

# **Ninth International Topical Meeting on Nuclear Reactor Thermal Hydraulics 1999 (NURETH-9)**

San Francisco, California, USA  
3-8 October 1999

Volume 1 of 5

ISBN: 978-1-7138-4829-5

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (1999) by American Nuclear Society  
All rights reserved.

Printed with permission by Curran Associates, Inc. (2022)

For permission requests, please contact American Nuclear Society  
at the address below.

American Nuclear Society  
555 North Kensington Avenue  
La Grange Park, Illinois 60526  
USA

Phone: (800) 323-3044  
(708) 352-6611  
Fax: (708) 352-0499

[www.ans.org](http://www.ans.org)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# 1999 NURETH-9 Conference Proceedings

October 3<sup>rd</sup> – 8<sup>th</sup>

San Francisco, California

## TABLE OF CONTENTS

### Plenary Lectures

- 1 JOHN J. TAYLOR, EPRI  
*“The Digital Revolution: Is Nuclear Power on the Bandwagon?”*
- 9 NOVAK ZUBER, FORMERLY WITH US NRC  
*“The Effects of Complexity, of Simplicity, and of Scaling in Thermal Hydraulics”*
- N/A TOSHIAKI ENOMOTO, TOKYO ELECTRIC POWER COMMISSION  
*“Vision of Japanese Utilities for Nuclear Industry in the 21<sup>st</sup> Century”*
- N/A ASHOK THADANI, USNRC  
*“Evaluation of the Safety Margins and the Role They Play in Burden Reduction and Enhanced Plant Safety”*

## Keynote Lectures

- 57 D. HELWIG (THERMAL HYDRAULICS PROBLEMS IN OPERATING REACTORS)  
*"Modernizing Thermal Hydraulic Methods: A Way to Enhance Nuclear Safety And Economics"*
- 63 B.R. SEHGAL (THERMAL HYDRAULICS OF SEVERE ACCIDENTS)  
*"Accomplishments And Challenges Of The Severe Accident Research"*
- 83 G. YADIGAROGLU (ADVANCED REACTOR THERMAL HYDRAULICS)  
*"Passive Core And Containment Cooling Systems: Characteristics And State Of The Art"*
- N/A J.M. DELHAYE (ADVANCES IN TWO-PHASE FLOW MODELLING)  
*"The Local Volumetric Interfacial Area Transport Equation: Derivation and Physical Significance"*
- 102 H. NINOKATA (COMPUTATIONAL FLUID DYNAMICS)  
*"Microscopic Approaches In Thermal Hydraulics Computations"*
- 123 M. CORRADINI, J. MURPHY, D. SCHMIDT, S.P. WANG  
(MULTI-DIMENSIONAL FLOW AND HEAT TRANSFER)  
*"Multi-Dimensional Modelling Of Multi-Phase Flow Physics: High-Speed Nozzle And Jet Flows - A Case Study"*

# NURETH-9 Conference Papers

## EXPERIMENTAL METHODS AND INSTRUMENTATION

### Session B.1

- 139 S. KIM, X. Y. FU, X. WANG AND M. ISHII  
*"Study On Interfacial Structures In Slug Flows Using A Miniaturized Four-Sensor Conductivity Probe"*
- 155 S. KIM, K. H. CHO, Y. J. LEE  
*"Impedance Imaging Of Two-Phase Flow Field with Mesh Grouping Algorithm"*
- 171 K. ITOH, Y. TSUJI, H. NAKAMURA , AND Y. KUKITA  
*"Optical Measurement Of Waves On High Speed Water Jet"*
- 187 Q. WU, K. WELTER, D. MCCREARY AND J. N. REYES  
*"Design Criteria Of Double-Sensor Conductivity Probe For The Measurement Of Bubble Velocity"*

### Session F.4

- 203 M. MAJED, G. NORBACK, T. NOREN  
*"Void Fraction Measurements in BWR Fuel Assemblies"*
- 212 F. GAVELLI, K. KIGER  
*"High-Resolution Boron Dilution Measurements Using Laser Induced Fluorescence (LIF)"*
- 229 T. J. LIU  
*"Reflux Condensation Behavior In A U-Tube Steam Generator With Or Without Noncondensables"*

- 244 A. V. GRIBOK, I. K. ATTIEEN, J. W. HINES, R. E. UHRIG  
*"Regularization Of Feedwater Flow Rate Evaluation For Venturi Meter Fouling Problem In Nuclear Power Plants"*

#### **Session H.4**

- 262 Y. MI, L. H. TSOUKALAS AND M. ISHII  
*"Investigation Of Vertical Slug Flow With Advanced Two-Phase Flow Instrumentation"*
- 286 A.K. KRÜSSENBERG, H.M. PRASSER, A. SCHAFFRATH  
*"A New Criterion For The Bubble Slug Transition In Vertical Tubes"*
- 302 T. TAKAMASA AND A. TOMIYAMA  
*"Three Dimensional Gas-Liquid Two-Phase Bubbly Flow In A C-Shaped Tube"*
- 319 M. TANAKA, J. KOBAYASHI, H. KAMIDE, K. SAITO, H. MONJI, J. SAKAKIBARA, G. MATSUI  
*"Visualization Of Flow Field In A Cubic Packing Of Spheres"*

#### **Session K.5**

- 334 A. ISKANDRANI AND G. KOJASOY  
*"Local Void Fraction And Velocity Field Description In Horizontal Bubbly Flow"*
- 353 D. R. NOVOG , K. HORI AND J. S. CHENG  
*"Void Distribution Measurement Of Swirl-Flow Boiling Freon By Real Time Neutron Radiography And High Speed X-Ray Computed Tomography"*
- 369 Z. LIU, M. F. ABDEL-HAFEZ, W.F. FU AND G. KOJASOY  
*"Experimental Investigation Of Internal Flow Structure Transition Through A Tee Junction"*

- 383 T.HIBIKI AND M. ISHII  
*"Effect Of Flow-Induced Vibration On Local Flow Parameters Of Bubbly Flow"*

