ANALYSIS OF K_v IN POWER-TO-VOLUME SCALING. APPLICATION TO A SBLOCA TRANSIENT

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ABSTRACT

In the frame of the OECD/NEA ROSA Project, Large Scale Test Facility (LSTF) of the Japan Atomic Energy Agency (JAEA) is used to reproduce some accidental scenarios to obtain measured data, which can be compared with simulation results to test the thermalhydraulic codes capability to reproduce experimental behavior. LSTF simulates a 4-loop PWR Westinghouse type, which was built applying the power-to-volume scaling methodology from its reference Nuclear Power Plant (NPP), Tsuruga unit II, with a volumetric scaling factor $K_v = 1/48$ and maintaining the height. In this work, different scale LSTF models have been developed using the thermalhydraulic code TRACE5 and varying the volumetric scaling factor, $K_{v,}$ in the range from $K_v = 1/100$ to $K_v = 1$, the latter corresponds to Tsuruga NPP. Test 1-2, which reproduces a hot leg Small Break Loss Of Coolant Accident (SBLOCA), has been simulated in this work. The main purpose of this work is to study how the volumetric scaling factor, relevant in the power-to-volume scaling criterion, affects the results obtained with TRACE5. With this aim, a comparison of the main thermalhydraulic variables, such as, the system pressures, the mass flow rate through the break, the Core Exit Temperature (CET) and the maximum Peak Cladding Temperature (PCT) are provided throughout some graphs. Furthermore, the trend of the ratio between the simulated and the experimental variables has been obtained for these scale models. In general, all the scale models are able to reproduce similar behavior and the ratio between the simulated and the experimental variables tends towards 1.0 in any case.

KEYWORDS
TRACE5; Large Scale Test Facility; power-to-volume; scaling methodology; volumetric scaling factor

1. INTRODUCTION

A Nuclear Power Plant (NPP) is characterized by high-power, high-pressure, and large geometry, thus it is well understandable the impossibility to perform experiments preserving all these three quantities [1]. The knowledge of thermalhydraulic phenomena during an accident occurring in a NPP is very important in the assessment of nuclear safety. However, as full-scale testing is usually impossible to perform, small scale Integral Test Facilities (ITFs) are necessary. Among these ITFs, Large Scale Test Facility (LSTF) [2] is used in the frame of the OECD/NEA ROSA Project to reproduce some accidental scenarios providing an experimental database to validate thermalhydraulic codes, such as TRACE5, used in this work.

LSTF simulates a 4-loop PWR Westinghouse type, which was built applying the power-to-volume scaling methodology from its reference NPP, Tsuruga unit II of the Japan Atomic Energy Agency (JAEA), with a volumetric scaling factor K_v= 1/48 and maintaining the height.

Some of the concerns in power-to-volume scaling is to determine the effects of the volumetric scaling factor characteristic of this scaling criterion. For this reason, some authors, such as Bovalini et al. [3] investigate this problem: considering any relevant variable in the transient (Y), the ratio (R_Y) between the simulated (Y_S) and experimental (Y_E) values, gives information about the code accuracy for predicting these variables. Applying this criterion to different variables and volumetric scaling factors, three situations may occur: 1) R tends towards 1 when the dimensions of the model are increased; 2) The opposite of 1), measured values deviate from 1 when the dimensions of the model are increased and 3) R are randomly dispersed. Case 1 is the preferable one for drawing scaling conclusions, case 2 prevents any possibility of scaling the considered data and case 3 does not allow obtaining any scaling conclusion due to it implies that the extrapolation to NPP conditions is not possible. The construction of large-scale ITFs justifies this approach by assuming that increasing the geometrical dimensions of the facility reduces the scaling distortions, thus improving the capability to simulate real system behavior.

In this work, different scale LSTF TRACE5 models have been used to reproduce Test 1.2 [4] of the OECD/NEA ROSA Project, which consists of a 1% hot leg Small Break Loss-Of-Coolant Accident (SBLOCA) transient performed in LSTF under the assumption of the High Pressure Injection (HPI) and Accumulators Injection (AIS) systems actuation. Specifically, five scale models have been developed using different scaling factors in the range from $K_v = 1/100$ to $K_v = 1$, which corresponds to Tsuruga NPP, in order to study how TRACE5 works varying the facility dimensions during a hot leg SBLOCA transient. Due to the HPI and AIS systems actuation, the CET and the PCT excursions are not produced in this transient. For this reason, this transient has been chosen to perform a first analysis avoiding difficulties in the simulation related with the temperature excursions.

A comparison of the results are provided throughout some graphs, which represent the main thermal hydraulic variables, such as, the primary and the secondary pressures, the mass flow rate through the break, the Core Exit Temperature (CET) and the maximum Peak Cladding Temperature (PCT). In general, all the scale models reproduce similar behavior. Furthermore, the trend of the ratio between the simulated and the experimental variables has been obtained for these scale models. These results show that all the scale models are able to reproduce similar behavior and the ratio between the simulated and the experimental variables is around 1.0 in all cases for a hot leg SBLOCA until a certain time. From this moment on, the ratio is randomly dispersed. Further work will be necessary to analyze how TRACE5 works when the facility dimensions and the break localization are modified.

2. SCALING CONSIDERATIONS

Scaling is the needed link between the ITF and the actual NPP and between the experiments performed in the integral test facility and their utilization in the code validation process [1]. The main objectives associated to the scaling can be summarized in:

- The design of an ITF,
- The code validation, and
- The extrapolation of the experimental data obtained in an ITF to predict the NPP behavior.

