NUREG/IA-0231

International Agreement Report

An Assessment of TRACE V4.160 Code Against PACTEL ATWS-10 – 13 and ATWS-20 – 21 Pressurizer Experiments

Prepared by:
E. Takasuo

VTT Processes
P.O.B. 1604
02044 VTT
Finland

A. Calvo, NRC Project Manager

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

June 2010

Prepared as part of
The Agreement on Research Participation and Technical Exchange
Under the International Code Assessment and Maintenance Program (CAMP)

Published by
U.S. Nuclear Regulatory Commission

AVAILABILITY OF REFERENCE MATERIALS IN NRC PUBLICATIONS

NRC Reference Material

As of November 1999, you may electronically access NUREG-series publications and other NRC records at NRC's Public Electronic Reading Room at http://www.nrc.gov/reading-rm.html. Publicly released records include, to name a few, NUREG-series publications; *Federal Register* notices; applicant, licensee, and vendor documents and correspondence; NRC correspondence and internal memoranda; bulletins and information notices; inspection and investigative reports; licensee event reports; and Commission papers and their attachments.

NRC publications in the NUREG series, NRC regulations, and *Title 10, Energy*, in the Code of *Federal Regulations* may also be purchased from one of these two sources.

1. The Superintendent of Documents
   U.S. Government Printing Office
   Mail Stop SSOP
   Washington, DC 20402–0001
   Internet: bookstore.gpo.gov
   Telephone: 202-512-1800
   Fax: 202-512-2250
2. The National Technical Information Service
   Springfield, VA 22161–0002
   www.ntis.gov
   1–800–553–6847 or, locally, 703–605–6000

A single copy of each NRC draft report for comment is available free, to the extent of supply, upon written request as follows:

Address: U.S. Nuclear Regulatory Commission
Office of Administration
Reproduction and Mail Services Branch
Washington, DC 20555-0001
E-mail: DISTRIBUTION@nrc.gov
Facsimile: 301–415–2289

Some publications in the NUREG series that are posted at NRC's Web site address http://www.nrc.gov/reading-rm/doc-collections/nuregs are updated periodically and may differ from the last printed version. Although references to material found on a Web site bear the date the material was accessed, the material available on the date cited may subsequently be removed from the site.

Non-NRC Reference Material

Documents available from public and special technical libraries include all open literature items, such as books, journal articles, and transactions, *Federal Register* notices, Federal and State legislation, and congressional reports. Such documents as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings may be purchased from their sponsoring organization.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at—

The NRC Technical Library
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852–2738

These standards are available in the library for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from—

American National Standards Institute
11 West 42nd Street
New York, NY 10036–8002
www.ansi.org
212–642–4900

Legally binding regulatory requirements are stated only in laws; NRC regulations; licenses, including technical specifications; or orders, not in NUREG-series publications. The views expressed in contractor-prepared publications in this series are not necessarily those of the NRC.

The NUREG series comprises (1) technical and administrative reports and books prepared by the staff (NUREG–XXXX) or agency contractors (NUREG/CR–XXXX), (2) proceedings of conferences (NUREG/CP–XXXX), (3) reports resulting from international agreements (NUREG/IA–XXXX), (4) brochures (NUREG/BR–XXXX), and (5) compilations of legal decisions and orders of the Commission and Atomic and Safety Licensing Boards and of Directors' decisions under Section 2.206 of NRC's regulations (NUREG–0750).

NUREG/IA-0231

International Agreement Report

An Assessment of TRACE V4.160 Code Against PACTEL ATWS-10 – 13 and ATWS-20 – 21 Pressurizer Experiments

Prepared by:
E. Takasuo

VTT Processes
P.O.B. 1604
02044 VTT
Finland

A. Calvo, NRC Project Manager

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

June 2010

Prepared as part of
The Agreement on Research Participation and Technical Exchange
Under the International Code Assessment and Maintenance Program (CAMP)

Published by
U.S. Nuclear Regulatory Commission

ABSTRACT

In this report an assessment of TRACE V4.160 against six pressurizer separate effect tests, namely PACTEL ATWS-10 - 13 and ATWS-20 – 21, is presented. The tests were conducted at the PACTEL test facility as a part of the ATWS test series in 1998 and they consist of four insurge-outsurge transients and two spray transients. A pressurizer model which consists of a 30-node pressurizer component, a surge line, a spray line and a powered heat structure to simulate the pressurizer wall and heaters was used in the simulations. A brief description of the test facility is also given.

The insurge-outsurge test simulation results show a slightly exaggerated peak pressure which may be due to underestimated wall condensation in the insurge. In the simulations in which the effectiveness of spray was studied a relatively good agreement between the simulation results and the experimental results was found.

CONTENTS

APPENDICES

FIGURES

TABLES

ABBREVIATIONS

ATWS	Anticipated Transient Without Scram
BWR	Boiling Water Reactor
CAMP	Thermal Hydraulic Code Applications and Maintenance Program
ECCS	Emergency Core Cooling System
FINNUS	Finnish Research Program on Nuclear Power Plant Safety 1999-2002
PACTEL	Parallel Channel Test Loop
PRIZER	TRACE pressurizer component
PWR	Pressurized Water Reactor
RELAP	Reactor Excursion and Leak Analysis Program
RETU	Finnish Research Program on Reactor Safety 1995-1998
SAFIR	Finnish Research Program on Nuclear Power Plant Safety 2003-2006
TRAC	Transient Reactor Analysis Code
TRACE	TRAC/RELAP Advanced Computational Engine
USNRC	Unites States Nuclear Regulatory Commission
VTT	Technical Research Centre of Finland
VVER	Russian type of PWR

1 INTRODUCTION

The PACTEL integral test facility located at the Lappeenranta University of Technology, Finland, which is designed to model the thermal hydraulic behavior of a VVER-440 PWR, was used for pressurizer experiments as a part of the second series of the ATWS experiments conducted in 1998. The test series was a part of the TEKOJA project under the national reactor safety program RETU. The RETU program was followed by FINNUS in 1999 and SAFIR in 2003, the current program in the series of national research programs on nuclear safety.

The pressurizer experiments included four insurge-outsurge tests in which the objective was to study steam compressibility under fast nearly isentropic compression and two spray tests to investigate the effect of the pressurizer spray. During the tests the primary loop and the other parts of the facility are used only to provide water into or remove water from the pressurizer through the surge line or the spray line, thus the tests can be examined as separate effect pressurizer tests.

The test facility contains a relatively comprehensive instrumentation and the tests are very well documented in comparison to the other pressurizer tests of which data is available and which are collected together in the OECD Separate Effect Test Validation Matrix (Aksan et al., 1993). The tests listed in the Validation Matrix are also remarkably older than the PACTEL ATWS tests. Being more recent and documented in detail, the PACTEL tests provide a valuable addition to the assessment case database of TRACE and other thermal hydraulic codes.

In this report, a study on the capability of the TRACE V4.160 code to predict pressurizer behavior during transients against the background provided by the experimental data of the PACTEL ATWS tests is presented. The PRIZER component of TRACE is used to represent the pressurizer in the simulations. TRACE has been designed to perform best-estimate analyses of loss of coolant accidents, operational transients and other accident scenarios in PWRs, BWRs and experimental facilities designed to simulate transients in reactor systems. The code is the latest in the series of advanced codes developed at the USNRC. The aim of the TRACE code development is to consolidate the capabilities of the legacy codes, TRAC-P, TRAC-B and RELAP into a modernized code whose models include i.e. 3D flow calculation simulation in the reactor vessel, generalized heat transfer, reflood and level tracking.

2 TEST FACILITY AND EXPERIMENTS

2.1 PACTEL Facility

The PACTEL test facility is a three-loop volume-scaled test facility designed to model the thermal hydraulic behavior of the Soviet-design VVER-440 reactors currently in operation in Loviisa, Finland. The volume scaling ratio of the facility is 1:305 but the major components of the facility preserve a 1:1 elevation equivalence to the reference reactor to ensure that the gravitational forces are equal to the reference reactor. The facility consists of a primary system, the secondary sides of steam generators and the ECCS. The maximum thermal power of the facility is 1 MW and the maximum operating pressure and temperature 8.0 MPa and 300°C, respectively. A general view of the facility is presented in Fig. 1. (Tuunanen et al., 1998)

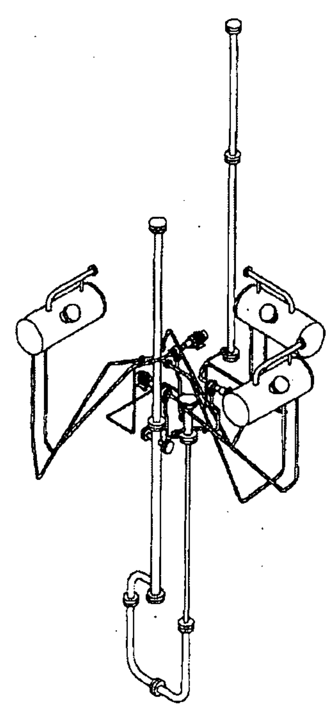

Figure 1. PACTEL test facility (Tuunanen et al., 1998).

2.2 PACTEL Pressurizer component

The pressurizer component of the PACTEL test facility is a steel container with the total height of 8.8 m and the inner diameter of 13.97 cm. The pressurizer surge line is connected to the Loop 1 of the facility, and a spray line is installed on the top of the tank. The pressurizer is made of two parts of equal diameter which are joined with flanges. The total heater power of the pressurizer is 13 kW which is distributed by three electrical heaters whose nominal powers are 2 kW, 4 kW and 7 kW (Tuunanen et al., 1998). The schematic of the PACTEL pressurizer is shown in Fig. 2 and the spray nozzle in Fig. 3.