## SUBCHANNEL THERMAL HYDRAULICS

### Session B.2

- 393 X. M. CHEN AND J. G. M. ANDERSEN  
*"Dynamics in BWR Fuel Bundles During Transients"*
- 406 H. NINOKATA AND V. KRIVENTSEV  
*"Calculation Of Detailed Velocity And Temperature Distributions in A Rod Bundle Of Nuclear Reactor"*
- 423 S.T. YIN, S.C. SUTRADHAR, R.M. TAIN  
*"An Experimental Investigation Of Enthalpy/Void Migration in An Interconnected Horizontal Twin-Subchannel Assembly"*
- 437 A. BELLIL, A. TEYSSEDOU, L. BONNET AND P. TYE  
*"Void Drift In Two Interconnected Subchannels"*

### Session C.2

- 455 H. SHIRAI AND H. NINOKATA  
*"Prediction Of The Equilibrium Two-Phase Flow Redistribution In A Rod Bundle And Void Drift"*
- 481 N. HOYER, M. STEPNIIEWSKI  
*"Dryout Prediction In Bundle Geometry"*
- 499 Y. AOUNALLAH AND P. CODDINGTON  
*"Assessment Of VIPRE-02 Void Fraction Prediction Against NUPEC Experimental BWR Data"*

515 J.W. PARK

*"A Theory Of Axial Void Propagation And Its Influence On CHF In Subchannels With Transverse Interchange"*

### **Session D.2**

524 A. BERGERON, D. CARUGE, P. CLEMENT, D. BARBIER

*"Assessment Of The 3D Thermal-Hydraulic Nuclear Core Computer Code FLICA-4 On Rod Bundle Experiments"*

545 V. LESTINEN, P. GANGO

*"Experimental And Numerical Studies Of The Flow Field Characteristics Of VVER-440 Fuel Assembly"*

572 S. KIM, B. J. CHUNG

*"A Scale Analysis Of The Turbulent Mixing Rate For Various Prandtl Number Flow Fields In Rod Bundles"*

589 G.A. SOROKIN, A.V. ZHUKOV, G.P. BOGOSLOVSKAYA, A.P. SOROKIN

*"Subchannel Analysis In Statistical Calculation Of LMR Core With Account Of Subassemblies Deformation And Other Factors"*

## **NATURAL CIRCULATION AND CONVECTION**

### **Session B.3**

604 M. RAMACCIOTTI, F. SUDREAU, C. JOURNEAU, G. COGNET

*"Viscosity Models For Corium Melts"*

625 G. COGNET , G. LAFFONT , C. JEGOU, C. JOURNEAU, F. SUDREAU, J. PIERRE, M. RAMACCIOTTI

*"First Findings On Corium Spreading From The VULCANO Experiments"*

640 M. HELLE, O. KYMÄLÄINEN AND H. TUOMISTO  
*"Experimental COPO II Data On Natural Convection In Homogenous And Stratified Pools"*

655 B. PIAR, G. GUILLARD, B.M. DELETIE, F. BABIK, J.C. LATCHE  
*"CROCO: A Computer Code For Corium Spreading"*

678 L.A.BOLSHOV AND P.S.KONDRATENKO  
*"Limiting characteristics Of heat transfer distribution And stratification in A heat-generating Fluid"*

### **Session C.3**

689 M.J. KONOVALIKHIN, T.N. DINH AND B.R. SEHGAL  
*"Experimental Simulation Of Core Melt Spreading In Two Dimensions"*

702 A. HORVAT, I. KLJENAK , J. MARN  
*"Dynamic Behavior Of The Melt Pool At Severe Accident Conditions"*

717 L.BERNAZ, J.M. BONNET, J.M. SEILER  
*"Investigation Of Natural Convection Heat Transfer To The Cooled Top Boundary Of A Heated Pool"*

737 L.A.BOLSHOV, P.S.KONDRATENKO AND V.F. STRIZHOV  
*"Peculiarities Of Heat Transfer From A Cooling Down Fluid Without Internal Heat Sources And Heat Transfer From A Heat-Generating Fluid"*

### Session D.3

- 750 E. MONIQUE  
*"Study On Heat Transfer In Lower Head Of Nuclear Power Plant Vessel During A Severe Accident, with MAAP Computer Code"*
- 774 S. TODA, M. SATOH, M. AKAMATSU, I. MAEKAWA, M. MAYUMI, H. MADARAME  
*"Study On Thermal Hydraulic Characteristics Of Natural Convection Inside A Long Container"*

## ADVANCED CODE DEVELOPMENT

### Session B.4

- 790 F. MOEHLE AND H. J. HALIN  
*"A Modular Concept For Code Generation And Simulation Of Complex Thermo-Hydraulic Systems"*
- 802 L.K.H. LEUNG, A. VASIC, K.F. RUDZINSKI, B. VERMA, AND D.C. GROENEVELD  
*"Thermalhydraulics Evaluation Package (TEP V3.0) – A User-Friendly Software Package for Evaluating Thermalhydraulics Parameters in Tubes and Bundles"*
- 825 F. DAVID  
*"Three Dimensional Thermal-Hydraulic Simulation In Steam Generators With THYC Exchangers Code Application To The UTSG Model 73/19"*
- 844 C. MOREL  
*"Validation Of The CATHARE Code Against PERICLES 2D Boil-Up Tests"*
- 861 G.T. ELICSON, R. E. HENRY, R. J. HAMMERSLEY, AND J. P. BURELBACH  
*"Dynamic Benchmarking Of TREMOLO - A Program For Pipeline Two-Phase Flow Transient Analysis"*

#### Session C.4

- 883 C. MOREL  
*"Validation Of The CATHARE Code Against PERICLES 2D Reflooding Tests"*
- 899 L.N. CARTECIANO, B. DORR, G. GROTZBACH  
*"Theoretical Interpretation Of The Single Phase Sump Cooling Experiments SUCOS With The FLUTAN Code"*
- 914 R. MACIAN, P. CEBULL, P. CODDINGTON AND M. PAULSEN  
*"Implementation Of A New Interfacial Mass And Energy Transfer Model In RETRAN-3D"*
- 936 M. NAITOH, T. IWASHITA, Y. ANDOH  
*"Boiling Transition Analysis Code For LWR Fuel Bundles In The IMPACT Project"*