During last years, many studies based on thermalhydraulic scaling laws have been developed to obtain small-scale ITF designs of NPPs for water reactor safety research. Results of these studies give a high variety of scaling methods. Among these scaling methods, linear scaling, power-to-volume scaling and power-to-mass scaling are the most used [5, 6, 7]. In SBLOCA scenarios and in Full-Height, Full-Pressure (FHFP) facilities, such as LSTF, the main reasons that justify the use of the power-to-volume scaling criterion are to preserve time, power and coolant mass inventory during the transient because of the same fluid properties at full pressure [8]. This scaling methodology is characterized by the volumetric scaling factor, K_v. A synthesis list of the design factors characterizing this scaling methodology is shown in Table I [9].

In this work, five scale models have been developed applying the power-to-volume scaling criterion with different design factor, K_v, from the smallest scale model (K_v = 1/100) to K_v = 1 (Tsuruga NPP). Furthermore, the Froude criterion [10, 11] has been used to simulate as well as possible the countercurrent flow in horizontal components. It implies modifying the scaled diameter and length in horizontal components. More details about the scaling methodology used to obtain the different scale models are given in next section.

Table I. Synthesis of dimensionless design factors characterizing the power-to-volume scaling criterion

Scaling of	Design factor	Scaling of	Design factor
Volume	K_v	Mass flow rate	K_v
Elevation change	1	Rod heat flux	1
Number of loops	1	Environment heat losses flux	1
Length and diameter of horizontal components	Froude	Thickness of passive structures	1
Break area	K_v	Recirculation ratio	1
Hydraulic diameter	1	Passive heat transfer area	K_v
Power	K_v	Fluid velocity	1
Time	1	ECC, steam line and feedwater flow	K_v
Fuel rod geometry and material	1	ECC and feedwater temperature	1
Fluid temperature	1	Non-dimensional characteristics for pumps and valves	1
Pressure	1		

3. TRACE5 MODELS

TRACE (TRAC/RELAP Advanced Computational Engine) [12, 13], developed by the United States Nuclear Regulatory Commission (US-NRC), is an advanced best estimate reactor code for analyzing thermalhydraulic behavior in light water reactors. One of the features of TRACE is its capability to model the reactor vessel in 3D geometry. In this section, the TRACE5 models used in this work are explained.

3.1. LSTF model

LSTF is a FHFP facility, which simulates the Tsuruga unit II NPP of JAEA, a 4-loop Westinghouse PWR of 3423 MWt [2] and 1/48 volumetrically scaled. The four primary loops of the reference PWR are represented by two equal loops in the facility. Each loop is sized to conserve the volumetric factor 2/48 and the relation $L/\sqrt{D}$ to reproduce the same flow regime transition in horizontal legs. The maximum core power is 10 MW, which corresponds to 14 % of the volumetrically scaled rated power of the reference PWR.

LSTF has been modelled with 81 hydraulic components (7 BREAKs, 11 FILLs, 23 PIPEs, 2 PUMPs, 1 PRIZER, 22 TEEs, 14 VALVEs and 1 VESSEL). Fig. 1 shows the nodalization of the LSTF TRACE5 model using Symbolic Nuclear Analysis Package, SNAP, [14]. The PV has been modelled using a 3D–

VESSEL component divided into 20 axial levels, 4 radial rings and 4 azimuthal sectors. Active core is located between levels 3 and 11. The three inner rings characterize the core region and the fourth ring represents the downcomer. 3-D VESSEL is connected to different 1-D components: 8 Control Rod Guide Tubes (CRGT), hot leg A and B (level 16), cold leg A and B (level 16) and a bypass channel (level 15). CRGT have been simulated by 8 PIPEs components, connecting levels 14 and 20 and allowing the flow between upper head and upper plenum.