The instrumentation of the test facility consists of temperature, pressure, differential pressure and flow transducers. In the pressurizer, there are seven fluid temperature measurements located in the centerline of the pressurizer, four structure temperature measurements, three of which are at the heaters and one in the upper part of the pressurizer, and six differential pressure transducers. A pressure transducer is installed on the top of the pressurizer. The temperature measurements of the facility use K-type mineral insulated thermocouples with the diameter varying from 0.5 mm to 3 mm, depending on the measurement location. (Tuunanen et al., 1998)

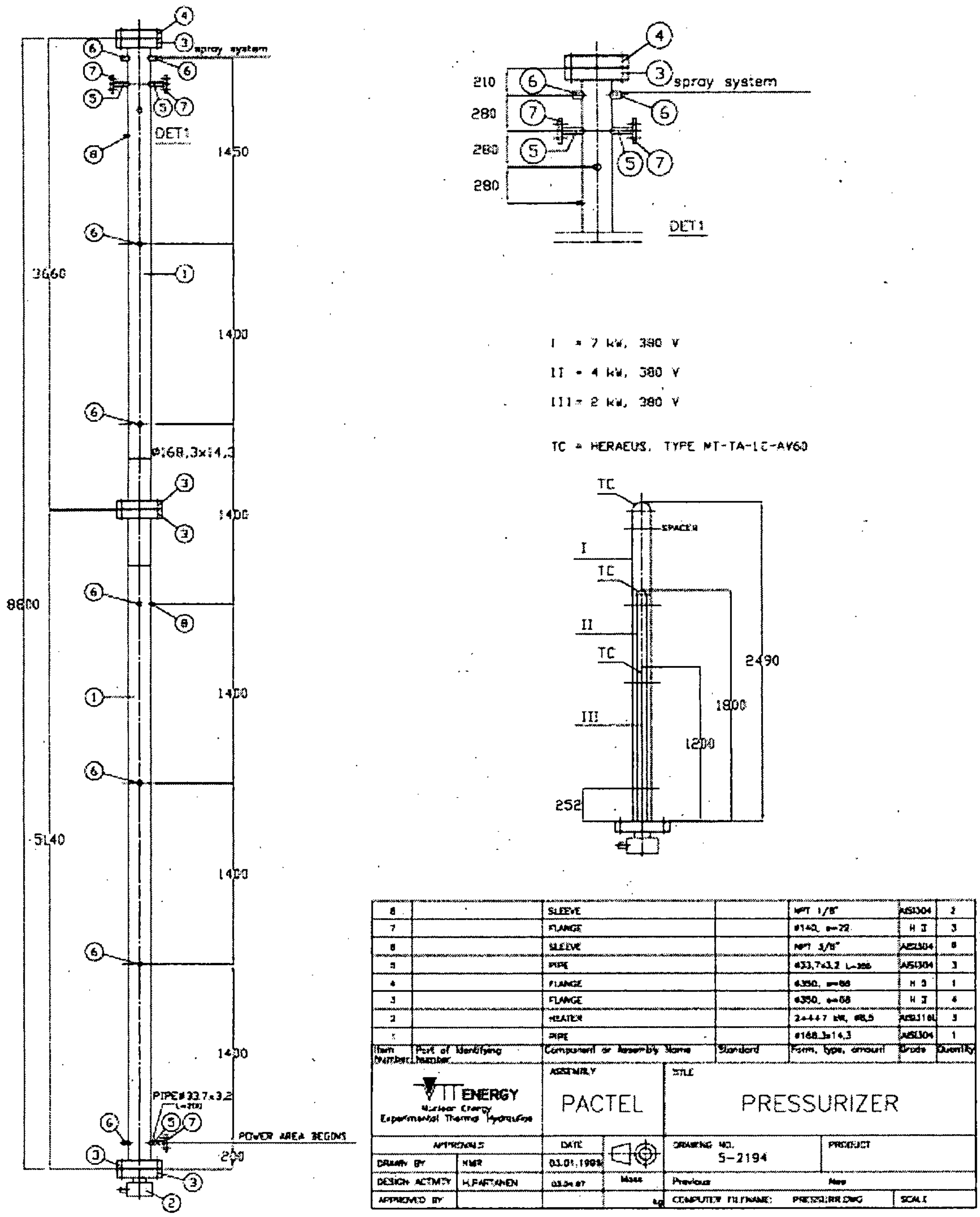

Figure 2. Schematic of the pressurizer of the PACTEL test facility (Tuunanen et al., 1998).

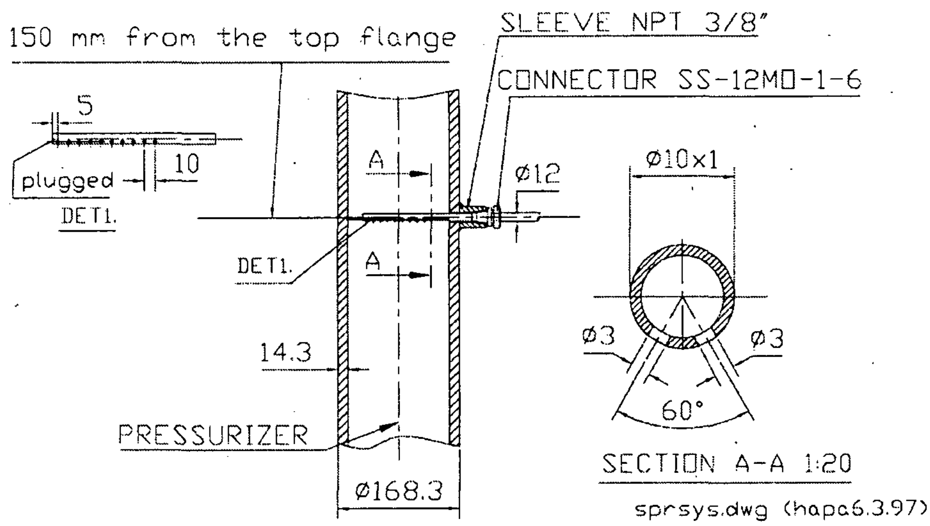

Figure 3. PACTEL pressurizer spray nozzle (Tuunanen et al., 1998).

2.2.1 PACTEL ATWS-10 – 13

The objective of the insurge experiments from ATWS-10 to ATWS-13 was to study steam compression under fast nearly isentropic compression. The procedure of the experiments was as follows. At first, a 100 s steady-state period was run with the heater power being 4 kW. At 100 s the heater was switched off and injection of nearly saturated water into the pressurizer using the high pressure piston pump began. A suitable core power was maintained to prevent the cooling of the facility. When the pressure was reaching 7.8 MPa the injection was stopped and draining began. A draining valve of 2 mm in diameter was opened in the cold leg. The primary circuit and the other components of the facility were used only to inject and drain water to and from the pressurizer. A low core power was maintained to prevent cooling of the facility. The initial state at the beginning of the experiments is given in Table 1. The operator actions during the experiments are presented in Table 2. (Riikonen, 1998).

Table 1. Initial parameters for the ATWS 10 – 13 tests.

Parameter	**ATWS-10**	**ATWS-11**	**ATWS-12**	**ATWS-13**
Pressure	5.9 MPa	5.9 MPa	6.0 MPa	6.0 Mpa
Water level	3.3 m	3.5 m	3.5 m	5.0 m
Mass flow rate	0.367 kg/s	0.217 kg/s	0.100 kg/s	0.100 kg/s
Core power	380 kW	245 kW	150 kW	150 kW

Table 2. Operator actions during the experiments.

Event	ATWS-10	ATWS-11	ATWS-12	ATWS-13
Test begins	0 s	0 s	0 s	0 s
Heaters off	100 s	100 s	100 s	100 s
Power increase	116 s	111 s	109 s	109 s
Insurge on	120 s	119 s	117 s	119 s
Insurge stopped	221 s	297 s	570 s	444 s
Draining begins	221 s	297 s	580 s	444 s
Core power off	221 s	305 s	602 s	456 s
Draining ends	407 s	502 s	813 s	593 s
End of test	500 s	600 s	1000 s	700 s

The analysis of the relationship between steam pressure and volume during a polytropic process showed that the steam reality coefficient ranged from 0.70 to 0.82. The highest values were obtained for the fastest process (ATWS-10) and the smallest for the slowest process (ATWS-13). The steam temperature was observed to follow the saturation temperature until at the end of the expansion the steam began to superheat slightly. During compression the condensed mass was 56%-64% of the initial mass. At the end of the experiment the steam mass was reduced to 82%-89% of the initial value. (Riikonen, 1998)

2.2.2 PACTEL ATWS-20 - 21

The effect of the pressurizer spray was studied in the experiments ATWS-20 and ATWS-21. After a steady-state period water (20°C-25°C) was sprayed to the pressurizer through the spray line. The pressurizer heaters were controlled by automation. The spray was stopped when the pressure was reaching 6.0 MPa. In the ATWS-20 experiment all the heaters were on at 660s and the pressure began to increase. To prevent further pressure increase the heaters were switched off between 890 s and 906 s (Riikonen, 1998). The initial state and the operator actions during the test are given in Tables 3 and 4, respectively.

Table 3. Initial parameters for the ATWS – 20-21 tests.

Parameter	ATWS-20	ATWS-21
Pressure	7.5 MPa	7.5 MPa
Water level	5.6 m	5.6 m
Mass flow rate	0.00667 kg/s	0.0167 kg/s

Table 4. Operator actions during the experiments.

Event	ATWS-20	ATWS-21
Test begins	0 s	0 s
Spray on	100 s	200 s
7 kW heater off	890 s	-
4 kW heater off	903 s	-
2 kW heater off	906 s	-
Spray off	1500 s	1220 s
End of test	1500 s	1220 s

Similarly to the previous tests, the steam temperature followed saturation temperature. In addition to the spray condensation, there was condensation of steam on the pressurizer walls and on the water surface. The condensed mass was 35%-55% of the initial mass. (Riikonen, 1998)

3 TRACE MODEL

The PRIZER component is designed to represent the pressurizer in TRACE and it is also used in the current study. Normally, the PRIZER models the pressurizer reservoir, with the connecting surge line modeled by a PIPE or TEE component. The PRIZER component can be connected by its both junctions to other 1D hydraulic components. The PRIZER component provides special functions for steady-state calculations. These are simulation of a BREAK component to set the system pressure and to permit the fluid to swell or contact as a response to temperature changes, without requiring the user to model these boundary conditions separately, and calculation of the effects of gravity head and thermal non-equilibrium in the fluid to prevent small secondary transients at the beginning of a transient calculation. The PRIZER component provides a representation of heaters and sprays by manipulating the energy deposited in or extracted from the liquid in the tank. The component creates a vertical stack of cells and calculates a collapsed liquid level. (Spore et al., 2000)

In the PRIZER component the operation of heaters and spray is controlled by a user-defined heater cutoff level and a user-defined pressure setpoint. In the case of spray the model is not fully mechanistic because a) the reduction in pressure relies on condensation of steam on the liquid pool surface as opposed to the spray itself, b) removing energy from the liquid results in artificially sub-cooling the entire water pool, c) there is net energy extraction from the PRIZER which does not actually occur and d) there are no mass flows associated with the spray in the PRIZER. For these reasons, the pressurizer spray is modeled by a separate boundary condition on top of the PRIZER component. A separate power component is also used to model the pressurizer heaters.