#### Session D.4

- 953 D. BESTION  
*"Strategy For Improving Two-Phase 3-D Modeling For Nuclear Safety Applications"*
- 976 S. M. BAJOREK, A. GINSBERG, D. J. SHIMECK, K. OHKAWA, M. Y. YOUNG, L. E. HOCHREITER, P. GRIFFITH, Y. HASSAN, T. FERNANDEZ, D. SPEYER  
*"Small Break Loss Of Coolant Accident Phenomena Identification And Ranking Table (PIRT) For Westinghouse Pressurized Water Reactors"*
- 990 I. TOUMI, A. KUMBARO, H. PAILLÈRE, F. BARRE AND O. CUETO  
*"Numerical Methods And Physical Models For Two-Phase Flow Simulations In the TRIO-U Code"*

## FUSION AND ACCELERATOR THERMAL HYDRAULICS

### Session B.5

- 1010 J.-C. LIN, D. A. SIEBE, D. R. LILES, AND K. O. PASAMEHMETOGLU  
*"Design Basis Accident Analyses For Accelerator-Production-Of-Tritium Tungsten Neutron Source Primary Heat Removal System"*
- 1028 C.UNAL, W. R. BOHL, AND K. O. PASAMEHMETOGLU  
*"Reaction Of Tungsten In Steam Flow At High Temperatures"*
- 1045 T. SPATZ, D. SIEBE, K. PASAMEHMETOGLU AND M. SHERMAN  
*"Flow Distribution In The Accelerator-Production-Of-Tritium Target"*
- 1059 E.F. AVDEEV, S.L DOROKHOVICH, Y.A. KOROVIN, P.L. KIRILLOV  
*"Thermal Hydraulics Of A Lead Liquid Target For Accelerator-Driven System"*

### Session F.5

- 1069 S.M. GHIAASIAAN, S.I. ABDEL-KHALIK, S.M. JETER, AND M. YODA  
*"Gas-Liquid Two-Phase Flow Regimes in Microchannels"*
- 1092 S.M. GHIAASIAAN, S.I. ABDEL-KHALIK, S.M. JETER  
*"The Onset Of Flow Instability And Low-Flow Critical Heat Flux in Microchannels"*
- 1110 T. L. SPATZ AND D. A. SIEBE  
*"Hydraulic Testing Of The Accelerator-Production-Of-Tritium Rod Bundle"*
- 1132 P. MELONI, G. DELL'ORCO  
*"Assessment Of ATHENA Code Capability To Simulate Helium Cooled Systems For Fusion Reactors"*

- 1 144 S. PACI, T. PINNA, AND M. T. PORFIR  
*"Analysis Of The ICE Experimental Tests Using the ECART Code"*

## **THERMAL HYDRAULICS PROBLEMS IN OPERATING REACTORS**

### **Session C.1**

- 1 160 K.S. LIANG, K. L. HWANG , M. S. SHIH, C. J. CHANG , H. J. HUNG  
*"Development And Assessment Of A Reactor On-Line Coolant Leakage Evaluation Model"*

- 1 170 I.C. KIRSTEN, N.A.J. BUTT, S. BALZUS AND R. ZIMMERMANN  
*"Changing Fuel Vendor: A Utility (British Energy) And Fuel Vendor (Siemens) Perspective Of The Thermal-Hydraulic Implications"*

### **Session D.1**

- 1 187 A. CARUSO, A. MARTIN, L. LEAL DE SOUSA, S. BELLET, E. MARTINO, E. MIGNOT  
*"Numerical Study Of The Flow Into The Upper Plenum And The Hot Legs Of A 1300 MW PWR Assessment On Experimental Models"*

- 1 201 D. ALVAREZ, A. MARTIN, S. STELLETTA  
*"3D computations Of The Primary Coolant Flow In A 1300 MW PWR Vessel. Normal Operation Steady State And Free Boron Plugs Mixing Transient Simulations"*

- 1 211 Y. SUNG  
*"Westinghouse VIPRE-01 Applications For PWR Core Analyses"*

- 1 223 K. UMMINGER, W. KASTNER, J. LIEBERT AND T. MULL  
*"Thermal Hydraulics Of PWRs With Respect To Boron Dilution Phenomena - Experimental Results From The Test Facilities PKL And UPTF -"*

- 1241 T.J. LIU, C.Y. CHANG, C.H. LEE AND W.T. HONG  
*"Accident Management On PWR Total Loss-of-Feedwater At The IIST Facility"*

**TRANSIENT ANALYSIS AND SIMULATION FOR  
CONTAINMENT THERMAL HYDRAULICS**

**Session C.5**

- 1256 J. VIHAVAINEN, M. HÄNNINEN AND J. TUUNANEN  
*"Improved Thermal Stratification Modeling In The APROS Code Simulations Of Passive Safety Injection Experiments"*
- 1278 S.Z. KUHN, C.J. LEE, AND P.F. PETERSON  
*"Density Stratification From Buoyancy-Driven Exchange Flow Through Horizontal Partitions In A Liquid Tank"*
- 1293 X. CHENG , P. BAZIN, P. CORNET, D. HITTNER, J.D. JACKSON, J. LOPEZ JIMENEZ, A. NAVIGLIO, F. ORIOLO, H. PLANK  
*"Experimental Data Base For Containment Thermalhydraulic Analysis"*
- 1312 J. WOODCOCK, P.F. PETERSON, D.R. SPENCER  
*"Quantifying The Effects Of Break Source Flow Rates On AP600 Containment Stratification"*
- 1328 Y.M.KANG, G.C.PARK  
*"An Experimental Study On Evaporative Heat Transfer Coefficient And Applications For Passive Cooling Of AP600 Steel Containment"*

## Session D.5

- 1344 F. ORIOLO, S. PACI  
*"Evaluation Of Heat And Mass Transfer Models In LWRs Containment Systems"*
- 1366 T. BANDURSKI, M. HUGGENBERGER, J. DREIER, C. AUBERT, R.E.GAMBLE, G. YADIGAROGLU  
*"Influence Of The Distribution Of Noncondensibles On The Passive Containment Condenser Performance In PANDA"*
- 1382 A. SCHAFFRATH, A. ASZODI, E. KREPPER  
*"Numerical Simulation Of The Emergency Condenser Of The SWR1000"*
- 1401 R.E. GAMBLE AND P.F. PETERSON  
*"Pressure Suppression Pool Mixing in Passive Advanced Boiling Water Reactors"*