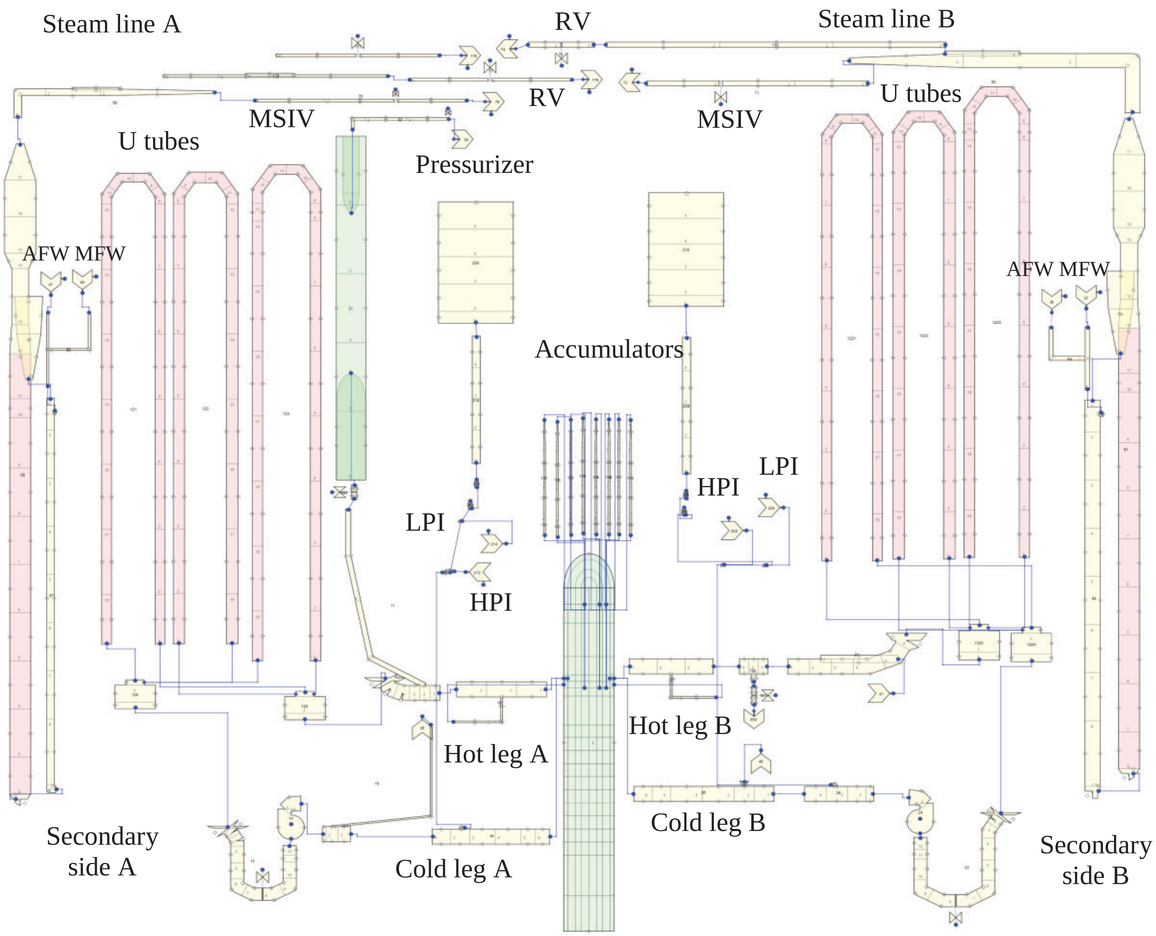

Figure 1. Model nodalization of the LSTF TRACE5 model.

The axial power ratio is a chopped-cosine with 9 divisions and a peaking factor of 1.495. The radial power profile in the active core is divided into three power zones using the first three radial rings with different peaking factors (0.66 in ring 1, 1.51 in ring 2 and 1.0 in ring 3). 12 HTSTR components simulate 1008 fuel assemblies. A POWER component manages the power supplied by each HTSTR to the 3D-VESSEL. The core power has been simulated by means of a decay curve [2]. The Emergency Core Cooling System (ECCS) consists of the AIS, HPI and Low Pressure Injection (LPI) systems, which are linked to cold legs. HPI and LPI have been simulated using FILL components while 2 PIPE components type ACCUMULATOR have been used to model the AIS.

Each Steam Generator (SG) consists of boiler, separator and downcomer. Main and Auxiliary Feedwater (MFW and AFW, respectively) are connected to the top of the SG downcomer. SG separator is joined to the Main Steam Line, where Safety Relief Valves (SRV) and Main Steam Isolation Valves (MSIV) are located. There are 141 U-tubes in each SG, which are simulated by 3 PIPE components depending on the average length. The heat transfer between primary and secondary sides is established by using HTSTR components. It has been tested that using 3 PIPE components to simulate the U-tubes, the primary pressure is better reproduced than using only 1 PIPE component [10].

The break VALVE is joined with a BREAK component to simulate the atmospheric coolant leakage. The break size is the one specified in Test 1-2 [4], which corresponds to the 1% of the volumetrically-scaled cross-sectional area of the reference PWR cold leg. It is located on the hot leg of loop B downwards orientation. Choked flow model, a special TRACE5 issue [12, 13], has been applied to improve the simulation results when the fluid phase change occurs. LSTF model has been developed and tested with experimental data by authors in previous works [15, 16] simulating different experiments performed in LSTF in the frame of the OECD/NEA ROSA Project.

3.2. Scale models

Based on LSTF model, four scale models have been developed applying the power-to-volume scaling method. The range of K_v is from 1/100 to 1, which corresponds to Tsuruga NPP. The main design factors that characterize each scale model are listed in Table II in comparison with LSTF model (K_v = 1/48).

Table II. The major design characteristics of the LSTF facility versus the scale TRACE5 models

Parameter	K_v =1/100	LSTF K_v = 1/48	K_v= 10/48	K_v =1	Tsuruga	Design Factor
Primary pressure (MPa)	15.55	15.55	15.55	15.55	15.55	1
Core power (MW)	4.8	10	100	480	480	K_v
Number of loops	2	2	2	2	4*	1
Core height (m)	3.66	3.66	3.66	3.66	3.66	1
Number of U-tubes per one Steam Generator (SG)	67.64	141	1410	6764	3382*	K_v
Average length of U-tubes (m)	19.7	19.7	19.7	19.7	20.2*	1
Vessel volume (m^3)	1.27	2.64	26.4	126.72	137.4*	K_v
Hot and Cold leg inner diameter (m)	0.154	0.207	0.519	0.974	0.737*	Fr. Num.
Hot leg length (m)	3.19	3.7	5.86	8.02	6.99*	Fr. Num.
Cold leg length (m)	2.88	3.34	5.29	7.24	7.25*	Fr. Num.
$L/\sqrt{D}$	8.1	8.1	8.1	8.1	8.1	1
1 % Break area (m^2)	3.85e-5	8.02e-5	8.02e-4	3.85e-3	3.85e-3	K_v
Accumulator volume (m^3)	0.79	1.64	16.4	78.93	33.86*	K_v
SG volume (m^3)	3.81	7.93	79.3	380.64	140.19*	K_v
MFW flow rate (kg/s)	1.32	2.74	27.4	131.52	68.64*	K_v
Total discharged inventory (kg)	2.44 e3	5.09 e3	5.09 e4	2.44 e5	2.44 e5	K_v

