Quality Assurance for Thermal Hydraulic Analysis Code, TASS/SMR-S

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1. Introduction

Safety analysis for a System-integrated Modular Advanced Reactor (SMART), a computer code called TASS/SMR-S has been developed by Korea Atomic Energy Research Institute (KAERI) [1, 2]. To guarantee the quality of the software, a series of software Quality Assurance (QA) procedures has been developed for the TASS/SMR-S code. These procedures are described herein, from the requirement phase to the Verification and Validation (V&V) phase, and representative results of the TASS/SMR-S QA are presented.

2. Methods and Results

The methods and procedures of TASS/SMR-S QA are described in this section including the description of a QA team, a code life cycle and so on.

2.1 TASS/SMR-S code QA team

The stakeholders of TASS/SMR-S are as follows; code developers, a code manager, independent reviewers, a department manager, the members of KAERI QA team and users in Fig. 1. The code developers develop the unique models of SMART such as the helical steam generator model. The source code management utility for developers is introduced in order to handle the source code and modification traceability [3]. The developers participate in code development using check in/out action with this utility. The developed models are reviewed by independent reviewer who is not a participant in the development of the particular model itself. The code manager coordinates the whole code development and has the authority to release a code. Software verification and validation reports (SVVRs) are written by the code manager before the code is released to users. The code is distributed to users with the approval of the department manager. The users can report found errors to the code manager. The KAERI QA team members audit all documents which are generated during code development [4].

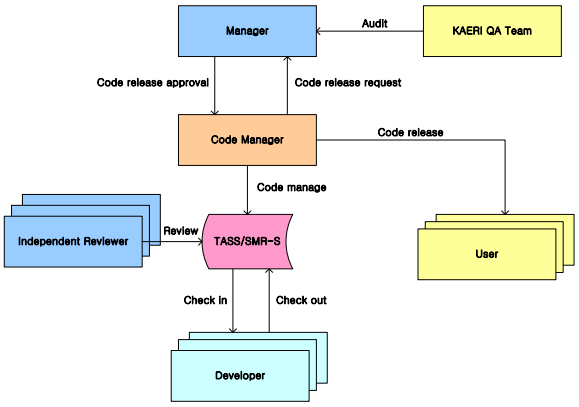

Fig. 1 The code manager orchestrates TASS/SMR-S code development with a source code management utility.

2.2 TASS/SMR-S code development life cycle

Among the Software Development Life Cycle (SDLC) recommended in software development for QA by IEEE [5], five phases are applied to TASS/SMR-S code SDLC as shown in Fig. 2. In every phase a result and a feedback are produced. The requirement and V&V phases are so important that more time allocation is desirable. Preparation (prior phase of requirement) and maintenance (posterior phase of V&V) phases are not described in this paper. TASS/SMR-S QA cycle begins with a requirement report in the requirement phase. The general requirements include items such as programming languages, computing platforms, operating systems, variable precisions, unit, coding/commenting rules, modular programming and input/output formats. The requirements of the functions and performance are the most important requisites. The requirements of user interface and interface to other software are also described in the requirement report. A total of 26 model design reports related to SMART were generated in the design phase. The developing versions of TASS/SMR-S were merged and compiled in the implementation phase. The 24 standard problems were tested in the test phase (Table 1). Some proper nouns in the test title column indicate the names of the thermal hydraulic experimental utility which were performed previously. The data of Separate Effect Tests (SET) and Integral Effect Tests (IET) were used for comparison in the V&V phase. After passing through the five phase cycles, SVVR were issued and the release version of TASS/SMR-S was generated and distributed to users. Feedback can occur in every phase but the more distance there is between feedback phase means

the more cost and endeavor can occur. So feedback from previous phase is ideal.

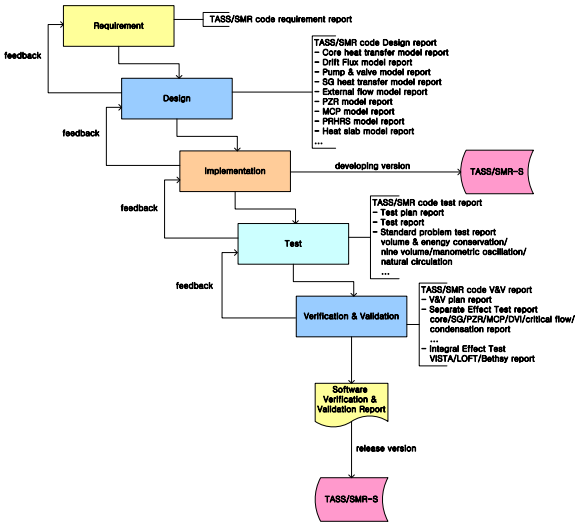

Fig. 2 TASS/SMR-S code development life cycle is depicted as a waterfall model.

Table 1 24 standard test problems for TASS/SMR-S code test are selected.

No.	Test ID	Test Title
1	TA[1]-001	Simple oscillation test
2	TA-002	Conceptual natural circulation test
3	TE[2]-001	Edward's pipe test
4	TE-002	Original form of helical steam generator test
5	TE-003	PRHRS heat exchanger heat transfer test
6	TE-004	THTF core heat transfer test
7	TE-005	Bennett test
8	TE-006	BETHSY test
9	TE-007	GE swell test
10	TE-008	KIT test
11	TE-009	MWR_SG test
12	TE-010	PACTEL test
13	TE-011	Chinese Test Facility test
14	TE-012	Super Moby-Dick(SMD) test
15	TE-013	THETIS test
16	TE-014	KAIST PRHR test
17	TE-015	VISTA LOFA test
18	TE-016	VISTA Natural Circulation
19	TE-017	VISTA Steam Generator
20	TP[3]-001	Simulation of feedwater increase accident
21	TP-002	Simulation of loss of feedwater accident
22	TP-003	Simulation of complete loss of RCS flow accident
23	TP-004	Simulation of control rod assembly withdrawal accident
24	TP-005	Simulation of SBLOCA(SI line break) accident

[1] TA: Analytical or conceptual test calculation
[2] TE: Experimental test calculation
[3] TP: Plant calculation

2.3 TASS/SMR-S code QA results

The quantitative results of TASS/SMR-S code development are described in Table 2. RCs are produced by each developer. The document numbers in the design and V&V phases come from the subdivision of the SMART model. The 24 standard test problem results were included in the SVVRs. The technical reports were written for validation of SMART.

Table 2 The respective reports become baselines in SDLC.

	Phase/Sort	Report Number
RC[1]s generated during SDLC	Requirement	1
	Design	26
	Implementation	-
	Test	5
	V&V	56
Documents related to release	SVVR	11
	Manual (UM[2], PM[3])	2
	Technical Report	16
Papers		25

[1] Recorded Calculation
[2] User's Manual
[3] Programmer's Manual

3. Conclusions

The TASS/SMR-S code has been developed complying with KAERI and IEEE software QA procedures. The TASS/SMR-S code QA procedure has been developed in accordance with SDLC. This procedure contributed to the improvement of standardization, documentation and trial and error reduction for TASS/SMR-S code development. It is suggested following the QA guidelines to develop thermal hydraulic analysis codes for a nuclear power reactor.

REFERENCES

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Vol. 4: Safety Analysis Methodology (911-TH464-004, Rev. 0)
Vol. 5: Programmer's Manual (911-TH464-005, Rev. 0)
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