## INSTABILITY MECHANISMS AND NONLINEAR DYNAMICS

### Session F.2

- 1427 J. ZHOU AND M.Z. PODOWSKI  
*"Modeling And Analysis Of Hydrodynamic Instabilities In Two-Phase Flow Using Two-Fluid Model"*
- 1445 H. MOCHIZUKI  
*"Flow Pattern Induced Oscillation under Natural Circulation in Boiling Channels with Long Outlet Pipes"*
- 1455 M. FURUYA, A. MANERA, D.D.B. VAN BRAGT, T.H.J.J. VAN DER HAGEN, W.J.M. DE KRUIJF  
*"Effect Of Liquid Density Differences On Two-Phase Flow Instability"*

- 1463 H. O. KANG, H. Y. KIM, J. H. YOON, J. P. KIM, D. J. LEE  
*"Development Of Simple Analytical Model For Helical Once-Through Steam Generator Instability"*

### **Session G.2**

- 1483 P. HÄNGGI , T. SMED AND P. LANSÅKER  
*"MATSTAB, A Fast Frequency Domain Based Code To Predict Boiling Water Reactor Stability Using A Detailed Three Dimensional Model"*
- 1505 R. ZBORAY, D.D.B. VAN BRAGT, R. UDDIN, T.H.J.J. VAN DER HAGEN  
*"Influence Of Asymmetrical Axial Power Distributions On Nonlinear BWR Dynamics"*
- 1518 V. CHUDANOV  
*"A New Approach To CFD Problems In Complex Geometries"*
- 1532 G.T. ANALYTIS, D. HENNIG, J.K.H. KARLSSON  
*"The Physical Mechanism Of Core-Wide And Local Instabilities At The Forsmark-1 BWR"*

### **Session H.2**

- 1551 R. ZBORAY, A. MANERA, W.J.M. DE KRUIJF, T.H.J.J. VAN DER HAGEN,  
D.D.B. VAN BRAGT  
*"Experiments On Nonlinear Density-Wave Oscillations In The DESIRE Facility"*
- 1563 C. K. SUNG, C. S. LEE  
*"A Study On The Two Instability Criteria For The Stratified Flow In A Horizontal Pipe At Cocurrent Flow Conditions"*

1575 D. GINESTAR, G. VERDÚ, J. MARCH-LEUBA  
*"Thermohydraulic Oscillations And Numerical Integration"*

1590 W. YAO , J. J. XU  
*"Thermal-Siphon Instability Mechanisms In A Two-Phase Natural Circulation System"*

## NUCLEAR POWER PLANT THERMAL HYDRAULICS

### Session F.3

1601 M. GAVRILAS, B. WOODS, M. ANTKOWIAK, V. PALAZOV, G. PERTMER, M. SALAY  
*"Rapid Boron-Dilution Transient Investigation In A PWR Integral Test Facility"*

1625 D. W. KIM, J. HUH  
*"Thermal Mixing Analysis In Reactor Vessel Downcomer For The Various DVI Nozzle Locations"*

1637 K. TAKEUCHI, M. E. NISSLEY, AND J. S. SPAARGAREN  
*"Modeling Of Upper Plenum Injection For The Best Estimate LOCA Analyses"*

1651 F. E. DUNN  
*"Comparisons Of Steady-State And Transient Thermal Hydraulic Results From SAS-DIF3DK And RELAP5 MOD3.2 For An RBMK Reactor"*

### Session G.3

1664 C. SARRETTE, J. KOUHIA, H. PURHONEN, D. BESTION  
*"Noncondensable Gas Release And Dissolution: Analytical Experiment And Calculation With CATHARE2 V1.3L"*

1683 J. F. PIGNATEL, Y. ALBERT  
*"Simulation Of The PANDA Isolation Condenser Using CATHARE Code"*

1697 G. CHEN AND S. ANGHAIE  
*"A Computational Fluid Dynamic Analysis Of Reflux Condensation"*

1712 H. Y. CHEN, Y. Z. CHEN, Z. Y. ZHANG  
*"Investigation Of Reflux Condensation In Single Inverted U-Tubes"*

### **Session H.3**

1730 Z. STOSIC  
*"On The Role Of Spacer Grids On Conditions Of Dryout/Rewetting And Local Thermal Hydraulics In Boiling Water Channels"*

1760 R. C. BORGES, A. N. GEBRIM  
*"Simulation Of ANGRA 1 Main Control And Protection Systems With RELAP5/MOD3.2 - Comparison To The Programmed And Measured Results"*

1777 G. E. WILSON, C. B. DAVIS  
*"Best Estimate Versus Conservative Model Calculations Of Peak CLAD Temperature: An Example Based On The LOFT Facility"*

N/A N. S. GRACHEV, P. L. KIRILLOV, P. N. MARTYNOV  
*"Steam Generators With Direct Contact Between Liquid Metal And Water"*

### **Session J.3**

1790 Q. WU, K. WELTER, D. MCCREARY AND J. N. REYES  
*"Design Of Experimental Investigation For Phase Separation In Vertical-Up Branch Of Reactor Hot-Leg"*

1809 H. Y. JEONG AND K. H. LEE, C. H. BAN AND S. J. LEE  
*"Evaluation Of Direct Vessel Injection During A Loss Of Coolant Accident With RELAP5/MOD3.1K"*

1821 J. W. KIM, D. S. LEE, J. H. KIM  
*"A Hydraulic Model Study Of Intake Structure"*

## **THERMAL HYDRAULICS OF SEVERE ACCIDENTS**

### **Session G.1**

1837 E. DÉCOSSIN  
*"Numerical Investigations On Particulate Debris Bed Coolability: Critical Analysis Of The Silfide Experimental Project"*

1852 A. ZEISBERGER, P. HORNER, F. MAYINGER  
*"Boiling In Particle Beds With Internal Heat Sources"*

### **Session H.1**

1866 P.P. MALGOUYRES, M.P. FERROUD-PLATTET, G. DUCROS, C. POLETIKO, M. TOURASSE, D. BOULAUD  
*"Influence Of Mox Fuel In Fission Product Release Up To Meltdown Conditions"*