As it can be seen, Tsuruga model presents some geometrical discrepancies in comparison with the other scale models. It reproduces 4 loops as the actual NPP, while the other scale models simulate 2 loops. And some variables*, such as the average length of the U-tubes, the vessel, accumulator and SG volume and the MFW flow rate and are not equal to the model with $K_v = 1$. It is due to all the major design characteristics of LSTF are not perfectly scaled down 1/48 times from Tsuruga NPP [2]. Furthermore, the core power in Tsuruga model is different from 3423 MW, which corresponds to Tsuruga NPP. This value has been obtained from the LSTF core power, which corresponds to 14% of the volumetrically scaled rated power of the reference NPP, multiplied by the corresponding K_v.

In the other scale models, the volume of their components is affected by the corresponding scaling factor, while heights are the same. The number of U-tubes and the heat structures used to simulate the heat transfer between the primary and the secondary system has been multiplied by the corresponding K_v. The pumps use the same dimensionless behavior curves (torque, head, etc.) and the coast-down curves than in LSTF model. The core power is defined from the core power decay curve of LSTF model considering the corresponding scaling factor, preserving the time. The number of LSTF fuel rods, simulated by HTSTRs, has been multiplied by the same factor. The heat transfer model is the same in all the models. Regarding horizontal components, such as hot and cold legs, their flow area is scaled to conserve the ratio of the length to the square root of pipe diameter, i.e. $l/\sqrt{d} = L/\sqrt{D}$, in LSTF and all the scale models. It is applied to improve the simulation of the flow regime transitions in horizontal pipes.

Furthermore, to simulate as well as possible the countercurrent flow in horizontal parts, the Froude number criterion is applied in these components [10, 11]. It implies modifying lengths and diameters of horizontal components in all the scale models, as follows.

$$D = d \cdot K_v^{2/5} \tag{1}$$

$$L = l \cdot K_v^{1/5} \tag{2}$$

being *D* and *L* the scaled diameter and length and *d* and *l* LSTF diameter and length, respectively.

Primary and Main Feedwater (MFW) mass flow rates have been scaled using the corresponding K_v factor. Trying to equalize the inventory discharged through the break, the flow area of the VALVE component simulating the break used in LSTF facility has been scaled too. The break localization and orientation is the same as in LSTF model. Initial and boundary conditions, temperature, pressure and velocities in primary and secondary system remain the same as in LSTF model.

4. TRANSIENT DESCRIPTION

Test 1.2 [4] simulates a 1% SBLOCA transient in the hot leg of loop without pressurizer, assuming the actuation of HPI and accumulator systems. The control logic and the sequence of the major events produced during this transient is listed in Table III.

The experiment started with the break valve opening. The primary pressure began then to fall due to the coolant release through the break. When the primary pressure reached the scram signal set point, pump coastdown and reactor scram were initiated. Reactor scram was simulated by a power decay curve. Simultaneously, in the secondary-side, Main Steam Isolation Valves (MSIV) were closed along with the Main Feedwater (MFW) termination. The transient continued with the Safety Injection (SI) signal activation when primary pressure reached the SI set point. Few seconds after the SI signal, HPI system was initiated. When the primary pressure fell to a predetermined pressure, the accumulators were actuated softening the pressure drop. Test 1.2 finished with the closure of the break valve when the primary and the secondary pressures were stabilized.

Table III. Control logic and major events sequence during Test 1-2 performed in LSTF

Event	Condition
Break	Time zero
Reactor scram signal	Primary pressure =determined value
Pressurizer (PZR) heater off	Scram signal or PZR level < value
Core power decay curve	Scram signal
Primary coolant pump coastdown	Scram signal
Closure of MSIV	Scram signal
Termination of MFW	Scram signal
Safety Injection (SI) signal	Primary pressure =determined value
High Pressure Injection (HPI)	SI signal + some seconds
Accumulator Injection System (AIS)	Primary pressure =determined value

5. RESULTS AND DISCUSSION

5.1. Steady-state results

Steady-state conditions achieved in all the simulations (LSTF and different scale models) are in reasonable agreement with the experimental values obtained in Test 1-2 reproduced in LSTF, as it can be seen in Table IV, where the relative errors (%) between experimental and simulated results for different items are listed. As it can be seen, all the values are lower than 6%, thus, the steady state conditions achieved in all simulations are in good agreement with experimental values.

Table IV. Steady-state condition. Relative error (%) respect to LSTF values.

Item	K_v = 1/100	LSTF K_v = 1/48	K_v = 10/48	K_v = 1	Tsuruga
Cold Leg Temperature	0.38	0.27	1.05	0.40	-1.24
PZR Pressure	0.32	0.32	0.32	0.32	-0.26
PZR Liquid Level	1.91	1.91	1.91	1.77	1.50
SG Pressure	1.36	0.82	0.82	1.09	0.27
SG Liquid Level	5.85	5.26	5.36	5.65	5.17

5.2. Transient results

In this section, the main variables representing the behavior of the SBLOCA transient are shown for all the scale TRACE5 models considered in this work. The results have been normalized to the steady state values. Fig. 2 shows the system pressures obtained for all the scale models in comparison to experimental data. As it can be seen, due to the break opening the primary pressure starts to decrease. Few seconds after, the primary pressure reaches the scram signal set point and the core power decay curve, the primary coolant pumps coastdown, the turbine trip, the closure of MSIV and the termination of the MFW are produced. With the MSIV closure, the secondary pressure rises and the opening/closure cycle of the Relief Valves (RV) is produced to maintain the secondary pressure between two fixed values.