The surge line is modeled by a three-cell pipe. At the beginning of the line which represents the connection to the loop there is a boundary condition component FILL. This is a mass-flow type boundary condition used for both defining the insurge mass flow rate and outsurge rate. The mass flow table option of the FILL is used to determine the changes in the flow rate with respect to time throughout the simulation. Usually, the BREAK component which imposes a pressure boundary condition is used to define the outflow. In this case, however, it is considered more convenient to set the outsurge flow rate directly to correspond the exact average flow rate measured at the facility, rather than attempt to model the actual geometry and flow resistance of the discharge orifice to obtain the appropriate flow rate.

The graphical user interface SNAP is used for model construction and simulation control. A SNAP layout of the 30-cell model is shown in Fig. 13. The nodalization of the PRIZER, the surge line and the spray line can also be seen in the figure. The input files for the ATWS-10 and ATWS-20 cases are presented in Appendix 1. The input files for the other transients are similar to these files, except for the values for the initial and boundary conditions which are set according to Tables 1, 2, 3 and 4.

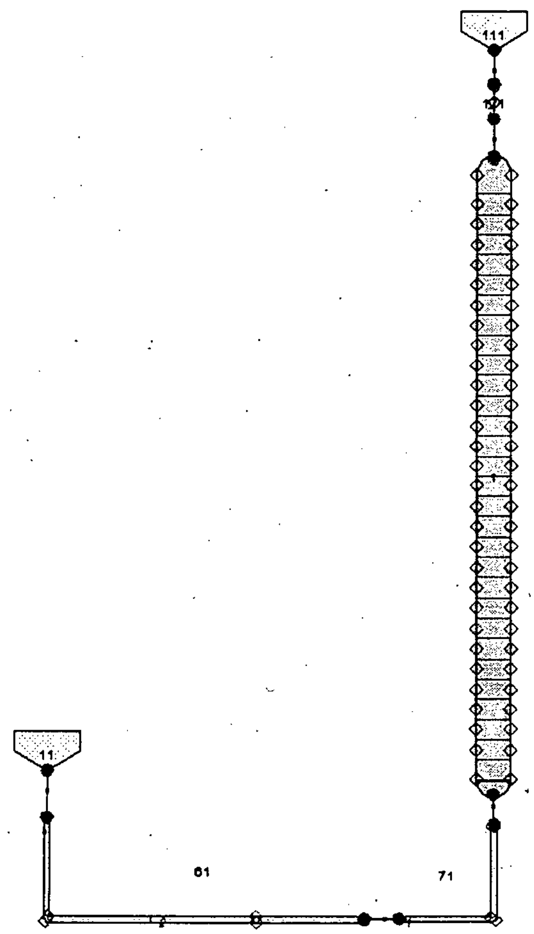

Figure 4. SNAP schematic of the PACTEL pressurizer including the FILL for surge line injection (11), the surge line and the FILL for spray (111). The width-length ratio of the PRIZER is 2:1.

3.1 Heat structures

The wall is divided into five radial heat transfer nodes and 30 axial nodes. The wall is simulated using a cylindrical heat structure component attached to the PRIZER. The axial conduction option is enabled as well as the liquid level tracking. A boundary condition for a constant heat transfer coefficient is defined at the outer surface of the heat structure which is in contact with the surroundings. A constant temperature of 25°C is given to the surroundings and the heat transfer coefficient between the inside wall and the environment is calculated from the evaluated heat loss of the facility under normal operation temperature. The coefficient for the PACTEL pressurizer is 3.44 W/(m^2K). A power component of the type "Table lookup power" is created and connected to the heat structure to represent the pressurizer heaters.

3.2 Simulation set-up

The maximum timestep used in the simulations was 0.05 s and the number of pressure iterations was 20. The default criterion of 0.0001 was used for pressure convergence. The interval for writing to the graphics output file used for plotting the results was 0.5 s.

4 RESULTS

In this chapter the code simulation results are compared to the experimental data and a brief analysis of the results is presented for each case.

4.1 ATWS-10

The measured and the calculated pressure during the ATWS-10 transient are shown in Fig. 5. TRACE calculation shows a slightly higher maximum pressure than was measured. The deviation is approximately 0.6 MPa. The final pressure is somewhat lower than the initial pressure since heat is lost through the pressurizer walls to the environment. The accuracy of the pressure measurement for this particular test according to the routine error estimates which are run for each PACTEL test was ±0.094 MPa at most. This is also true for the other experiments presented here.

During an insurge transient the dominating heat transfer mechanism is condensation of steam at the pressurizer walls. As a result of the piston effect, in which a saturated layer is formed on top of the pool surface isolating the steam volume from the cooler insurge water, the condensation at the phase interface is practically negligible. The slightly exaggerated pressure increase may be due to the inaccuracy of the heat transfer correlation used by the code for the flow condition present in the test. According to the TRAC-M (TRACE) Theory Manual (Spore et al., 2000) the heat transfer correlation for wall condensation for low Reynolds numbers, which is based on a theoretical analysis by Nusselt, underestimates the wall condensation by approximately 20% and the condensation might not be able to limit the pressure rise effectively.

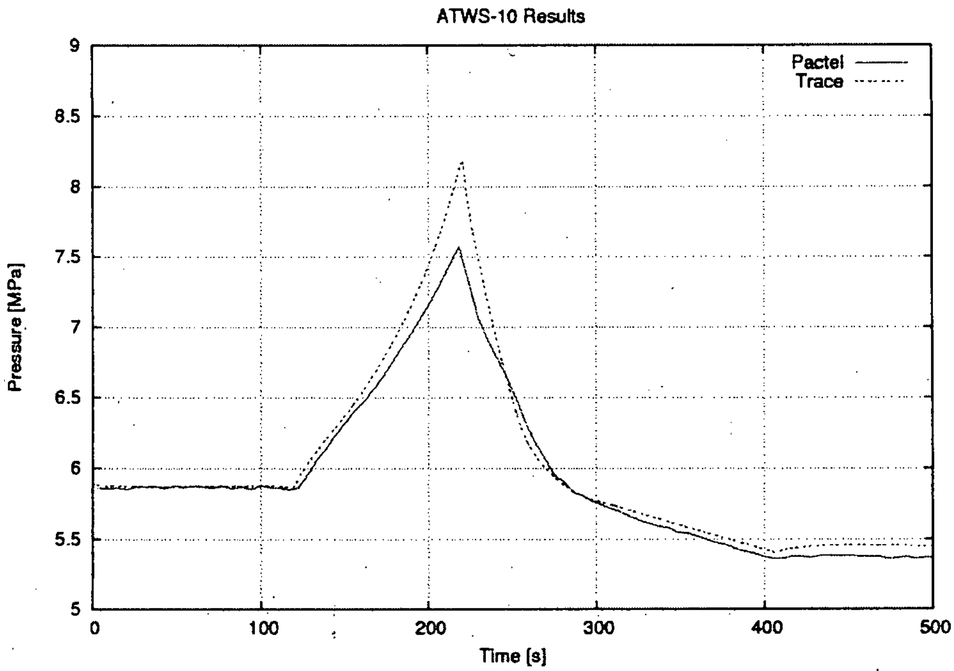

Figure 5. Pressure during the ATWS-10 transient.

4.2 ATWS-11

The ATWS-11 pressure calculation is compared to the experimental data in Fig. 6. The calculated and measured pressure curves are very similar to the ATWS-10 transient. In this test the insurge flow rate is smaller than in the previous experiment and the pressure rise is not as rapid. At around 200 s into the test the calculated pressure starts to increase more rapidly than the measured pressure resulting in a 0.6 MPa higher peak pressure than was measured at the test facility.

The pressure drop during the outsurge period is computed accurately, ending to a steady-state with the pressure being around 5.4 MPa. During the outsurge phase the steam is expanded, the pressure drops and the governing heat transfer mechanism is flashing of water to steam which starts when the decreasing saturation temperature reaches the water temperature and water becomes superheated.

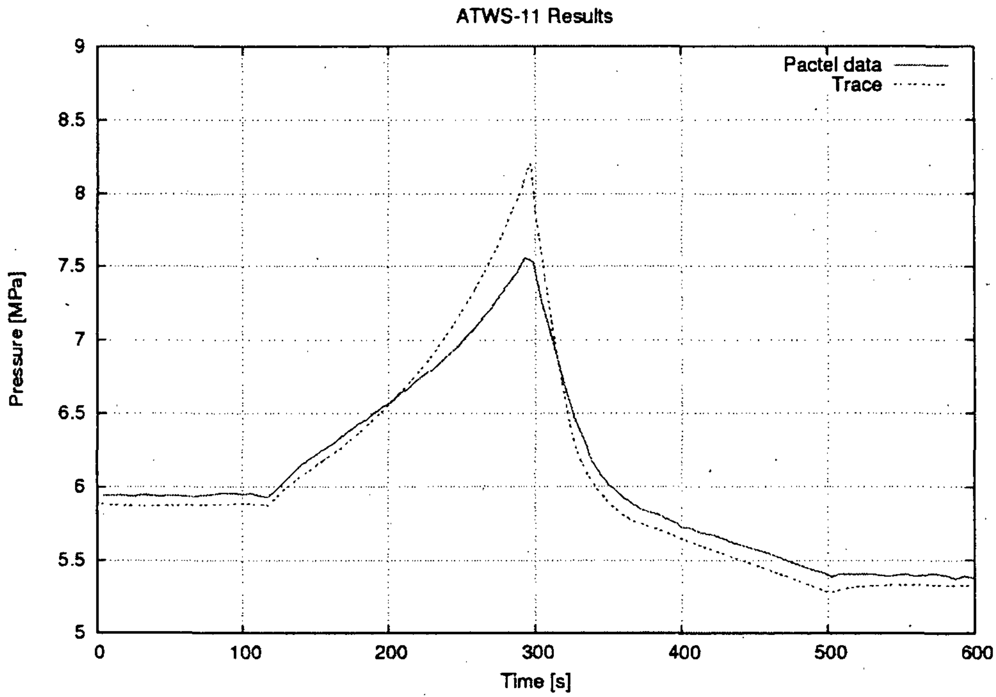

Figure 6. Pressure during the ATWS-11 transient.

4.3 ATWS-12

In this experiment the insurge flow rate is remarkably lower than in the previous transients. The pressure comparison is shown in Fig. 7. The peak pressure is predicted to be approximately 1.1 MPa higher than the measured peak pressure which is a significant deviation.