1871 N. DODA, H. NINOKATA  
*"Prediction Of Release Rate Of Burnt Sodium As Aerosol"*

1890 H. SHIBAZAKI, Y. MARUYAMA, A. MAEDA, Y. HARADA, A. HIDAKA AND J. SUGIMOTO  
*"Revaporization Of CsI Aerosol in Horizontal Straight Pipe In Severe Accident Condition"*

1903 K.FROMENT, J.M. SEILER  
*"On The Importance Of A Strong Coupling Between Physicochemistry And Thermalhydraulics For Modelling Late Phases Of Severe Accidents In LWRs"*

### Session J.2

1925 N. I. KOLEV  
*"Ex-Vessel Melt-Water Interaction Caused By Symmetric Lower Head Unzipping Within The Reactor Pit"*

1934 H.O. HARALDSSON, T.N. DINH AND B.R. SEHGAL  
*"Breakup Of High Temperature Oxide Jet In Water"*

N/A D. MAGALLON AND I. HUHTINIEMI  
*"Corium Melt Quenching Tests At Low Pressure And Subcooled Water In FARO"*

1945 I. HUHTINIEMI AND D. MAGALLON  
*"Insight To Steam Explosions With Corium Melts In KROTOS"*

### Session K.2

1959 A. ANNUNZIATO, C. ADDABBO, P. PLA  
*"COMETA Code Analysis Of Fuel Coolant Interaction Premixing Phenomena In A Reactor Geometry"*

1977 S. SOHAL AND L. J. SIEFKEN  
*"A Model For Molten Fuel-Coolant Interaction During Melt Slumping In A Nuclear Reactor"*

2007 N. I. KOLEV  
*"Verification Of IVA5 Computer Code For Melt-Water Interaction Analysis"*

2051 N. I. KOLEV  
*"In-Vessel Melt-Water Interaction Caused By The Failure Of The Crust Above The Core Support Plate Under Molten Pool"*

### **Session L.2**

N/A A.V.BERDYSHEV, A.V.BOLDYREV, A.V.PALAGIN, V.E.SHESTAK,  
M.S.VESHCHUNOV  
*"SVECHA/QUENCH Code For The Modeling Of Reflooding Phenomena In Severe Accidents Conditions"*

2078 P. HORNER, A. ZEISBERGER, F. MAYINGER  
*"Boiling And Flow Regimes In A Gap With Adjustable Inclination And Heating From The Top"*

2092 A. DAVIDY, E. ELIAS, S. OLEK  
*"Quenching Of Hot Oxidizing Surfaces"*

2105 P. HOFMANN, W. LEILING, A. MIASSOEDOV, D. PIEL, L. SCHMIDT, L.  
SEPOLD, M. STEINBRUCK  
*"Reflooding Experiments With LWR-Type Fuel Rod Simulators In The QUENCH Facility"*

### **Session N.2**

2128 F. BOULANGER, C. BASSI  
*"Validation Of The VULCAIN Thermo-Hydraulic Code For PWR Severe Accidents"*

2149 K.FROMENT, F. VALIN, J.M. SEILER  
*"Model Development For The Calculation Of Corium-Ceramic Interaction During Severe Accidents In LWRs"*

2167 Y. MARUYAMA, K. MORIYAMA, H. S. PARK, Y. YANG AND J. SUGIMOTO  
*"Analysis Of Debris Coolability Experiments in ALPHA Program With CAMP Code"*

2184 R. M. BILBAO DE LEON AND M. CORRADINI  
*"Solid Particle Effects On Heat Transfer In A Molten Pool With Gas Injection"*

### **Session O.2**

2200 B.R. SEHGAL, R.R. NOURGALIEV, AND DINH T.N.  
*"Characterization Of Heat Transfer Processes In A Melt Pool Convection And Vessel-Creep Experiment"*

2218 K. I. AHN, D. H. KIM, S. B. KIM, H. D. KIM  
*"A Comparative Study On The Reactor Lower Head Models Employed In The Current Severe Accident Codes"*

2233 C. JOURNEAU , J. M. GATT, G. D. PALMA  
*"Transient Effects In Corium Temperature Measurements"*

2250 G. ALBRECHT, F. HUBER, W. SCHÜTZ  
*"KAJET-Experiments On Pressurized Melt Jets With View To Their Interaction With Substratum Materials"*

## **COUPLING BETWEEN REACTOR THERMAL HYDRAULICS AND NEUTRONICS**

### **Session G.4**

2262 Y.N. KUZNETSOV, ET AL.  
*"New Self-Regulation Effects In Homogeneous Reactor With Circulating Metal Fuel"*

- 2272 V.ZIMIN, H. ASAKA, Y. ANODA AND M. ENOMOTO  
*"Verification Of The J-TRAC Code With 3D Neutron Kinetics Model SKETCH-N For PWR Rod Ejection Analysis"*
- 2288 A. HOTTA, H. NINOKATA  
*"Development Of Three Dimensional Kinetic Code ENTREE Coupled With TRAC-BF1"*
- 2303 P. RASCLE, C. DUVAL  
*"Thermal-Hydraulic Neutronic Coupling For PWR Steam Line Break Accident Studies"*
- 2317 D. A. BARBER, R. M. MILLER, T. J. DOWNAR, W. D. WANG, D. D. EBERT AND V. A. MOUSSEAU  
*"Application Of A Generalized Interface Module To The Coupling Of Spatial Kinetics And Thermal-Hydraulics Codes"*

## **BOILING AND CONDENSATION HEAT TRANSFER**

### **Session G.5**

- 2333 J. L. MUÑOZ-COBO, L. E. HERRANZ, M. J. PALOMO  
*"Predictive Modeling Of Steam Condensation Onto Finned Tubes In Presence Of Noncondensable Gases For Containment Heat Exchangers Of Passive Safety Reactors"*
- 2354 G.T. ANALYTIS, V. FALUOMI  
*"The Effect Of Three Different Condensation Models In The Presence Of Non-Condensibles On The Analysis Of Two PANDA Transient Tests With RELAP5/MOD3.2"*
- 2375 A. SCHAFFRATH, M.FESSEL, A. FJODOROW, W.LISCHKE  
*"Modeling Of Condensation In Horizontal Tubes"*

2399 M. LOTZ

*"The Heat Transfer Coefficient On A Wall In Presence Of A Noncondensable Gas In The Framework Of French PWR Containment Calculations"*