After the scram signal, the primary pressure continues decreasing, almost reaching the secondary one, remaining slightly above it since then. During this time, the secondary side keeps removing heat from the primary system, while natural circulation in primary loop is still on. Once the U-tubes of both SG are emptied (see Fig. 3a) at 1000 s, approximately, natural circulation is finished and the primary pressure becomes lower than the secondary one, which is maintained until the end of the transient. The primary pressure continues to fall reaching the accumulators injection system pressure, which injects cool water into the cold legs. As it can be seen, all models are able to reproduce similar behavior during the entire transient regarding to the system pressures. However, there are some differences between them, which have been explained in the following paragraphs.

The first differences are observed when the primary pressure reaches the secondary one. As it can be seen, all the models reproduced this event about 100 s before than the experiment. Furthermore, in the Tsuruga model, the primary pressure drop is more pronounced although, it reaches the secondary one at the same time as the other models. More discrepancies are found when the U-tubes are emptied. As it can be observed in Fig. 3a, the SG U-tubes are empty at 1000 s in any case. However, depending on the model, the primary pressure becomes lower than the secondary one between 1000 and 1250 s. Despite of these differences, at 1500 s, all the models reach similar primary pressure (around 0.4 NV).

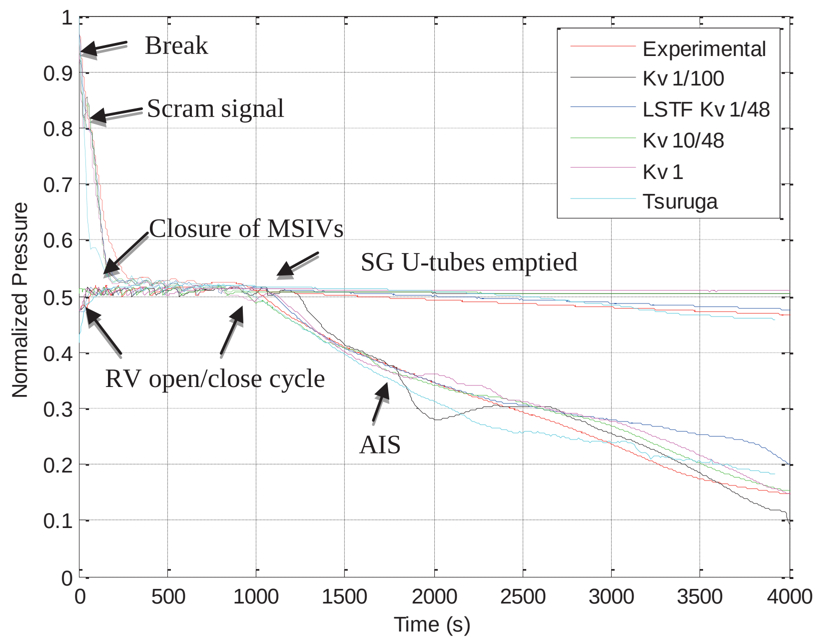

Figure 2. The system pressures for different scale models in comparison with experimental data.

The main differences in the primary pressures are observed when the accumulator injection system is activated (at around 1700 s). For K_v = 1/100, this injection produces a drop in the primary pressure, while for K_v = 1 a slight increase is reproduced. However, for K_v = 10/48 and K_v = 1/48, the primary pressure is not affected by the accumulator injection system and continues falling close to the experiment. These discrepancies could be attributed to the accumulators coolant injection reproduced with TRACE5, which is different depending on the model considered, as it can be seen in Fig. 3b. Furthermore, Tsuruga model reproduces a lower primary pressure than the other models, which could be due to geometrical differences that exist in Tsuruga model (see Table II). At the end of the transient, the primary pressure is overestimated in comparison to the experiment for all the cases (effect more pronounced for LSTF model) except for $K_v = 1/100$, which is lower than the experiment. Regarding the secondary pressure, slight differences are observed at long term due to discrepancies in the secondary side heat losses.

