D	1.35	2.434
G	1.25	3.447

TABLE V
THE SENSITIVITY STUDY- AIR TEMPERATURE

Air temperature (℃)	Time (min)	Concentration (g/m^3)
37.2	1.25	3.166
25	1.25	3.166
31	1.25	3.166
40	1.25	3.166

TABLE VI
THE SENSITIVITY STUDY- CONTROL ROOM INTAKE FLOW RATE

Control room intake flow rate (ft^3/min)	Time (min)	Concentration (g/m^3)
1000	1.25	3.166
1500	1.2	4.716
2000	1.1	6.248
2350	1.1	7.31

TABLE VII
THE STABILITY CLASSIFICATION [5]

Stability classification	Pasquill stability category
Extremely unstable	A
Moderately unstable	B
Slightly unstable	C
Neutral	D
Slightly stable	E
Moderately stable	F
Extremely stable	G

IV. CONCLUSION

The main purpose of this study is to develop and establish the HABIT analysis methodology for Maanshan NPP. This methodology performed the analysis about CO_2 storage burst. The HABIT result was below the R.G. 1.78 failure criteria (7.36 g/m^3)**.** It implies that the control room habitability can be maintained. In addition, the sensitivity study results present that the wind speed, atmospheric stability classification, and control room intake flow rate have more effect in the maximum concentration calculation. Based on the above results and experiences, this HABIT methodology will be applied to perform other cases analysis in the future.

References

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