2407 Y.H. LEE, W.P. BAEK, S.H. CHANG

*"Development Of A Correction Method For The Heated Length Effect On Critical Heat Flux"*

### **Session H.5**

2421 H. Y. KIM, Y. Y. BAE, K. B. LEE, S. M. CHOI

*"Characteristics Of Stable Steam Condensation In A Sub-cooled Water Pool"*

2443 T. CHATAING, P. CLEMENT, J. EXCOFFON, G. GEFFRAYE

*"A General Correlation For Steam Condensation In Case Of Wavy Laminar Flow Along Vertical Tubes"*

2464 Z.L. YANG, T.N. DINH, R.R. NOURGALIEV, B.R. SEHGAL

*"Numerical Investigation Of Boiling Regime Transition Mechanism By A Lattice-Boltzmann Model"*

2478 A. SAKURAI, M. SHIOTSU, K. HATA, K. FUKUDA

*"The Transition Process From Natural Convection Or Nucleate Boiling To Film Boiling Caused By Rapid Pressure Reduction"*

### **Session J.4**

2502 F. B. CHEUNG AND Y. C. LIU

*"Effects Of Thermal Insulation On External Cooling Of Reactor Vessels Under Severe Accident Conditions"*

2518 M. D. BARTEL, M. ISHII, Y. MI, S. REVANKAR, T. MASUKAWA, K. SATO, M. MORI

*"Experimental Investigation Of Subcooled Boiling Under BWR Flow Conditions"*

2536 P. CODDINGTON, Y. AOUNALLAH, D. MAIER, AND D. REEDHA

*"Assessment Of The Subcooled Boiling Models In RETRAN-3D, VIPRE-02 And TRAC-BF1 Against Rod Bundle And Subchannel Data"*

2563 J. Y. TU

*"Improvement Of A Two-Fluid Model For Predicting Subcooled Flow Boiling At Low Pressure"*

### **Session K.3**

N/A D. C. GROENEVELD, N. AKSAN, A. BADULESCU, F. D'AURIA, X. CHENG, J. CLEVELAND, P. L. KIRILLOV, L. K. H. LEUNG AND J. MACEK

*"A General Method Of Predicting Critical Heat Flux (CHF) In Advanced Water-Cooled Reactors (AWCRs)"*

2576 K. FUKUDA, K. HATA, M. SHIOTSU, A. SAKURAI

*"The Mechanisms Of Flow Boiling Critical Heat Fluxes On A Vertical Cylinder And A Short Tube With Upward Flowing Highly Subcooled Water"*

2612 S. DOERFFER AND D.C. GROENEVELD

*"Fluid-To-Fluid Modelling Of Critical Heat-Flux Enhancement In A Tube"*

2631 D. H. HWANG, J. T. KWON

*"A Phenomenological Approach To Predicting CHF For Non-Uniform Axial Heat Flux Distribution"*

### Session L.3

- N/A D.C. GROENEVELD, L.K.H. LEUNG, J. ZHANG, S.C. CHENG AND A. VASIC  
*"Effect Of Appendages On Film-Boiling Heat Transfer In Tubes"*
- 2644 Y. M. KWON, S. D. SUK, S. H. CHANG  
*"Prediction Of Critical Heat Flux In Highly Subcooled Convective Boiling"*
- 2662 R.W.L. FONG, G.A. MCRAE, T. NITHEANANDAN, D.B. SANDERSON, AND  
C.E. COLEMAN  
*"Correlation Between The Critical Heat Flux And The Fractal Surface Roughness Of  
Zirconium Alloy Tubes"*
- 2674 K. HATA, K. FUKUDA, M. SHIOTSU, A. SAKURAI  
*"The Effect Of Diameter On Critical Heat Flux In Vertical Heated Short Tubes Of  
Various Inside Diameters Cooled With An Upward Flow Of Subcooled Water"*
- 2694 I.L. PIORO, S.C. CHENG, D.C. GROENEVELD, S. DOERFFER, A. VASIC AND I.  
SALAH  
*"Experimental Study Of The Effect Of Flow Obstructions In A Circular Tube On The  
Critical Heat Flux"*

### Session N.3

- 2714 P. DUMAZ, B. DUC  
*"The DIVA Program: Some Experimental Results And First Cathare Calculations"*
- 2726 Y. BUYEVICH  
*"Cyclic Boiling In Inverted Geometries"*

- 2745 A.P. SOROKIN, E.F. IVANOV, G.P. BOGOSLOVSKAYA, D.E. MARTSINOUK,  
K.S. RYMKEVICH, V.L. MALKOV  
*"Experimental And Numerical Investigations Of Liquid Metal Pin Bundle Boiling  
Under Natural Circulation Conditions"*

## ADVANCED REACTOR THERMAL HYDRAULICS

### Session J.1

- 2759 T.H.J.J. VAN DER HAGEN AND A. MANERA  
*"The Influence Of Carry Under On Natural-Circulation BWR Statics And Dynamics"*
- 2777 H. RINGEL, J. KNORR, A. SCHAFFRATH  
*"Investigation Of The Operation Mode Of Passive Pressure Pulse Transmitter"*

### Session K.4

- 2791 Y. SUZUKI, T. OKAWA AND M. ARITOMI  
*"Numerical Simulation Of Rising Bubbles Using A Euler-Lagrange Method"*
- 2801 J. H. SONG, K. H. BAE  
*"Evaluation Of Analytically Scaled Models Of A Pressurized Water Reactor Using The  
RELAP5/MOD3 computer code"*
- 2815 A.Y. LAFI AND J.N. REYES, JR.  
*"Two-Inch Cold Leg Break Tests In APEX And ROSA/AP600 -Comparative Study-"*
- 2828 T. TAKEMOTO, M. ARITOMI, M. MATSUZAKI, K. USUI, Y. YOSHIOKA  
*"Experimental Study On The Driving Mechanism Of Geysering (The Coalescence  
Mechanism Of Slug Bubbles)"*

## ADVANCES IN TWO PHASE FLOW/MODELING

### Session K.1

2840 E. HERVIEU, N. COUTRIS & C. BOICHION

*"Oscillations Of A Drop In Aerodynamic Levitation"*

2853 J. N. REYES, JR., C. RUSHER

*"An Analytical Model For Pressure Vessel Blowdowns Of Saturated Fluid Mixtures"*