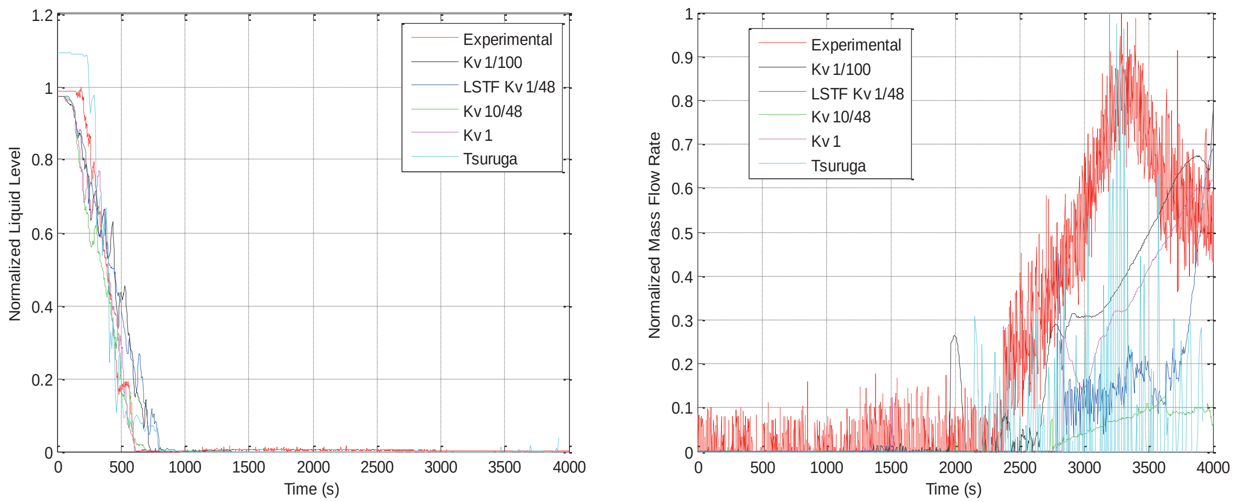

Figure 3. a) The SG U-tubes liquid level and b) the AIS mass flow rates for different scale models in comparison with experimental data.

Fig. 4 shows the mass flow rate and the discharged inventory through the break obtained for all the scale models in comparison to experimental data. In this figure, scale results have been affected by their corresponding value of K_v in order to be all compared in one graph. In this transient, it is important to predict correctly the changes of phase in the fluid. For this reason, the Choked Flow model available in TRACE5 [12, 13] has been considered to improve the simulation results when the fluid changes of phase. TRACE5 only allows adjusting two multipliers: the subcooled and the two-phase coefficients. After a sensitivity analysis, authors tested that the coefficients used in this work were the best to reproduce the experimental data, so these values have been maintained in all models.

As it can be seen in Fig. 4a, all the cases reproduce similar behavior. The break mass flow rate is entirely one-phase liquid until 100 s, when it turns to a two-phase mixture liquid vapor. This two-phase fluid regime is maintained until 1000 s, when the fluid changes to single-phase vapor and the natural circulation ends. At this moment, the primary pressure starts to fall below the secondary one due to the large amount of vapor leaving the system. For this reason, the simulated break mass flow rates show the same behavior as the primary pressures. Furthermore, all the results underestimate the break mass flow rate during the two-phase flow. The discharged inventories shown in Fig. 4b are in agreement with these results. Although, in this figure it is observed that the discharged inventory is lower than the experiment during the entire transient.

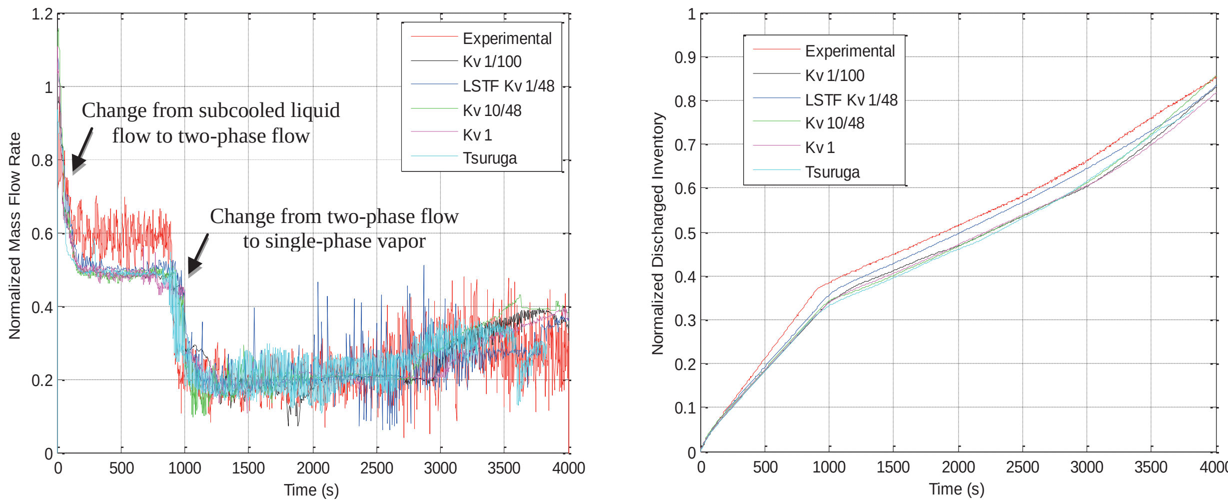

Figure 4. a) The mass flow rate and b) the discharged inventory through the break for different scale models in comparison with experimental data.

In this transient, as it has been said, there is not a temperature excursion as it can be seen in Fig. 5 and Fig. 6, where CET and PCT evolutions are shown, respectively. Nevertheless, CET and PCT values obtained with all the scale models have been compared with experimental data in order to observe if the K_v value affects the CET and the PCT values. As it can be observed, CET and PCT behaviors obtained for all models are similar to the experiment. However, some differences are found such as in the primary pressures. Despite of these discrepancies, in all cases the maximum difference between each model and the experiment is lower than 0.075 NV.

In general, all models developed with different volumetric scaling factors are able to reproduce similar behavior than in the experiment, despite of some slight differences in the system pressures, CET and PCT evolutions. These discrepancies could be produced by an improper reproduction of the accumulators injection and geometrical differences found in the Tsuruga model. However, these results show that the thermalhydraulic code TRACE5 accuracy is not dependent of the facility model dimensions to reproduce a SBLOCA in the hot leg until the AIS actuation time. However, further work will be necessary to study other transients, in which the CET and the PCT excursions are produced.