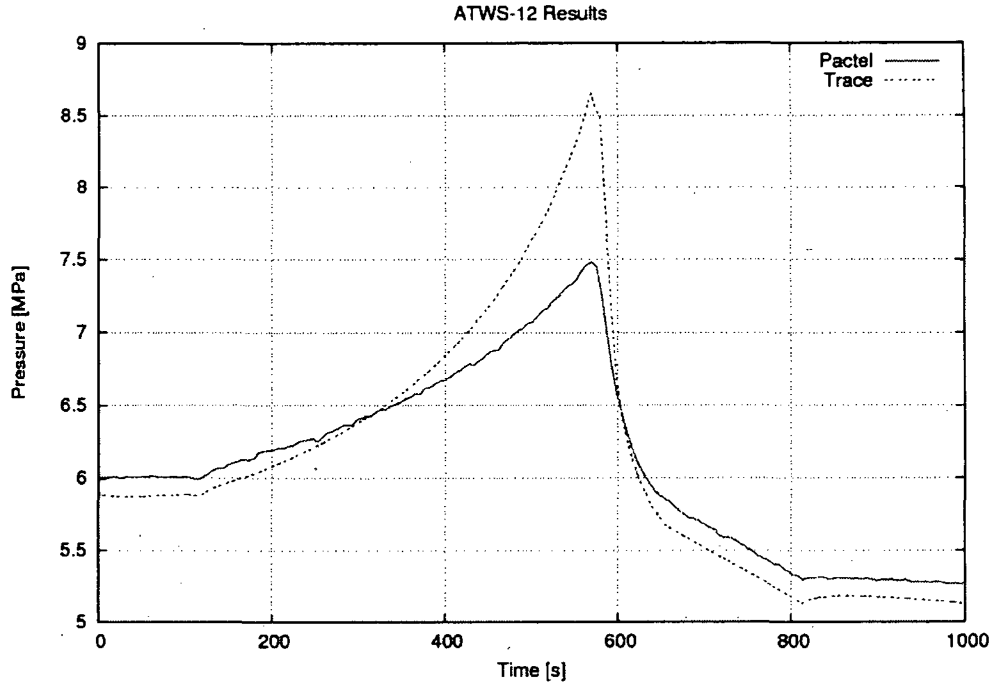

Figure 7. Pressure during the ATWS-12 transient.

4.4 ATWS-13

In this experiment the insurge flow rate is the same as in the ATWS-12 transient but the initial water level is higher. The calculated pressure shows an even greater deviation from the measured pressure as seen in Fig. 8. The TRACE simulation predicts the maximum pressure to be as much as 1.5 MPa higher.

The error in the pressure behavior increases when the insurge mass flow is decreased and the process is slower. The cause for this observation is not clear. One possibility is that the heat losses are not calculated correctly when the temperature inside the container increases. When the transient is fast the heat losses to the environment have very little effect on the system behavior but their effect becomes more significant in the case of slow processes. The difference between the initial and final pressures gives an idea of the total heat losses in the process and it seems to correlate with the measured data. It seems unlikely that inaccuracy in the heat loss calculation could cause such a large deviation since the pressure behavior is not very sensitive to the heat lost through the pressurizer walls.

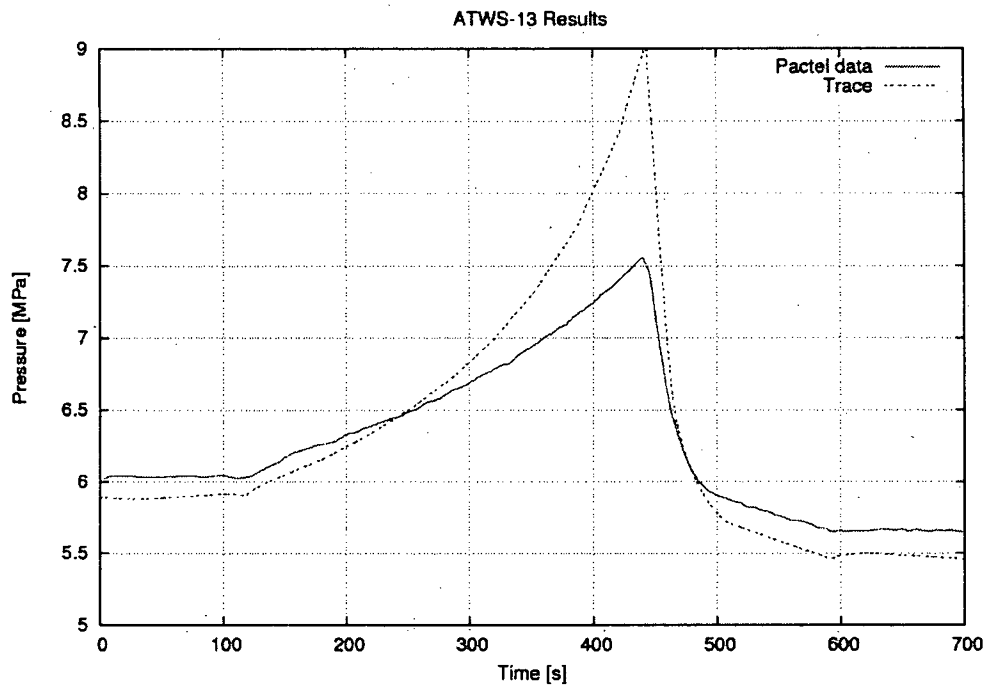

Figure 8. Pressure during the ATWS-13 transient.

4.5 ATWS-20

The measured pressure and the calculated pressure for the ATWS-20 spray transient are presented in Fig. 9. TRACE predicts the pressure decrease phases between 100 s – 660 s and 900 s – 1500 s with a very good accuracy. At 660 s, when the pressure has decreased to about 7.1 MPa the 7 kW heater is turned on and the full heater power of 13 kW is utilized. Because of this the pressure increases until all the heaters are switched off at around 900 s according to Table 4. TRACE predicts the pressure rise during this period to be too rapid.

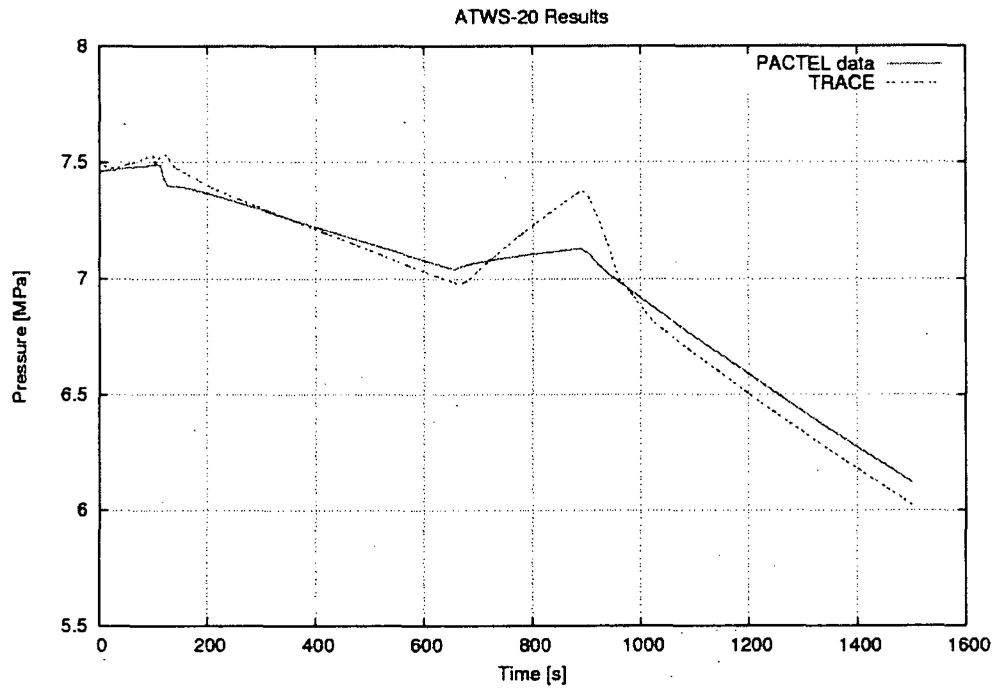

Figure 9. Pressure during the ATWS-20 transient.

4.6 ATWS-21

The simulation of this simple transient shows a good agreement with the measured pressure as seen in Fig. 10. The deviation is 0.1 MPa at most throughout the transient which is a remarkably accurate result, taking into account that the error in the pressure measurement might be close to 0.1 MPa according to the error estimates. The reported maximum error in the spray mass flow rate measurement is ±0.000793 kg/s.

In this case all the heaters are on from approximately 400 s on but the spray rate is high enough to keep the pressure decreasing steadily.

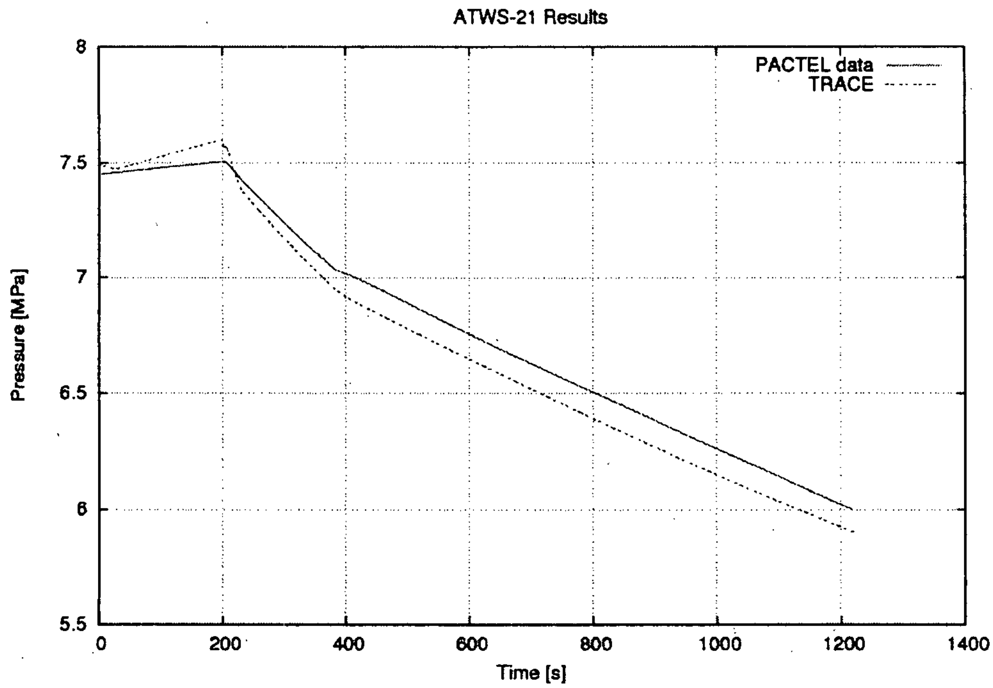

Figure 10. Pressure during the ATWS-21 transient.