### Session N.4

2881 K. D. KIM, W. P. CHANG, S. D. SUK, H. G. LIM AND U. C. LEE

*"Application Of New Hyperbolic Equations For Two-Phase Flows"*

2890 B. CHEXAL, J. HARRISON, C. PETERSON, D. HUGHES

*"A General Two Phase Pressure Gradient Model For Two Fluid And Mixture Momentum Equations"*

2923 NOURGALIEV, R.R., DINH, T.N., AND SEHGAL, B.R.

*"Free-Energy-Based Lattice Boltzmann Model Of Phase Transitions In An Isothermal Non-Ideal Fluid"*

2957 D. JAMET, O. LEBAIGUE, N. COUTRIS, J.M. DELHAYE

*"The Second Gradient Theory: A Tool For The Direct Numerical Simulation Of Liquid-Vapor Flows With Phase-Change"*

### Session O.4

2975 U. WINDECKER AND C. Y. GU, J. DENNHARDT

*"Droplet Deposition In The Annular Flow Regime With And Without The Influence Of A Spacer"*

- 2995 G. WINDECKER AND H. ANGLART  
*"Phase Distribution In BWR Fuel Assembly And Evaluation Of Multidimensional Multi-Field Model"*
- 3019 C. ELLIS, Q. WU, D. MCCREARY AND J. N. REYES  
*"Assessment Of Level Swell Measurements And Models In An Air/Water System"*
- 3029 M. H. CHUN , I.C. CHU, AND S. O. YU  
*"Interfacial Condensation Heat Transfer For Countercurrent Steam-Water Stratified Flow In A Circular Pipe"*

## COMPUTATIONAL FLUID DYNAMICS

### Session N.1

- 3048 G.T. ANALYTIS, M. ANDREANI  
*"A Simplified Treatment Of The Boundary Conditions Of The k-e Model In CFD-Type Codes Like GOTHIC"*
- 3070 K. EL AMINE, S. CLERC  
*"An Upwind Numerical Method For Thermal-Hydraulics Simulation"*

### Session P.2

- 3086 E. FAUCHER, J. M. HÉRARD, M. BARRET, C. TOULEMONDE  
*"Comparing Three Schemes Devoted To The Computation Of Flashing Flows"*
- 3104 M. NISHIMURA, A. TOKUHIRO, N. KIMURA AND H. KAMIDE  
*"Computational Study On Quasi-planar Jets Mixing With Low Reynolds Number Turbulent Stress And Flux Equation Models"*
- 3124 S. KOKH, G. ALLAIRE, S. CLERC  
*"Towards Boiling Crisis Simulation : The Level Set Method"*

3139 P. RAUTAHEIMO, E. SALMINEN AND T. SIIKONEN, J. HYVÄRINEN  
*"Turbulent Mixing Between VVER-440 Fuel Bundle Subchannels: A CFD Study"*

3163 H. TINOCO  
*"Three-Dimensional Modeling Of A Steam Line Break In A BWR"*

## **MULTI-DIMENSIONAL FLOW AND HEAT TRANSFER**

### **Session O.1**

3179 C. CAROLI, P. CORNET, J. C. COCHE, J. P. MAGNAUD  
*"A Multi-Dimensional Two-Fluid Model For The Sprays In The Reactor Containment"*

3197 Y. MATSUKUMA, Y. ABE AND H. ADACHI  
*"Lattice Gas Automata Simulations Of Flow Through Porous Media"*

### **Session P.1**

3212 R. T. LAHEY, JR. AND D. DREW  
*"The Analysis Of Two-Phase Flow And Heat Transfer Using A Multidimensional, Four Field, Two-Fluid Model"*

3239 S. EBARA, S. TODA AND H. HASHIZUME  
*"Application Of Porous Matrix To High Heat Load Removal System"*

3250 D. SCORZIELLO, A.M.C. CHAN, M. SHOUKRI  
*"Vapour Film Thickness In Surface Quenching Inside Horizontal Tubes"*

### Session Q.1

- 3266 M. KAWAJI, E. STAMATIOU AND P. CHUNG.  
*"Turbulence Modification Due To Wave Action At Low Reynolds Numbers In Horizontal Open-Channel Flow"*
- 3287 H. ANGLART AND M. Z. PODOWSKI  
*"Fluid Mechanics Of Taylor Bubbles And Slug Flows In Vertical Channels"*
- 3301 J. O. VILLAFUERTE, Y. A. HASSAN, W. D. SCHMIDL  
*"Three-Dimensional Bubbly Flow Measurements Using Stereoscopic Particle Image Velocimetry"*

## THERMAL HYDRAULICS OF VVER & RBMK REACTORS

### Session O.3

- 3325 E. ZVINYS AND K. ALMENAS  
*"Verification Of Two-Phase Pressure Drop Correlations For RBMK-Type Reactor Conditions"*
- 3340 J. B. KING JR  
*"Critical Heat Flux In Horizontal Tube Bundles: A Possible Paradigm For Complexity"*
- 3352 L. VANHOENACKER, C. LEVÊQUE, W. VAN HOVE, H.P. GAUL , D. GALLORI, G. EZSOL, I. TOTH, L. SZABADOS  
*"The Phare SRR3/95 Project"*
- 3370 A. KALIATKA  
*"Thermal-Hydraulic Evaluation Of Additional Shutdown System At The Ignalina Nuclear Power Plant"*

3385 G. SDOUZ, G. SONNECK  
*"VVER-1000 Reactors: Source Terms Versus Containment Spray"*

### Session P.3

3394 S. KLIEM, T. HÖHNE  
*"Main Steam Line Break Analysis Of A VVER-440 Reactor Using The Coupled Thermohydraulic System/3D-Neutron Kinetic Code DYN3D/Athlet In Combination With The CFD Code CFX-4"*

3410 J. B. KING JR.  
*"A Critical Review Of Hydrodynamic Models For Vertical, Two-Phase Crossflow Through Horizontal Tube Bundles"*