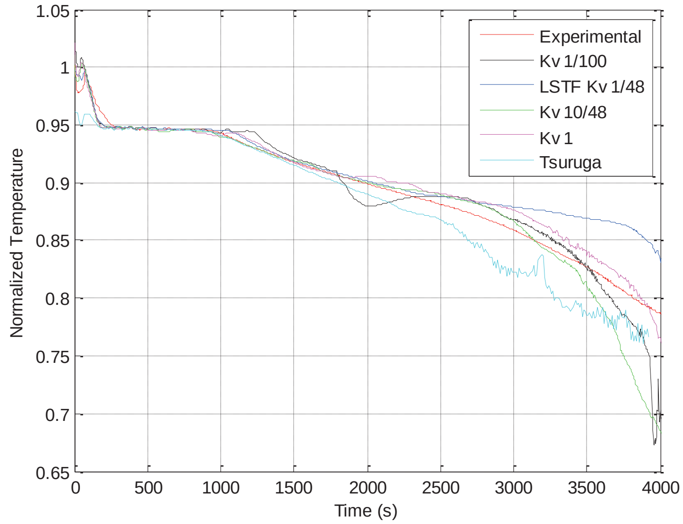

Figure 5. CET for different scale models in comparison with experimental data.

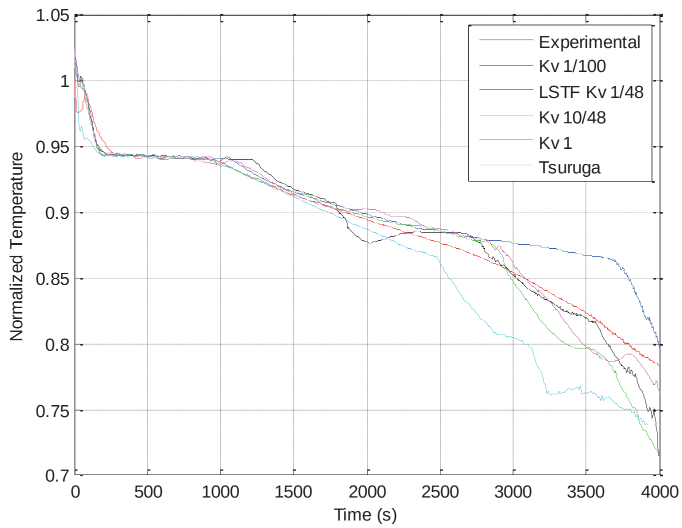

Figure 6. PCT for different scale models in comparison with experimental data.

Trying to study with more details the effects of the volumetric scaling factor, K_v, the ratio (R_Y) between the simulated (Y_S) and the experimental (Y_E) values have been obtained for the main variables of this transient. Fig. 7 shows the ratios obtained for the primary and secondary pressures, CET and PCT values divided by the experimental data for different scale models.

In general, all the ratios calculated are around 1.0 until the AIS actuation time. From 1700s on, the ratios could be considered as randomly dispersed. In this part of the transient, ratios calculated for primary pressure are between 0.8 and 1.2 except for the LSTF model, in which a ratio of 1.55 is observed. It can be stated that any TRACE5 model is not able to well reproduce the experimental primary pressure from this moment until the end of the transient, as it can be observed in Fig. 2.