5 CONCLUSIONS

The simulation results obtained for the slow insurge followed by an outsurge transients (ATWS-10 and ATWS-11) are in relatively good agreement with the experimental results. The deviation from the experimental results becomes greater in the ATWS-12 and ATWS-13 cases. The cause of this discrepancy is not clear. One possible explanation is that the heat losses during the temperature increase in the pressurizer are not accurately computed since the contribution of the heat losses to the system behavior becomes more important in slower processes.

Generally, TRACE slightly exaggerates the pressure increase for the insurge transients. This may indicate that the wall condensation during the compression of steam is underestimated. A further assessment of the heat transfer correlations used in the code for the PRIZER component and possibly incorporating a more suitable correlation for wall condensation could improve the pressurizer calculation. Keeping in mind that the ability of thermal hydraulic codes to predict phenomena occurring in the pressurizer such as spray injection has generally not been good since the models are not fully mechanistic and there are aspects which are not taken into account in the models, there is a potential to significantly improve the performance of the pressurizer model in these types of separate effect test simulations by incorporating more detailed heat transfer models into the code.

The simulation results obtained for spray transients ATWS-20 and ATWS-21 agree well with the experimental results. An exception is the pressure rise which is too rapid in the ATWS-20 transient during the period when all the heaters are on. Based on the results, a simple spray transient, without simultaneous insurge or outsurge flows in the surge line or rapid heater-induced enthalpy changes, is accurately computed by TRACE. To complete the validation of the TRACE pressurizer model separate calculations on more complex cases such as simultaneous insurge and spray cooling are recommended.

The model built for current simulation has some drawbacks. A single channel pressurizer was used in all the cases but it is not capable of simulating convection in the water volume and mixing of hot and cold water which may be of importance in cases where heaters play an important role on the overall heat transfer processes in the system.

6 REFERENCES

Aksan, N., D'Auria, F., Glaeser, H., Pochard, R., Richards, C., Sjoberg, A. 1993. OECD/NEA-CSNI Separate Effects Test Matrix for Thermal-hydraulic Code Validation. Volume 1. Phenomena Characterisation and Selection of Facilities and Tests. Organisation for Economic Co-operation and Development. OCDE/GD (94)/82. Paris. 678 p.

Riikonen, V. 1998. ATWS Experiments with PACTEL: Pressurizer Experiments. Espoo, VTT Energy, TEKOJA 1/98. 11 p.

Spore, J.W., Elson, J.S., Jolly-Woodruff, S.J., Knight T.D., Lin, J.-C., Nelson, R.A., Pasamehmetoglu, K.O., Steinke, R.G., Unal, C., Mahaffy, J.H., Murray, C. 2000. TRAC-M/FORTRAN 90 (Version 3.0) Theory Manual. Los Alamos National Laboratory, Los Alamos. LA-UR-00-910. 923 p.

TRACE V4.160 User's Manual. Volume 1: Input Specification. 2005. USNRC, Division of System Analysis and Regulatory Effectiveness. Washington DC. 600 p.

Tuunanen, J., Kouhia, J., Purhonen, H., Riikonen, V., Puustinen, M., Semken, R.S., Partanen, H., Saure, I., Pylkkö, H. 1998. General description of the PACTEL test facility. Espoo, VTT, VTT Tiedote – Research Note No. 1929. 35 p.