3430 P. A. ROTH  
*"Assessment Of RELAP5/MOD3.2 For Simulating An SBLOCA In A VVER-1000 Reactor"*

3461 A. KALIATKA, G. KRIVOSHEIN, E. USPURAS  
*"Benchmark Analysis Of One Main Circulation Pump Trip Event At IGNALINA NPP Using The RELAP5 Code"*

3471 BRUS N.A., IOUSSOUPOV O.E., BLINKOV V.N. , VINOGRADOV V.A.  
*"Computer Codes RELAP5 And ATHLET Validation For Transient Analysis Of RBMK Reactors"*

### Session Q.3

3491 E. KREPPER  
*"Natural Circulation Experiments At The ISB-VVER Integral Test Facility And Calculations Using The Thermalhydraulic Code Athlet"*

- 3502 A. GUBA, L. PERNECKY AND I. TOTH  
*"Analysis Of Total Loss Of AC Power To The PAKS NPP In Support Of EOP Development"*
- 3515 B. CESNA, S. RIMKEVICIUS  
*"Influence Of Condensing Pools Modelling To Thermal Hydraulic Response Of Ignalina NPP Accident Localization System In The Case Of Loss Of Coolant Accidents"*
- 3533 E. USPURAS, A. KALIATKA  
*"Thermal-Hydraulic Analysis Of Potential Waterhammer At The IGNALINA Nuclear Power Plant"*
- 3548 V.N.BLINKOV, O.I.MELIKHOV, V.I.MELIKHOV, M.V.DAVYDOV,  
E.YU.CHTCHEPETILNIKOV, A.V.SOCOLIN  
*"VVER-440/V213 LOCA modeling At EREC test Facility. Analysis with ATHLET code"*

## COMPUTATIONAL AND MATHEMATICAL MODELLING

### Session P.4

- 3568 J. CHRISTENSEN, C. J. LEE, J. KUHN, AND P. F. PETERSON  
*"A One-Dimensional Lagrangian Model For Large-Volume Mixing And Containment Response"*
- 3605 J. M. GHIDAGLIA, G. L. COQ, I. TOUMI  
*"A Finite Volume Approach Based On Flux-Schemes For Computing Two-Phases Flows"*

3621 Y. MI, L. H. TSOUKALAS AND M. ISHII  
*"Flow Regime Identification Methodology With Neural Networks And Two-Phase Flow Models"*

3641 B. L. WESCOTT AND R. UDDIN  
*"An Efficient Formulation Of The Modified Nodal Integral Method And Application To 2-D Burgers' Equation"*

3660 I. TISELJ, S. PETELIN  
*"Integration Of The Source Terms In The Two-Fluid Models"*

#### **Session Q.4**

3669 P. FILLION, D. CARUGE, S. CLERC  
*"FLICA-4 :An Advanced Code For Two-Phase Flow Parallel Computing"*

3682 K. LAM, R. YU  
*"A Multi-Nodal Thermal-Hydraulic Model For U-Tube Steam Generator"*

3707 F. D'AURIA, M. FROGHERI, G.M. GALASSI  
*"Application Of Cathare Code To The Analysis Of Pactel Experiments Relevant To Innovative Reactors"*

3727 A. MADEIRA, W. GIANNOTTI, F. S. D'AURIA  
*"Sample Use Of CIAU For A Two Loop Pressurized Water Reactor"*

3741 H. TINOCO  
*"Analytical Solution Of Pressure Waves In A Bubbly Mixture"*

**THERMAL ASPECTS OF MATERIALS COMPATIBILITY:  
INTEGRITY OF FUEL RODS AND STRUCTURES**

**Session Q.2**

- 3755 F. FORREST, L. D. MACDONALD, A. SHALABI  
*"Ballooning Experiments For CANDU Pressure Tubes"*
- 3771 F. KASAHARA AND H. NINOKATA  
*"Development Of Multi-Fluid Multi-Phase Subchannel Analysis Code KAMUI For Analyzing Accident Conditions In A Subassembly Of LMFR"*
- 3796 Z. HOZER, L. MAROTI, P. WINDBERG  
*"Quenching Of High Temperature VVER Bundle"*
- 3806 SI Y. LEE AND R. L. SINDELAR  
*"Thermal Performance Analysis Of Repository Codisposal Waste Packages Containing Aluminum-Clad Spent Nuclear Fuel"*

## Additional Papers

- 3825 V.N. MINEEV, A.V. MINEEV, T.A. DMITRIEVA  
*"Using of Structural Failure Criteria May Lead to Error of Strength for the AP600 Assessment"*
- 3828 G.N. POLETAEV  
*"Heat Transfer from Curvilinear Boundaries of Heat Generating Pools"*
- 3841 K. ITOH, H. KOBAYASHI, A. SHIKICHI, M. MAYUMI, H. MADARAME  
*"Thermal-Hydraulic Tests and Analysis on the FBR Ductless Fuel Assembly"*
- 3867 T. ITO, H. TAKEUCHI, Y. TSUJI, Y. KUKITA  
*"Fluid Inertia Effects on Core Cooling during Pump Trip Event"*
- 3882 E. ROYER, D. GALLO, D. CARUGE, E. RAIMOND, S. VILLALONGA  
*"PWR Main Steam Line Break Benchmark Using the Cathare2-Cronos2-Flica4 Coupled Codes"*
- 3897 G. CERNE, S. PETELIN  
*"Simulation of the Kelvin-Helmholtz Instability with the Volume of Fluid Method"*
- 3911 D.G. PENN, M. LOPEZ DE BERTODANO, P. LYKLOUDIS  
*"Dry Patch Stability in Adiabatic Annular Flow"*
- 3933 A.Y. LAFI, J.N. REYES  
*"Comparative Study of Station Blackout Counterpart Tests in APEX and ROSA/AP600"*
- 3947 S.E. COLPO, J.N. REYES  
*"Counter Current Flow Limitation as Observed in the Apex Test Facility"*

- 3960 M.F. STROHECKER, T.S. PALMER, J.N. REYES  
*"CFD Simulation of the IRWST Flow Patterns During a Simulated Station Blackout Experiment on the OSU APEX Facility"*
- 3976 D.M. WACHES, J.N. REYES, L. DAVIS  
*"Cold Leg Thermal Stratification in the OSU APEX Test Facility"*
- 3991 J.H. SONG, M. ISHII  
*"On the Stability of a One-Dimensional Two-Fluid Model"*