MARS Validation Plan and Status

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1. Introduction

The KINS Reactor Thermal-hydraulic Analysis System (KINS-RETAS) [1] under development is directed toward a realistic analysis approach of best-estimate (BE) codes and realistic assumptions. In this system, MARS is pivoted to provide the BE Thermal-Hydraulic (T-H) response in core and reactor coolant system to various operational transients and accidental conditions. As required for other BE codes, the qualification is essential to ensure reliable and reasonable accuracy for a targeted MARS application.

Validation is a key element of the code qualification, and determines the capability of a computer code in predicting the major phenomena expected to occur. The MARS validation was made by its developer KAERI, on basic premise that its backbone code RELAP5/MOD3.2 is well qualified against analytical solutions, test or operational data. A screening was made to select the test data for MARS validation; some models transplanted from RELAP5, if already validated and found to be acceptable, were screened out from assessment. It seems to be reasonable, but does not demonstrate whether code adequacy complies with the software QA guidelines [2]. Especially there may be much difficulty in validating the life-cycle products such as code updates or modifications.

This paper presents the plan for MARS validation, and the current implementation status.

2. MARS Validation Plan

2.1 Review of Previous Code Validation Matrices

The current regulations such as 10CFCR50.36 allow the use of the BE codes, if accompanied by quantification of uncertainties. Before issuance of the regulations, international efforts were initiated to develop the BE system codes, to generate test data for code validation and to perform code validation. Many test facilities were operated to generate relevant data. Intensive studies of the large break LOCA also identified the governing phenomena and processes by partitioning into the phases of phenomenological windows.

Indebted to the international efforts, the OECD/NEA CSNI published a number of validation matrices for various code applications with compilation of extensive data of the world-wide test facilities [3, 4]. The matrices provide relationships of phenomena, test types and facilities, but each not well defined. Phenomena selection was made on basis of expert experiences rather than by quantitative decision criteria.

The TRAC-M matrix as reported uses a more well-refined process, relating the Phenomena Identification & Ranking Table (PIRT)-derived phenomena to TRAC-M models and test facilities simultaneously [5]. Each validation steps using Other Standard Tests (OST), often classified by Separate (SET), Component (CET) and Integral Effect Tests (IET) are supported by clearly defined terms such as code elements and success metrics.

2.2 MARS Validation Process

A validation process is (1) to elicit important phenomena to be assessed through the PIRT process and cross-correlation with those used in other matrices, (2) to classify the selected phenomena by local (LL), component (CL) and system levels (SL) corresponding to SET, CET and IET, respectively, (3) to compose the validation matrices of phenomena versus test facilities, and (4) to choose the test data through a screening assessment. Figure 1 shows MARS validation process

3. MARS Validation Status

3.1 PIRT Development and Phenomena Elicitation

Among applications requested to MARS are noted three areas, (1) regulatory audits of licensing calculations, (2) analyses of operational events and (3) support for probabilistic risk assessment. Assuming that all important phenomena in these targeted applications occur during large and small break LOCA, and heat-up, over-cooling and SGTR transients, the PIRT study drew a highly ranked phenomena (HRP) list [6].

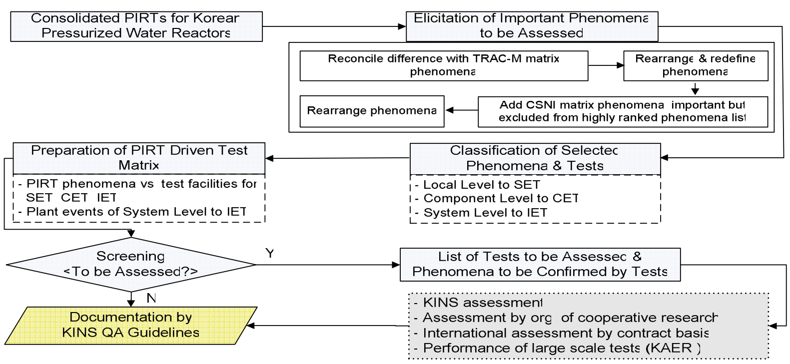

Figure 1 MARS Validation Process

To minimize the PIRT evaluation errors or biases, the HRP was reconciled with those in TRAC-M matrix; all phenomena in TRAC-M matrix except three, evaporation-interfacial, flow-multi-channel effect and pressure wave propagation, were covered by the HRP list; by adding them to the HRP list and after removing or combining phenomena of duplicative meanings, the 83 HRP were reduced to 54. The phenomena in CSNI matrix (67) is not always HRP, but reviewed to confirm whether all phenomena to be assessed are included in the HRP list.