APPENDIX A

MODEL INPUT FILES

ATWS-10 input file

```
free format
*
*************
* main data *
*************
*
*       numtcr          ieos          inopt          nmat          id2o
             1             0              1             0             0

*
*
*****************
* namelist data *
*****************
*
 &inopts
  dtstrt=-1.0,
  iconht=0,
  nsdl=0,
  nsdu=500,
  nspl=0,
  nspu=500,
  usesjc=3,
  npower=1,
  nhtstr=1,
  igas=1
 &end
*
***************
* Model Flags *
***************
*
*        dstep         timet
             0           0.0
*       stdyst        transi          ncomp          njun          ipak
             0             1              8             5             0
*         epso          epss
        1.0E-4        1.0E-4
*       oitmax        sitmax         isolut        ncontr         nccfl
            20            10              0             0             0
*         ntsv          ntcb           ntcf          ntrp          ntcp
             1             0              0             0             0
*
************************
* component-number data *
************************
*
* iorder*           1           11           61           71          111s
* iorder*         121          131         141e
*
*
**************************************************
* Starting Signal Variable Section of Model      *
**************************************************
*
*         idsv          isvn           ilcn          icn1          icn2
             1             0              0             0             0
**************************************************
* Finished Signal Variable Section of Model      *
**************************************************
*
*
*
*
```

```
*******   type           num        userid                component name
prizer                    1           1                        unnamed
*        ncells        nodes        jun1        jun2
             30            0          12          10
*          ichf        iconc        qp3in
              1            0          0.0
*         radin           th        houtl       houtv         toutl
            0.0          0.0          0.0         0.0           0.0
*         toutv        qheat         pset       dpmax          zhtr
            0.0          0.0        6.0E6       1.0E6           7.0
* dx    *    0.2933333   0.2933333   0.2933333   0.2933333s
* dx    *    0.2933333   0.2933333   0.2933333   0.2933333s
* dx    *    0.2933333   0.2933333   0.2933333   0.2933333s
* dx    *    0.2933333   0.2933333   0.2933333   0.2933333s
* dx    *    0.2933333   0.2933333   0.2933333   0.2933333s
* dx    *    0.2933333   0.2933333   0.2933333   0.2933333s
* dx    *    0.2933333   0.2933333   0.2933333   0.2933333s
* dx    *    0.2933333   0.2933333e
* vol   *   4.49618E-3  4.49618E-3  4.49618E-3  4.49618E-3s
* vol   *   4.49618E-3  4.49618E-3  4.49618E-3  4.49618E-3s
* vol   *   4.49618E-3  4.49618E-3  4.49618E-3  4.49618E-3s
* vol   *   4.49618E-3  4.49618E-3  4.49618E-3  4.49618E-3s
* vol   *   4.49618E-3  4.49618E-3  4.49618E-3  4.49618E-3s
* vol   *   4.49618E-3  4.49618E-3  4.49618E-3  4.49618E-3s
* vol   *   4.49618E-3  4.49618E-3  4.49618E-3  4.49618E-3s
* vol   *   4.49618E-3  4.49618E-3e
* fa    *   5.85349E-4   0.0153279   0.0153279   0.0153279s
* fa    *    0.0153279   0.0153279   0.0153279   0.0153279s
* fa    *    0.0153279   0.0153279   0.0153279   0.0153279s
* fa    *    0.0153279   0.0153279   0.0153279   0.0153279s
* fa    *    0.0153279   0.0153279   0.0153279   0.0153279s
* fa    *    0.0153279   0.0153279   0.0153279   0.0153279s
* fa    *    0.0153279   0.0153279   0.0153279   0.0153279s
* fa    *    0.0153279   0.0153279     7.1E-5e
* fric  *          0.1         0.0         0.0         0.0s
* fric  *          0.0         0.0         0.0         0.0s
* fric  *          0.0         0.0         0.0         0.0s
* fric  *          0.0         0.0         0.0         0.0s
* fric  *          0.0         0.0         0.0         0.0s
* fric  *          0.0         0.0         0.0         0.0s
* fric  *          0.0         0.0         0.0         0.0s
* fric  *          0.0         0.0         0.1e
* grav  *          1.0         1.0         1.0         1.0s
* grav  *          1.0         1.0         1.0         1.0s
* grav  *          1.0         1.0         1.0         1.0s
* grav  *          1.0         1.0         1.0         1.0s
* grav  *          1.0         1.0         1.0         1.0s
* grav  *          1.0         1.0         1.0         1.0s
* grav  *          1.0         1.0         1.0         1.0s
* grav  *          1.0         1.0         1.0e
* hd    *       0.0273      0.1397      0.1397      0.1397s
* hd    *       0.1397      0.1397      0.1397      0.1397s
* hd    *       0.1397      0.1397      0.1397      0.1397s
* hd    *       0.1397      0.1397      0.1397      0.1397s
* hd    *       0.1397      0.1397      0.1397      0.1397s
* hd    *       0.1397      0.1397      0.1397      0.1397s
* hd    *       0.1397      0.1397      0.1397      0.1397s
* hd    *       0.1397      0.1397      3.0E-3e
* nff   *            1          -1          -1          -1s
* nff   *           -1          -1          -1          -1s
* nff   *           -1          -1          -1          -1s
* nff   *           -1          -1          -1          -1s
* nff   *           -1          -1          -1          -1s
* nff   *           -1          -1          -1          -1s
* nff   *           -1          -1          -1          -1s
* nff   *           -1          -1          1e
* alp   *          0.0         0.0         0.0         0.0s
* alp   *          0.0         0.0         0.0         0.0s
```

```
* alp    *        0.0         0.0         0.0        0.75s
* alp    *        1.0         1.0         1.0         1.0s
* alp    *        1.0         1.0         1.0         1.0s
* alp    *        1.0         1.0         1.0         1.0s
* alp    *        1.0         1.0         1.0         1.0s
* alp    *        1.0         1.0e
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0e
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0e
* tl     *     547.64      547.64      547.64      547.64s
* tl     *     547.64      547.64      547.64      547.64s
* tl     *     547.64      547.64      547.64      547.64s
* tl     *     547.64      547.64      547.64      547.64s
* tl     *     547.64      547.64      547.64      547.64s
* tl     *     547.64      547.64      547.64      547.64s
* tl     *     547.64      547.64      547.64      547.64s
* tl     *     547.64      547.64e
* tv     *     547.64      547.64      547.64      547.64s
* tv     *     547.64      547.64      547.64      547.64s
* tv     *     547.64      547.64      547.64      547.64s
* tv     *     547.64      547.64      547.64      547.64s
* tv     *     547.64      547.64      547.64      547.64s
* tv     *     547.64      547.64      547.64      547.64s
* tv     *     547.64      547.64      547.64      547.64s
* tv     *     547.64      547.64e
* p      *      5.9E6       5.9E6       5.9E6       5.9E6s
* p      *      5.9E6       5.9E6       5.9E6       5.9E6s
* p      *      5.9E6       5.9E6       5.9E6       5.9E6s
* p      *      5.9E6       5.9E6       5.9E6       5.9E6s
* p      *      5.9E6       5.9E6       5.9E6       5.9E6s
* p      *      5.9E6       5.9E6       5.9E6       5.9E6s
* p      *      5.9E6       5.9E6       5.9E6       5.9E6s
* p      *      5.9E6       5.9E6e
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0e
*
*
*******    type           num        userid                 component name
fill                       11             1                        unnamed
*          junl          ifty          ioff
             11             5             0
*          iftr          ifsv          nftb          nfsv          nfrf
              0             1             7             1             0
*        twtold          rfmx        concin          felv
            0.0        1.0E20           0.0           0.0
*          dxin         volin         alpin          vlin          tlin
           3.15   1.843851E-3           0.0           0.0         547.0
*           pin          pain        flowin          vvin          tvin
          5.9E6           0.0           0.0           0.0         547.0
```

```
*         vmscl         vvscl
            1.0           1.0
*
* vmtbl  *         0.0          0.0s
* vmtbl  *       119.0          0.0s
* vmtbl  *       120.0       0.3666s
* vmtbl  *       220.0       0.3666s
* vmtbl  *       221.0       -0.215s
* vmtbl  *       406.0       -0.215s
* vmtbl  *       407.0          0.0e
*
*
******    type             num        userid                component name
pipe                        61             1                       unnamed
*        ncells          nodes          jun1         jun2         epsw
              2              0            11            1          0.0
*        nsides
              0
*          ichf          iconc          iacc         ipow       npipes
              1              0             0            0            1
*         radin             th         houtl        houtv        toutl
            0.0            0.0           0.0          0.0          0.0
*         toutv           pwin         pwoff        rpwmx        pwscl
            0.0            0.0           0.0          0.0          0.0
* dx     *        3.15          3.15e
* vol    *    1.84385E-3  1.84385E-3e
* fa     *    5.85349E-4  5.85349E-4  5.85349E-4e
* fric   *         0.0           0.0          0.1e
* grav   *        -1.0           0.0          0.0e
* hd     *      0.0273        0.0273      0.0273e
* nff    *           1             1           1e
* alp    *         0.0          0.0e
* vl     *         0.0           0.0          0.0e
* vv     *         0.0           0.0          0.0e
* tl     *      547.64       547.64e
* tv     *      547.64       547.64e
* p      *       5.9E6        5.9E6e
* pa     *         0.0          0.0e
*
*
******    type             num        userid                component name
pipe                        71             1                       unnamed
*        ncells          nodes          jun1         jun2         epsw
              1              0             1           12          0.0
*        nsides
              0
*          ichf          iconc          iacc         ipow       npipes
              1              0             0            0            1
*         radin             th         houtl        houtv        toutl
            0.0            0.0           0.0          0.0          0.0
*         toutv           pwin         pwoff        rpwmx        pwscl
            0.0            0.0           0.0          0.0          0.0
* dx     *        1.47e
* vol    *    8.60464E-4e
* fa     *    5.85349E-4  5.85349E-4e
* fric   *         0.1          0.1e
* grav   *         0.0          1.0e
* hd     *      0.0273      0.0273e
* nff    *           1           1e
* alp    *        0.0e
* vl     *         0.0          0.0e
* vv     *         0.0          0.0e
* tl     *     547.64e
* tv     *     547.64e
* p      *      5.9E6e
* pa     *        0.0e
*
*
```

```
*******   type            num         userid                component name
fill                      111              1                       unnamed
*         junl           ifty           ioff
             9              2              0
*       twtold           rfmx         concin          felv
           0.0        .1.0E20            0.0           0.0
*         dxin          volin          alpin          vlin          tlin
           0.3   1.756048E-4            0.0           0.0         547.0
*          pin           pain         flowin          vvin          tvin
         5.9E6            0.0            0.0           0.0         547.0
*
*
*******   type            num         userid                component name
pipe                      121              1                       unnamed
*       ncells          nodes           junl          jun2          epsw
             1              0             10             9           0.0
*       nsides
             0
*         ichf          iconc           iacc          ipow        npipes
             1              0              0             0             1
*        radin             th          houtl         houtv         toutl
           0.0            0.0            0.0           0.0           0.0
*        toutv           pwin          pwoff         rpwmx         pwscl
           0.0            0.0            0.0           0.0           0.0
* dx     *        0.3e
* vol    *   1.75605E-4e
* fa     *      7.1E-5      7.1E-5e
* fric   *         0.1         0.1e
* grav   *         1.0         1.0e
* hd     *      3.0E-3      3.0E-3e
* nff    *           1           1e
* alp    *        1.0e
* vl     *         0.0         0.0e
* vv     *         0.0         0.0e
* tl     *     547.64e
* tv     *     547.64e
* p      *       5.9E6e
* pa     *        0.0e
*
*
********************************************
* Starting Heat Structure Section of Model *
********************************************
*
*******   type            num         userid                component name
htstr                     131              0                       unnamed
*       nzhstr           ittc          hscyl          ichf
            30              0              1             1
*       nopowr          plane         liqlev        iaxcnd
             0              3              1             1
*        nmwrx           nfci          nfcil          hdri          hdro
             0              0              0           0.0           0.0
*         nhot          nodes          irftr         nzmax        irftr2
             0              5              0           100             0
*     dtxht(1)       dtxht(2)          dznht         hgapo
           2.0           10.0         1.0E-3        6300.0
*
*  idbcin *          2            2            2            2s
*  idbcin *          2            2            2            2s
*  idbcin *          2            2            2            2s
*  idbcin *          2            2            2            2s
*  idbcin *          2            2            2            2s
*  idbcin *          2            2            2            2s
*  idbcin *          2            2            2            2s
*  idbcin *          2            2e
*  idbcon *          1            1            1            1s
*  idbcon *          1            1            1            1s
*  idbcon *          1            1            1            1s
```

```
*   idbcon *          1          1          1          1s
*   idbcon *          1          1          1          1s
*   idbcon *          1          1          1          1s
*   idbcon *          1          1          1          1s
*   idbcon *          1          1e
* hcomon1   *          1          1          0          0e
* hcomon1   *          1          2          0          0e
* hcomon1   *          1          3          0          0e
* hcomon1   *          1          4          0          0e
* hcomon1   *          1          5          0          0e
* hcomon1   *          1          6          0          0e
* hcomon1   *          1          7          0          0e
* hcomon1   *          1          8          0          0e
* hcomon1   *          1          9          0          0e
* hcomon1   *          1         10          0          0e
* hcomon1   *          1         11          0          0e
* hcomon1   *          1         12          0          0e
* hcomon1   *          1         13          0          0e
* hcomon1   *          1         14          0          0e
* hcomon1   *          1         15          0          0e
* hcomon1   *          1         16          0          0e
* hcomon1   *          1         17          0          0e
* hcomon1   *          1         18          0          0e
* hcomon1   *          1         19          0          0e
* hcomon1   *          1         20          0          0e
* hcomon1   *          1         21          0          0e
* hcomon1   *          1         22          0          0e
* hcomon1   *          1         23          0          0e
* hcomon1   *          1         24          0          0e
* hcomon1   *          1         25          0          0e
* hcomon1   *          1         26          0          0e
* hcomon1   *          1         27          0          0e
* hcomon1   *          1         28          0          0e
* hcomon1   *          1         29          0          0e
* hcomon1   *          1         30          0          0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
*    htc2   *       3.44       298.0e
* dhtstrz *   0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *   0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *   0.2933333   0.2933333   0.2933333   0.2933333s
```

```
* dhtstrz *   0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *   0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *   0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *   0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *   0.2933333   0.2933333e
*   rdx *        1.0e
* radrd *     0.06985    0.073425       0.077    0.080575      0.08415e
* matrd *         6           6           6           6e
*     nfax *          1           1           1           1s
*     nfax *          1           1           1           1s
*     nfax *          1           1           1           1s
*     nfax *          1           1           1           1s
*     nfax *          1           1           1           1s
*     nfax *          1           1           1           1s
*     nfax *          1           1           1           1s
*     nfax *          1           1e
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0       547.0       547.0s
*     rftn *      547.0       547.0e
* fpuo2 *         0.0e
*    ftd *        1.0e
*   gmix * f      0.0e
*    gmles *        0.0e
*    pgapt *        0.0e
*    plvol *         0.0 e
*    pslen *         0.0 e
*    clenn *         0.0 e
*   burn *        0.0         0.0         0.0         0.0s
*   burn *        0.0         0.0         0.0         0.0s
*   burn *        0.0         0.0         0.0         0.0s
*   burn *        0.0         0.0         0.0         0.0s
*   burn *        0.0         0.0         0.0         0.0s
*   burn *        0.0         0.0         0.0         0.0s
```

```
*  burn *         0.0          0.0          0.0          0.0s
*  burn *         0.0          0.0e
*********************************************
* Finished Heat Structure Section of Model *
*********************************************
*
*
*
*
******************************************
*     Starting Power Components          *
******************************************
*
*******   type            num        userid                 component name
power                     141             1                        unnamed
*       numpwr       chanpow
             1             0
* htnum *        131e
*       irpwty          ndgx          ndhx          nrts         nhist
             6             0             0            10             0
*       irpwtr        irpwsv        nrpwtb        nrpwsv        nrpwrf
             0             1             3             0             0
*       izpwtr        izpwsv        nzpwtb        nzpwsv        nzpwrf
             0             1             1             0             0
*       ipwrad        ipwdep      promheat      decaheat      wtbypass
             0             0           0.0           0.0           0.0
*         nzpwz         nzpwi        nfbpwt          nrpwr         nrpwi
             0             0             0             1             0
*         react         tneut        rpwoff        rrpwmx        rpwscl
           0.0           0.0           0.0        1.0E20           1.0
*       rpowri         zpwin        zpwoff        rzpwmx
        4000.0           0.0       -1.0E19        1.0E20
*       extsou          pldr         pdrat        fucrac
           0.0           0.0           1.0           1.0
* rdpwr *         1.0          1.0          1.0          1.0          1.0e
* cpowr *         1.0e
* zpwtbl*         0.0s
* zpwtbl*         1.0s
* zpwtbl*         1.0s
* zpwtbl*         1.0s
* zpwtbl*         1.0s
* zpwtbl*         1.0s
* zpwtbl*         1.0s
* zpwtbl*         1.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0s
* zpwtbl*         0.0e
* rpwtbr*         0.0       4000.0s
```

```
* rpwtbr*        99.0      4000.0s
* rpwtbr*       100.0         0.0e
*****************************************
*     Finished Power Components         *
*****************************************
*
*
*
end
*
*****************
* Timestep Data *
*****************
*        dtmin         dtmax          tend         rtwfp        powerc
        1.0E-6          0.05         500.0          10.0           0.0
*        edint         gfint        dmpint        sedint
          10.0           0.5         100.0           1.0
*
*      endflag
          -1.0
```