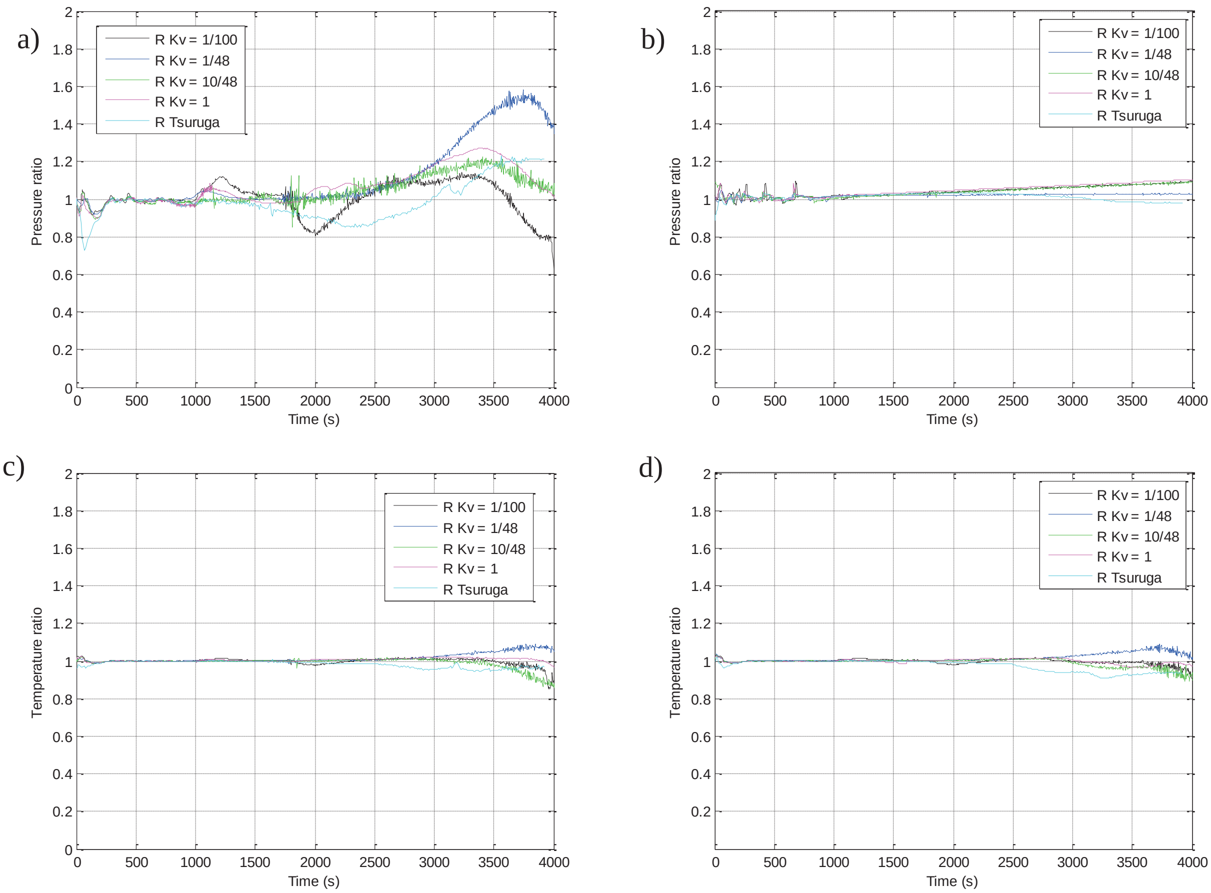

Figure 7. For different scale models, the ratio between simulated and experimental for: a) primary pressure, b) secondary pressure, c) CET and d) PCT values.

Similar behavior is observed in the ratios calculated for the secondary pressure, CET and PCT, which are closer to 1.0 for all the cases until 1700 s. Differences observed in the secondary pressure, CET and PCT excursions produce a variation in the calculated ratios between 0.9 and 1.1. With these results, it can be said that, in general, the ratios R_Y of the main thermalhydraulic variables are around 1.0 in all the scale models considered until the AIS actuation time. It means that until this time the volumetric scaling factor, K_v, does not affect the simulation results. However, from this moment on, the ratios are randomly dispersed and for this reason, the results could not be extrapolated to NPP conditions.

6. CONCLUSIONS

In this work, different scale models of Large Scale Test Facility (LSTF) have been developed using the thermalhydraulic code TRACE5 and varying the volumetric scaling factor, K_v, relevant in the power-to-volume scaling criterion, to reproduce a hot leg Small Break Loss-Of-Coolant Accident (SBLOCA). During this test, the High Pressure Injection (HPI) and Accumulators Injection (AIS) systems actuate preventing the CET and PCT excursions. Despite of this fact, this transient has been chosen to perform a first analysis to study how TRACE5 works varying the dimensions of the facility in the range from K_v = 1/100 to K_v = 1, which corresponds to Tsuruga Nuclear Power Plant (NPP), avoiding difficulties in the simulation related with the temperature excursions. The main thermalhydraulic variables, such as, the primary and the secondary pressures, the mass flow rate through the break, CET and PCT obtained for all the scale models have been compared with experimental data. Results show that, in general, all the scale models are able to reproduce similar behavior than in the experiment, despite of some differences observed from the accumulator injection and some geometrical differences. For this transient, the ability of TRACE5 code to predict correctly the changes of phase in the hot leg is very important. Results show that TRACE5 predicts well the change of phase from single-phase liquid to two-phase and from two-phase to single-phase vapor in all the scale models.

With these results, it has been obtained that the thermalhydraulic code TRACE5 accuracy is not dependent of the facility model dimensions to simulate a SBLOCA in the hot leg until the accumulators actuation time. From this moment on, the experimental primary pressure is not properly reproduced and no conclusions can be obtained. Further work will be necessary to study other transients varying the break localization.

Considering the main variables in this transient, the ratios, $R_{Y,}$ between simulated and experimental values have been obtained. The results show that, in general, the value of the ratios calculated for the main variables of this transient are around 1.0 in all the scale models until the accumulators injection time. It means that until this time the volumetric scaling factor, K_v, does not affect the simulation results. However, from this moment on, the ratios are randomly dispersed and for this reason, the results could not be extrapolated to NPP conditions.

NOMENCLATURE (IF NEEDED)

AIS: Accumulator Injection System.
AFW: Auxiliary Feed Water
CET: Core Exit Temperature.
CRGT: Control Rod Guide Tube.
D: Scale diameter.
d: Facility diameter.
ECCS: Emergency Core Cooling System.
FHFP: Full-Height, Full-Pressure.
HPI: High Pressure Injection.
HTSTR: Heat Structure.
ITF: Integral Test Facility.
JAEA: Japan Atomic Energy Agency.
K_v: Volumetric scaling factor.
L: Scale length.
l: Facility length.
LPI: Low Pressure Injection.
LSTF: Large Scale Test Facility.
MSIV: Main Steam Isolation Valves.
MFW: Main Feed Water.
NEA: Nuclear Energy Agency.
NPP: Nuclear Power Plant.
OECD: Organization for Economic Co-operation and Development.
PCT: Peak Cladding Temperature.
PV: Pressure Vessel.
PWR: Pressurized Water Reactor.
PZR: Pressurizer.
ROSA: Rig of Safety Assessment.
RV: Relief Valve.
SBLOCA: Small Break Loss-Of-Coolant Accident.

SG: Steam Generator.
SI: Safety Injection.
SNAP: Symbolic Nuclear Analysis Package.
TRACE: TRAC/RELAP Advanced Computational Engine.
US-NRC: United States Nuclear Regulatory Commission.

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