3.2 Development of PIRT-Driven Validation Matrix

In advance of constructing a PIRT-driven validation matrix as used in TRAC-M, the HRP list was arranged so that 27 LL, 22 CL and 5 SL could correspond to SET, CET and IET, respectively, as seen in Table 1.

Table 1 Relationship of PIRT and classified tests

Rearranged Phenomena		Level	Accident Types: LBLOCA	SBLOCA	Transient	Classified Tests
Boiling-film		LL	X			SET
•		•				
•		•				
Rewet		LL	X	X		
Downcomer boiling	DC	CL	X			CET
•		•				
•		•				
Void distribution	CO,DC,UH, HL	CL	X	X	X	
Asymmetries		SL	X		X	IET
•		•				
•		•				
pressure wave propagation		SL	X	X		

Plant Types	Plants Considered for Assessment
W06 (600MWe)	K-1, -2
W09(900MWe)	K-3, -4, Y-1, -2, U-1, -2
C10(1000MWe)	Y-3, -4, -5, -6, U-3, -4, -5, -6, sK-1, -2, sW-1,-2
C14(1400MWe)	sK-3, -4, sW-3, -4, sU-1, -2

The Downcomer boiling is unique to C-14 (called APR1400 design), while pressure wave propagation was taken from TRAC-M matrix. To gather information on various test facilities and data, the CSNI compilation and KAERI data bank are reviewed, and in parallel the frame of the validation matrix is constructed.

3.3 Assessments in Progress

Low reflood test data FLECHT-SEASET 31504

The data was selected to assess MARS prediction of low flow reflood T-H in a simulated LOCA conditions. The assessment results indicated that MARS underpredicts cladding temperature by turnaround and quenching earlier than the measurements, as seen in fig.2 (red/blue color: max./min. measured, M/ MARS_NODE: 20/40 core nodes).

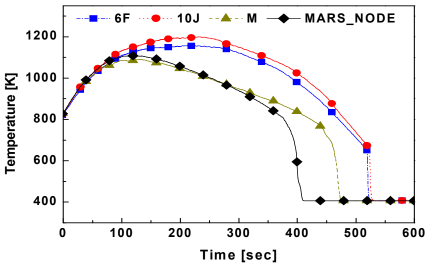

Figure 2 Calculated and measured clad temperatures

Analyses of operational reactor events

To confirm MARS capability to predict real plant data, three events and one preoperational test were analyzed:

a) Trip of all main feedwater pumps due to fail of condenser system deaerator level controller in 2000 (Ulchin 3) [8]
b) Trip of all reactor coolant pumps due to 13.8 kV bus breaker open in 2000 (Ulchin 4) [8],
c) Full load reduction test at 80% rated power in 2002 (Yonggwang 5) [9], and
d) Transient in main steam line (MSL) by inadvertent SG PORV opening in 2005 (Kori 1) [10].

The first three analyses explained that MARS predictions of the system T-H parameters are in good agreement with the measured plant data, but it was pointed out that modeling of the control logics is complicated and inconvenient to users.

In the last event, there was an indication of MSL safety valve liftoff followed by PORV opening, not caught by plant I&C. As seen in fig.3, some MSL pressures calculated at positions distant from PORV reach safety valve opening setpoints, 74-77bar.

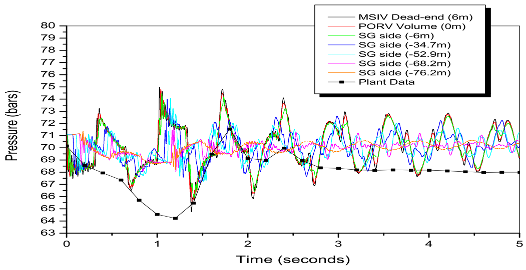

Figure 3 Measured and calculated steam line pressure

Assessment of Multi-dimensional capability

MARS assessment is in progress to validate prediction of multi-dimensional phenomena. Of a series of UPTF tests, there are test runs to simulate the behavior of UPI injection type ECC water. MARS assessment against the UPTF test 20, is in progress and will be completed this year.

Recently a contract with Univ. of Pisa was made to assess MARS capability to simulate flow distribution in ROCOM facility. The independent assessment aims at comparing MARS with RELAP-3D predictions against the test data.

4. Conclusion

MARS validation plan and status were presented. KINS develops the matrix for MARS validation with the help of KAERI, and in parallel performs assessment of the selected test data. Other assessments are supported by in-kind contributions of domestic CAMP/MUG member organizations, and often by contractual works of the foreign or international organizations. It is expected that validation of the current MARS version will complete at the end of 2012.

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