ATWS-20 input file

```
free format
*
*************
* main data *
*************
*
*       numtcr          ieos          inopt          nmat          id2o
             1             0              1             0             0

*
*
*****************
* namelist data *
*****************
*
 &inopts
  dtstrt=0.05,
  iconht=0,
  nsdl=0,
  nsdu=500,
  nspl=0,
  nspu=500,
  usesjc=3,
  npower=1,
  nhtstr=1,
  igas=1
 &end
*
***************
* Model Flags *
***************
*
*        dstep         timet
             0           0.0
*       stdyst        transi          ncomp          njun          ipak
             0             1              8             5             0
*         epso          epss
        1.0E-4        1.0E-4
*       oitmax        sitmax         isolut        ncontr         nccfl
            20            10              0             0             0
*         ntsv          ntcb           ntcf          ntrp          ntcp
             1             0              0             0             0
*
*************************
* component-number data *
*************************
*
* iorder*          1           11            61           71          111s
* iorder*        121          131          141e
*
*
**************************************************
* Starting Signal Variable Section of Model      *
**************************************************
*
*         idsv          isvn           ilcn          icn1          icn2
             1             0              0             0             0
**************************************************
* Finished Signal Variable Section of Model      *
**************************************************
*
*
*
```

```
*
*******   type           num          userid               component name
prizer                     1             1                        unnamed
*        ncells          nodes         jun1        jun2
            30             0            12           10
*         ichf          iconc         qp3in
             1             0           0.0
*        radin            th          houtl        houtv         toutl
           0.0           0.0           0.0          0.0           0.0
*        toutv          qheat          pset        dpmax          zhtr
           0.0           0.0          6.0E6        1.0E6          7.0
* dx     *     0.2933333  0.2933333  0.2933333  0.2933333s
* dx     *     0.2933333  0.2933333  0.2933333  0.2933333s
* dx     *     0.2933333  0.2933333  0.2933333  0.2933333s
* dx     *     0.2933333  0.2933333  0.2933333  0.2933333s
* dx     *     0.2933333  0.2933333  0.2933333  0.2933333s
* dx     *     0.2933333  0.2933333  0.2933333  0.2933333s
* dx     *     0.2933333  0.2933333  0.2933333  0.2933333s
* dx     *     0.2933333  0.2933333e
* vol    *   4.49618E-3 4.49618E-3 4.49618E-3 4.49618E-3s
* vol    *   4.49618E-3 4.49618E-3 4.49618E-3 4.49618E-3s
* vol    *   4.49618E-3 4.49618E-3 4.49618E-3 4.49618E-3s
* vol    *   4.49618E-3 4.49618E-3 4.49618E-3 4.49618E-3s
* vol    *   4.49618E-3 4.49618E-3 4.49618E-3 4.49618E-3s
* vol    *   4.49618E-3 4.49618E-3 4.49618E-3 4.49618E-3s
* vol    *   4.49618E-3 4.49618E-3 4.49618E-3 4.49618E-3s
* vol    *   4.49618E-3 4.49618E-3e
* fa     *   5.85349E-4  0.0153279  0.0153279  0.0153279s
* fa     *     0.0153279  0.0153279  0.0153279  0.0153279s
* fa     *     0.0153279  0.0153279  0.0153279  0.0153279s
* fa     *     0.0153279  0.0153279  0.0153279  0.0153279s
* fa     *     0.0153279  0.0153279  0.0153279  0.0153279s
* fa     *     0.0153279  0.0153279  0.0153279  0.0153279s
* fa     *     0.0153279  0.0153279  0.0153279  0.0153279s
* fa     *     0.0153279  0.0153279    7.1E-5e
* fric   *           0.1        0.0        0.0        0.0s
* fric   *           0.0        0.0        0.0        0.0s
* fric   *           0.0        0.0        0.0        0.0s
* fric   *           0.0        0.0        0.0        0.0s
* fric   *           0.0        0.0        0.0        0.0s
* fric   *           0.0        0.0        0.0        0.0s
* fric   *           0.0        0.0        0.0        0.0s
* fric   *           0.0        0.0        0.1e
* grav   *           1.0        1.0        1.0        1.0s
* grav   *           1.0        1.0        1.0        1.0s
* grav   *           1.0        1.0        1.0        1.0s
* grav   *           1.0        1.0        1.0        1.0s
* grav   *           1.0        1.0        1.0        1.0s
* grav   *           1.0        1.0        1.0        1.0s
* grav   *           1.0        1.0        1.0        1.0s
* grav   *           1.0        1.0        1.0e
* hd     *        0.0273     0.1397     0.1397     0.1397s
* hd     *        0.1397     0.1397     0.1397     0.1397s
* hd     *        0.1397     0.1397     0.1397     0.1397s
* hd     *        0.1397     0.1397     0.1397     0.1397s
* hd     *        0.1397     0.1397     0.1397     0.1397s
* hd     *        0.1397     0.1397     0.1397     0.1397s
* hd     *        0.1397     0.1397     0.1397     0.1397s
* hd     *        0.1397     0.1397    3.0E-3e
* nff    *            -1         -1         -1         -1s
* nff    *            -1         -1         -1         -1s
* nff    *            -1         -1         -1         -1s
* nff    *            -1         -1         -1         -1s
* nff    *            -1         -1         -1         -1s
* nff    *            -1         -1         -1         -1s
* nff    *            -1         -1         -1         -1s
* nff    *            -1         -1          1e
* alp    *           0.0        0.0        0.0        0.0s
```

```
* alp    *        0.0         0.0         0.0         0.0s
* alp    *        0.0         0.0         0.0         0.0s
* alp    *        0.0         0.0         0.0         0.0s
* alp    *        0.0         0.0         0.0      0.9091s
* alp    *        1.0         1.0         1.0         1.0s
* alp    *        1.0         1.0         1.0         1.0s
* alp    *        1.0         1.0e
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0         0.0s
* vl     *        0.0         0.0         0.0e
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0         0.0s
* vv     *        0.0         0.0         0.0e
* tl     *    563.685     563.685     563.685     563.685s
* tl     *    563.685     563.685     563.685     563.685s
* tl     *    563.685     563.685     563.685     563.685s
* tl     *    563.685     563.685     563.685     563.685s
* tl     *    563.685     563.685     563.685     563.685s
* tl     *    563.685     563.685     563.685     563.685s
* tl     *    563.685     563.685     563.685     563.685s
* tl     *    563.685     563.685e
* tv     *    563.685     563.685     563.685     563.685s
* tv     *    563.685     563.685     563.685     563.685s
* tv     *    563.685     563.685     563.685     563.685s
* tv     *    563.685     563.685     563.685     563.685s
* tv     *    563.685     563.685     563.685     563.685s
* tv     *    563.685     563.685     563.685     563.685s
* tv     *    563.685     563.685     563.685     563.685s
* tv     *    563.685     563.685e
* p      *      7.5E6       7.5E6       7.5E6       7.5E6s
* p      *      7.5E6       7.5E6       7.5E6       7.5E6s
* p      *      7.5E6       7.5E6       7.5E6       7.5E6s
* p      *      7.5E6       7.5E6       7.5E6       7.5E6s
* p      *      7.5E6       7.5E6       7.5E6       7.5E6s
* p      *      7.5E6       7.5E6       7.5E6       7.5E6s
* p      *      7.5E6       7.5E6       7.5E6       7.5E6s
* p      *      7.5E6       7.5E6e
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0         0.0         0.0s
* pa     *        0.0         0.0e
*
*
*******  type          num        userid                component name
fill                    11             1                        unnamed
*         junl        ifty          ioff
            11           2             0
*       twtold        rfmx        concin        felv
           0.0      1.0E20           0.0         0.0
*         dxin       volin         alpin        vlin          tlin
          3.15  1.843851E-3          0.0         0.0         563.0
*          pin        pain        flowin        vvin          tvin
         7.5E6         0.0           0.0         0.0         563.0
*
```

```
*
*******   type              num         userid                 component name
pipe                         61              1                        unnamed
*        ncells           nodes           jun1          jun2          epsw
              2               0             11             1           0.0
*        nsides
              0
*          ichf           iconc           iacc          ipow        npipes
              1               0              0             0             1
*         radin              th          houtl         houtv         toutl
            0.0             0.0            0.0           0.0           0.0
*         toutv            pwin          pwoff         rpwmx         pwscl
            0.0             0.0            0.0           0.0           0.0
* dx    *         3.15         3.15e
* vol   *   1.84385E-3  1.84385E-3e
* fa    *   5.85349E-4  5.85349E-4  5.85349E-4e
* fric  *          0.0          0.0          0.1e
* grav  *         -1.0          0.0          0.0e
* hd    *       0.0273       0.0273       0.0273e
* nff   *            1            1            1e
* alp   *          0.0         0.0e
* vl    *          0.0          0.0          0.0e
* vv    *          0.0          0.0          0.0e
* tl    *        563.0       563.0e
* tv    *        563.0       563.0e
* p     *        7.5E6       7.5E6e
* pa    *          0.0         0.0e
*
*
*******   type              num         userid                 component name
pipe                         71              1                        unnamed
*        ncells           nodes           jun1          jun2          epsw
              1               0              1            12           0.0
*        nsides
              0
*          ichf           iconc           iacc          ipow        npipes
              1               0              0             0             1
*         radin              th          houtl         houtv         toutl
            0.0             0.0            0.0           0.0           0.0
*         toutv            pwin          pwoff         rpwmx         pwscl
            0.0             0.0            0.0           0.0           0.0
* dx    *        1.47e
* vol   *  8.60464E-4e
* fa    *   5.85349E-4  5.85349E-4e
* fric  *          0.1         0.1e
* grav  *          0.0         1.0e
* hd    *       0.0273      0.0273e
* nff   *            1          -1e
* alp   *         0.0e
* vl    *          0.0         0.0e
* vv    *          0.0         0.0e
* tl    *       563.0e
* tv    *       563.0e
* p     *       7.5E6e
* pa    *         0.0e
*
*
*******   type              num         userid                 component name
fill                        111              1                        unnamed
*          jun1            ifty           ioff
              9               5              0
*          iftr            ifsv           nftb          nfsv          nfrf
              0               1              5             0             0
*        twtold            rfmx         concin          felv
            0.0          1.0E20            0.0           0.0
*          dxin           volin          alpin          vlin          tlin
            0.3     1.756048E-4            0.0           0.0         298.0
*           pin            pain         flowin          vvin          tvin
```

```
        7.5E6           0.0           0.0           0.0         373.0
*       vmscl         vvscl
          1.0           1.0
*
* vmtbl  *        0.0          0.0s
* vmtbl  *       99.0          0.0s
* vmtbl  *      100.0     6.667E-3s
* vmtbl  *     1499.0     6.667E-3s
* vmtbl  *     1500.0          0.0e
*
*
*******    type           num       userid                component name
pipe                      121            1                       unnamed
*       ncells          nodes         jun1         jun2         epsw
             1              0           10            9          0.0
*       nsides
             0
*         ichf          iconc         iacc         ipow       npipes
             1              0            0            0            1
*        radin             th        houtl        houtv        toutl
           0.0            0.0          0.0          0.0          0.0
*        toutv           pwin        pwoff        rpwmx        pwscl
           0.0            0.0          0.0          0.0          0.0
* dx     *        0.3e
* vol    *  1.75605E-4e
* fa     *      7.1E-5      7.1E-5e
* fric   *         0.1         0.1e
* grav   *         1.0         1.0e
* hd     *      3.0E-3      3.0E-3e
* nff    *           1           1e
* alp    *        1.0e
* vl     *         0.0         0.0e
* vv     *         0.0         0.0e
* tl     *      563.0e
* tv     *      564.0e
* p      *      7.5E6e
* pa     *        0.0e
*
*
*******************************************
* Starting Heat Structure Section of Model *
*******************************************
*
*******    type           num       userid                component name
htstr                     131            0                       unnamed
*       nzhstr           ittc        hscyl         ichf
            30              0            1            1
*       nopowr          plane       liqlev       iaxcnd
             0              3            1            1
*        nmwrx           nfci        nfcil         hdri         hdro
             0              0            0          0.0          0.0
*         nhot          nodes        irftr        nzmax       irftr2
             0              5            0          100            0
*     dtxht(1)      dtxht(2)        dznht        hgapo
           2.0           10.0       1.0E-3       6300.0
*
*  idbcin *          2          2          2          2s
*  idbcin *          2          2          2          2s
*  idbcin *          2          2          2          2s
*  idbcin *          2          2          2          2s
*  idbcin *          2          2          2          2s
*  idbcin *          2          2          2          2s
*  idbcin *          2          2          2          2s
*  idbcin *          2          2e
*  idbcon *          1          1          1          1s
*  idbcon *          1          1          1          1s
*  idbcon *          1          1          1          1s
*  idbcon *          1          1          1          1s
```

```
*  idbcon *        1        1        1        1s
*  idbcon *        1        1        1        1s
*  idbcon *        1        1        1        1s
*  idbcon *        1        1e
* hcomon1  *        1        1        0        0e
* hcomon1  *        1        2        0        0e
* hcomon1  *        1        3        0        0e
* hcomon1  *        1        4        0        0e
* hcomon1  *        1        5        0        0e
* hcomon1  *        1        6        0        0e
* hcomon1  *        1        7        0        0e
* hcomon1  *        1        8        0        0e
* hcomon1  *        1        9        0        0e
* hcomon1  *        1       10        0        0e
* hcomon1  *        1       11        0        0e
* hcomon1  *        1       12        0        0e
* hcomon1  *        1       13        0        0e
* hcomon1  *        1       14        0        0e
* hcomon1  *        1       15        0        0e
* hcomon1  *        1       16        0        0e
* hcomon1  *        1       17        0        0e
* hcomon1  *        1       18        0        0e
* hcomon1  *        1       19        0        0e
* hcomon1  *        1       20        0        0e
* hcomon1  *        1       21        0        0e
* hcomon1  *        1       22        0        0e
* hcomon1  *        1       23        0        0e
* hcomon1  *        1       24        0        0e
* hcomon1  *        1       25        0        0e
* hcomon1  *        1       26        0        0e
* hcomon1  *        1       27        0        0e
* hcomon1  *        1       28        0        0e
* hcomon1  *        1       29        0        0e
* hcomon1  *        1       30        0        0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
*   htc2   *     3.44     298.0e
* dhtstrz *  0.2933333  0.2933333  0.2933333  0.2933333s
* dhtstrz *  0.2933333  0.2933333  0.2933333  0.2933333s
* dhtstrz *  0.2933333  0.2933333  0.2933333  0.2933333s
* dhtstrz *  0.2933333  0.2933333  0.2933333  0.2933333s
```

```
* dhtstrz *    0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *    0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *    0.2933333   0.2933333   0.2933333   0.2933333s
* dhtstrz *    0.2933333   0.2933333e
*   rdx *          1.0e
* radrd *      0.06985    0.073425        0.077    0.080575      0.08415e
* matrd *          6           6           6            6e
*     nfax *         1           1           1            1s
*     nfax *         1           1           1            1s
*     nfax *         1           1           1            1s
*     nfax *         1           1           1            1s
*     nfax *         1           1           1            1s
*     nfax *         1           1           1            1s
*     nfax *         1           1           1            1s
*     nfax *         1           1e
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0       563.0       563.0s
*     rftn *       563.0       563.0e
* fpuo2 *          0.0e
*   ftd *          1.0e
*  gmix * f        0.0e
*   gmles *          0.0e
*   pgapt *          0.0e
*   plvol *           0.0 e
*   pslen *           0.0 e
*   clenn *           0.0 e
*  burn *        0.0         0.0         0.0         0.0s
*  burn *        0.0         0.0         0.0         0.0s
*  burn *        0.0         0.0         0.0         0.0s
*  burn *        0.0         0.0         0.0         0.0s
*  burn *        0.0         0.0         0.0         0.0s
*  burn *        0.0         0.0         0.0         0.0s
*  burn *        0.0         0.0         0.0         0.0s
```

```
*  burn *          0.0.        0.0e
*******************************************
* Finished Heat Structure Section of Model *
*******************************************
*
*
*
*
****************************************
*     Starting Power Components        *
****************************************
*
*******    type           num        userid                component name
power                     141             1                       unnamed
*       numpwr       chanpow
             1             0
* htnum *        131e
*       irpwty          ndgx          ndhx          nrts         nhist
             6             0             0            10             0
*       irpwtr        irpwsv        nrpwtb        nrpwsv        nrpwrf
             0             1            11             0             0
*       izpwtr        izpwsv        nzpwtb        nzpwsv        nzpwrf
             0             1             1             0             0
*       ipwrad        ipwdep      promheat      decaheat      wtbypass
             0             0           0.0           0.0           0.0
*        nzpwz         nzpwi        nfbpwt         nrpwr         nrpwi
             0             0             0             1             0
*        react         tneut        rpwoff        rrpwmx        rpwscl
           0.0           0.0           0.0        1.0E20           1.0
*       rpowri         zpwin        zpwoff        rzpwmx
        4000.0           0.0       -1.0E19        1.0E20
*       extsou          pldr         pdrat        fucrac
           0.0           0.0           1.0           1.0
* rdpwr *          1.0         1.0         1.0         1.0         1.0e
* cpowr *          1.0e
* zpwtbl*          0.0s
* zpwtbl*          1.0s
* zpwtbl*          1.0s
* zpwtbl*          1.0s
* zpwtbl*          1.0s
* zpwtbl*          1.0s
* zpwtbl*          1.0s
* zpwtbl*          1.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0s
* zpwtbl*          0.0e
* rpwtbr*          0.0       4000.0s
* rpwtbr*        105.0       4000.0s
```

```
* rpwtbr*       106.0       6000.0s
* rpwtbr*       659.0       6000.0s
* rpwtbr*       660.0         1.3E4s
* rpwtbr*       889.0         1.3E4s
* rpwtbr*       890.0       6000.0s
* rpwtbr*       902.0       6000.0s
* rpwtbr*       903.0       2000.0s
* rpwtbr*       905.0       2000.0s
* rpwtbr*       906.0          0.0e
****************************************
*     Finished Power Components        *
****************************************
*
*
*
end
*
****************
* Timestep Data *
****************
*       dtmin        dtmax         tend        rtwfp       powerc
       1.0E-6         0.05       1500.0         10.0          0.0
*       edint        gfint       dmpint       sedint
         10.0          0.5        100.0          1.0
*
*     endflag
         -1.0
```

NRC FORM 335
(9-2004)
NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER
(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)
NUREG/IA-0231

2. TITLE AND SUBTITLE
An Assessment of TRACE V4.160 Code Against PACTEL ATWS-10 – 13 and ATWS-20 – 21 Pressurizer Experiments

3. DATE REPORT PUBLISHED

MONTH	YEAR
June	2010

4. FIN OR GRANT NUMBER

5. AUTHOR(S)
Eveliina Takasuo

6. TYPE OF REPORT
Technical

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*
VTT - Processes
P.O.B. 1604
02044 VTT, Finland
Finland

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*
Division of Systems Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES
A. Calvo, NRC Project Manager

11. ABSTRACT *(200 words or less)*
In this report an assessment of TRACE V4.160 against six pressurizer separate effect tests, namely PACTEL ATWS-10 - 13 and ATWS-20 – 21, is presented. The tests were conducted at the PACTEL test facility as a part of the ATWS test series in 1998 and they consist of four insurge-outsurge transients and two spray transients. A pressurizer model which consists of a 30-node pressurizer component, a surge line, a spray line and a powered heat structure to simulate the pressurizer wall and heaters was used in the simulations. A brief description of the test facility is also given.

The insurge-outsurge test simulation results show a slightly exaggerated peak pressure which may be due to underestimated wall condensation in the insurge. In the simulations in which the effectiveness of spray was studied a relatively good agreement between the simulation results and the experimental results was found.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*
TRACE V4.160
Code Application Maintenance Program (CAMP)
VTT - Technical Research Centre of Finland
PACTEL (Parallel Channel Test Loop)
ATWS (Anticipated Transient Without Scram)-10 - 13
ATWS (Anticipated Transient Without Scram)-20 – 21
Lappeenranta University of Technology
Finland
VVER-440 PWR

13. AVAILABILITY STATEMENT
unlimited

14. SECURITY CLASSIFICATION
(This Page)
unclassified
(This Report)
unclassified

15. NUMBER OF PAGES

16. PRICE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS