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SRESA Newsletter

December 2011 / Issue No.5

Quarterly publication from Society of Reliability and Safety [Reg. No. 3141/2010/G.B.B.S.D.]

New

International Workshop On 'New Horizons in Nuclear Reactor Thermal Hydraulics and Safety', January 2-3, 2012, SRI, Kalpakkan

From the President's Desk

The Society for Reliability and Safety (SRESA) is an umbrella organization which provides forum for exchange of information on recent developmental work in the area of reliability and safety and platform for discussion of new ideas. The news letter fulfills the objective of sharing the ideas and experiences of the members of the different organizations. Four issues have already been issued. This is the fifth issue of newsletter of the society, which concentrate on issues related to assuring safety, be it at corporate level or through advancements in software tools for assessment. There are two articles featured in the newsletter. The first article provides the steps taken and the approach adopted by Nuclear Power Corporation of India for ensuring safety in Indian NPPs. The second article is on the advanced software tools for carrying out deterministic and probabilistic safety analyses for ensuring the safety of the nuclear plants.

I am delighted to inform that SRESA is playing a significant role in organizing an international workshop on 'New Horizons in Nuclear Reactor Thermal Hydraulics and Safety' in co-operation with AERB and BRNS. A brief note on the topics covered in this conference is also included in this newsletter.

Dr. S. K. Gupta

Inside this issue:

Ensuring Safety in Indian NPPs

Umesh Chandra
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1. Introduction

For Indian NPPs, comprehensive and systematic safety assessments are carried out with in NPCIL by multidisciplinary review processes during all phases of design, construction, commissioning and operation of Nuclear Power Plants. The Directorate of Safety is the nodal agency at NPCIL headquarters, assigned to ensure safety of Indian NPPs during all states of plant construction and operation.

A systematic approach using well defined principles of defense in depth, diversity and redundancy is followed in the design of NPP to provide the required safety features. NPPs are constructed in accordance with the design intent and with required quality of workmanship to ensure highest quality of standards. Commissioning processes and procedures, which test and demonstrate adequacy of each plant system, carry out actual performance tests to check that systems meet the design intent before commencing operation of the power plants.

Comprehensive safety assessments are carried out for all systems and processes in the plant for various postulated states through normal operational modes of plant, during anticipated operational occurrences, during design basis accidents and during combination of events leading to beyond Design Basis scenarios. The assessments are by rigorous deterministic analysis and by complementary probabilistic methods to identify and evaluate all possible failures which could become sources of radiation exposure for workers and the public.

Verification of design by analysis as well as by surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

At the Apex level, two separate corporate level Safety Review Committees (SRCs) are established for review of these assessments. NPC SRC (Project & Design) reviews the design details of the projects including the results of safety analysis and verification of safety. NPC SRC (Operating Plants) reviews all issues for operating plants including proposals from the plant management for system modification and upgradation. Every event in an operating NPP is reviewed. Analysis of events is done to establish their root cause, and accordingly, the systems, procedures, and aspects related to training and safety culture are also improved. The assessments are documented and lessons are learnt. Internationally reported events and their applicability to Indian NPPs are checked. After clearance by the respective SRC, the results of reviews are submitted to regulators for safety clearance.

2. Safety Review Mechanism of Operating Plants

In Indian NPPs a three tier review process is adopted to ensure that all safety aspects of Nuclear Power Plants are thoroughly reviewed for all aspects during design and operation.

2.1 First Tier : Plant Level

This review is started at station level by the Station Operation Review Committee (SORC) headed by Station Director/Chief Superintendent and having senior plant officials of various disciplines as members. SORC reviews the station operation at regular intervals to detect potential safety issues at plant and recommends corrective actions. After incorporating the SORC recommendations the proposal is out up for second tier review.

2.2 Second Tier : Corporate Level

The corporate level review committee, NPC-SRC (O), consists of experts from various disciplines. SRC undertakes interdisciplinary review of all safety, proposals (inclusive of SORC recommendations) and submissions from NPCIL operating stations. At this level of review, it is ensured that the proposals are confirming to NPCIL safety policy, regulatory requirements, codes and guides and legislation of central and state government as applicable. The Committee also ensures that the safety proposals are comprehensive and implementable.

2.3 Third Tier : Regulatory Body

The safety proposal after review in first and second tier is submitted for third tier review which is undertaken by the regulators. At this tier also, there are further three levels of reviews. This is done by Committees consisting of officials of regulatory body and experts in various related aspects of nuclear technology and the case is submitted by representatives from NPPs under review.

- The first level of safety review is carried out by the Unit Safety Committee (USC) consisting of representatives from AERB and the experts in various aspects of nuclear technology drawn from different institutions.
- The second level of safety review of Indian NPPs is by Safety Review Committee for Operating Plants (SARCOP), which is the apex body to decide on the matters of nuclear safety pertaining to NPPs.
- The third level is the Board of AERB, which considers the major safety issues pertaining to the NPP based on the recommendations of SARCOP.

3. Safety Verification Programmes

There are established codes and guides, which gives the requirements related to operation of NPPs. These are:

a. Surveillance, maintenance and in-service inspection programmes.
b. Performance review and operational experience feedback programmes.
c. Programmes for ageing management and equipment qualification.
d. Re-training programme for operating personnel.

The plants have established several plant life management programmes to meet regulatory requirements for authorization and also as a good practice for effective monitoring. These include:

- Maintenance Programme – The maintenance programme is put in place to ensure that

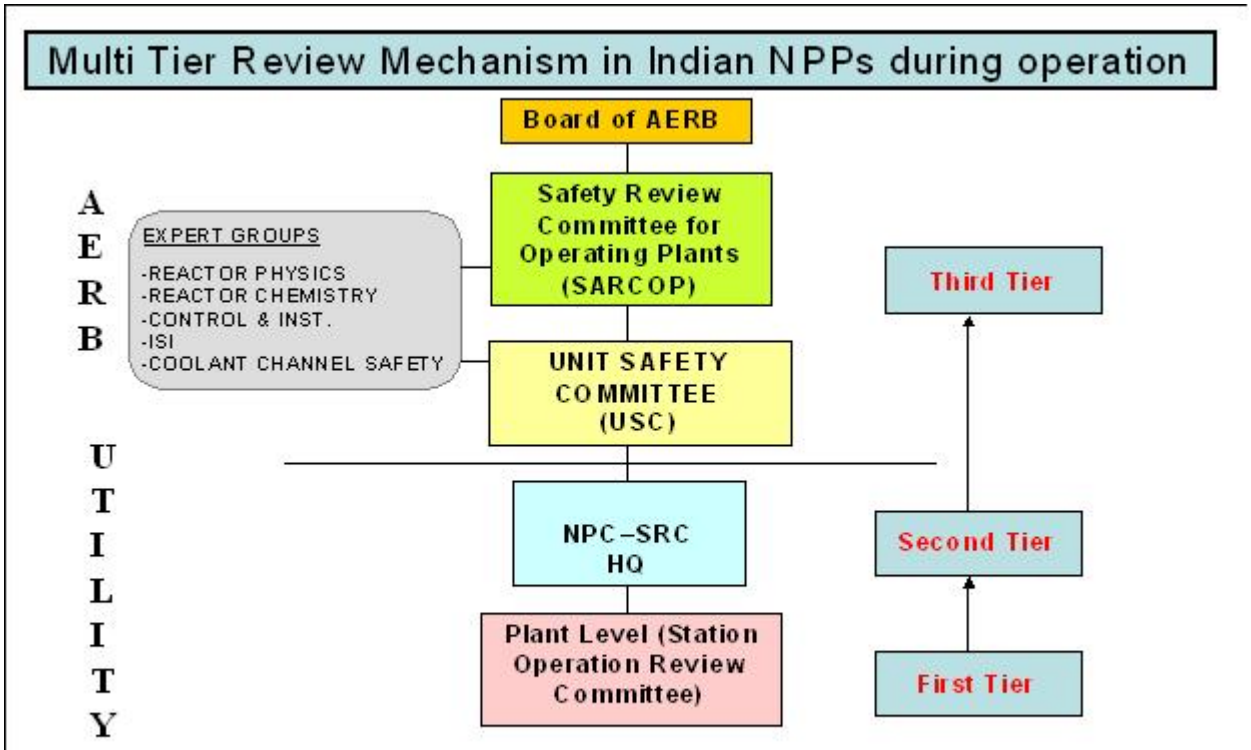

Figure 1: Safety Review Mechanism of Operating Plants

⇒ Safety status of the plant is not adversely affected due to aging, deterioration, degradation or defects of plant structures, systems or components, since commencement of operation and

⇒ It is carried out through preventive maintenance of systems, structures and components and corrective actions based on trend monitoring of parameters.

- Surveillance Programme – The surveillance programme for safety systems and systems important to safety are included as part of the Technical Specifications for Operation. These tests includes functional test/ calibration checks for Protection Systems, Emergency Core Cooling System, Containment Systems, Emergency Power Systems and various other important Systems, Structures and Components (SSC).
- In-service Inspection Programme – The plant components and systems are inspected for possible deterioration in safety margins and their acceptability for continued operation of the plant. Systems, Structures and Components (SSC) important to safety of the plant are identified in the In-service Inspection manual, which gives the requirements with respect to :
  - ⇒ Areas and scope of inspection
  - ⇒ Frequency of inspection
  - ⇒ Method of inspection, and
  - ⇒ The acceptance criteria.
- Performance Review Programme – The basic purpose of this programme is to identify and rectify gradual degradation, chronic deficiencies, potential problem areas or causes. This includes review of safety-related incidences and failures of SSC of the plant, determination of their root causes, trends, pattern and evaluation of their safety significance, lessons learnt and corrective measures taken.
  - ⇒ The performance review is carried by establishing/monitoring the station operating performance indicators, WANO performance indicators (as a good practice). The performance review of all operating plants is also carried out at the headquarters by HSE Directorate based on the review of station documents.
  - ⇒ Feedback based on performance review and identification of generic issues/safety concern, is conveyed to Directorate of Operation. Also, generic issues are reviewed in Apex Committee for Review of Operating Station Safety (ACROSS) meetings for collective decision.
- Establishment of programme related to life management. This programme is used to obtain information on behavior of the components, as identified for ageing management purpose, under reactor environment and to undertake necessary studies/experiments with respect to their residual life assessment.
- Programme to update Probabilistic Safety Assessment (PSA). The programme for collection of plant-specific failure data at NPPs is established for evaluation of reliability of safety systems. These data are judiciously used to update the results of PSA studies. The proposals for design modifications or revision in technical specification requirements are required to be supported by the results of PSA studies.

4. Review and Assessment

There are various committees at station level, corporate level and regulators level to ensure that verification programmes are meeting the requirements.

4.1 Corporate Level

Based on Internal Reviews and International industry inputs, a system of Corporate Reviews (CR) has been developed, which has the following objectives:

⇒ Independent Safety Review of NPPs

⇒ To integrate Audit and Peer Reviews to optimize efforts of NPCIL.

⇒ To align with international system of peer reviews.

Corporate Reviews based on WANO Peer Review methodology are used to sensitize NPPs.

- The Corporate Reviews are supervised by Apex Committee for Review of Operating Station Safety (ACROSS) at HQ.
- The committee comprises of Sr.Executive Director (Safety & Knowledge Management) as its Chairman and senior members from Design, Safety analysis, HS&E, QA and Operations.
- CR Team Leader presents review findings to ACROSS.

Member Secretary follows-up the recommendations and disseminates ACROSS directives.

4.2 Regulatory Inspection and Enforcement

Depending upon the requirements, AERB carries out periodic regulatory inspections as well as special unannounced inspections. These inspections are carried out by a group of experts from within AERB and/or through consultants. The review process typically extends to 5-day duration and covers all functional areas of an operating NPP. The emphasis is mainly on compliance to regulatory stipulations, station technical specifications, recommendations of earlier inspections, document updating, event reporting, surveillance tests, radiological & industrial safety. Recommendations are categorized based on their safety significance and becomes a part of Station Technical Audit Engineer's report for status monitoring, follow up and completion.

4.3 Renewal of Authorization for Operating Plants

AERB exercises regulatory control over the nuclear power plants by a system of inspections and periodic assessment for renewal of authorization. Authorization for operation is issued by AERB for a specified period. During this period, the operational NPPs undergo routine and special safety reviews. The elements covered during the reviews and assessment of safety in NPPs within the authorization period are,

1. Review of periodic reports submitted by the plant.
2. Review of off-normal occurrences of safety significance.
3. Training and qualification of operating staff
4. Radiological safety status
5. Management of radioactive waste
6. Review of proposals for modification in hardware, control logics, plant configuration and procedures.
7. Report of planned outages for carrying out surveillance, in-service inspection and major maintenance.
8. Reports of Special Investigation Committees and / or special regulatory inspections following an event of major safety significance.
9. In addition to the above, special reviews are also undertaken following an event or observations of major safety significance occurring abroad, for their applicability in the Indian NPPs and need for any corrective measures.

The renewal of authorization is of two types: (a) Limited Safety review of Application for Renewal and Authorization (ARA) submitted in the prescribed format prior to completion of five years of operation and (b) Comprehensive review of Report on Periodic Safety Review (PSR) submitted prior to completion of ten years of operation.

Safety assessment performed during PSR takes into account improvements in safety standards and operating practices, cumulative effects of plant ageing, modifications, feedback of operating experience and development in science and technology. Through this process of PSR, the strengths and shortcomings of the NPP against the requirements of current standards are identified.

4.4 Assessment of Safety Significant Event Team (ASSET)

Effective Operating Experience (OE) programmes at nuclear power plants provide methods to analyse both in-house and external operational events to identify actions needed to prevent the occurrence of similar events. Experience has shown that Significant Events are frequently the result of known problems and most Significant Events are preceded by similar, less significant occurrences. In-depth analyses to determine root causes, along with the timely identification and implementation of corrective actions for precursor events, can prevent or reduce the consequences of similar events. Assessment of Safety Significant Event Team (ASSET) adopts the root cause analysis methodology developed to support the IAEA ASSET service programme. The ASSET approach is based on the logic that events always occur because of a failure (of people, procedures or equipment) to perform as expected due to a latent weakness (direct cause), which were not eliminated due to deficiencies in plant surveillance programme on personnel, procedures or equipment (root cause). The method can be used as a framework for plant event investigation and analysis in order to determine direct and root causes.

ASSET methodology is selectively followed in NPCIL for issues having wider perspective.

4.5. Safety Assessment at NPCIL after Major National/International Events

As part of operation safety experience feedback programme, events occurring within the country and abroad are reviewed regularly. Comprehensive safety reviews are also carried out both by Utility in response to major events.
Through these reviews important lessons are learnt and improvements in design, procedures, training, safety culture, etc. are improved wherever applicable.

5. Conclusions

Systematic safety assessments with in NPCIL and by AERB are carried out for the NPPs in India. Over the years, these mechanisms have resulted in progressive improvements in the safety and reliability of operating units. The inputs from operational experience are utilized for design improvements in new reactors.

Shri Umesh Chandra is Senior Executive Director, Safety and Knowledge Management in Nuclear Power Corporation of India Ltd. His areas of responsibilities include Reactor Safety & Analysis of Design, Health, Safety & Environment of nuclear power plants in operation and construction, Software Quality Assurance of C&I Systems, Training Simulators and Knowledge Management. He has established R&D activities and infrastructure including an R&D Centre at Tarapur Site and a digital C&I systems lab at Mumbai. He has been responsible for design and engineering of Control and Instrumentation systems of 540 MWe PHWRs, TAPS-3&4 at Tarapur.He has also been responsible for establishment of qualification methodology and safety guide for Digital I&C Systems in NPPs

Before joining NPCIL in 2001, he worked in Reactor Control Division, BARC for 30 years. At BARC, his major contributions were towards creation of teams and fostering of technology for development of computer based Control and Monitoring Systems for nuclear power plants. These systems are operating in 14 Nuclear Power Plants (NPP).

He has also contributed in the preparation of C&I related safety guides for Atomic Energy Regulatory Board (AERB). He is also a part-time Director on the Board of ECIL, Hyderabad. Shri Umesh Chandra is a Distinguished Scientist and is a graduate in Electrical Engineering from IIT, Kanpur.

Enhancing the Safety of Nuclear Plants: Advanced Software Tools

Johan Sörman,& N. R. Bhatt
Lloyd's Register-ScandPower

Deterministic and probabilistic analysis plays a very significant role in the evaluation of safety of Nuclear Plants for Design and Beyond Design Bases Accidents. However, one begins to think that the analysis technology is matured, accident alarms for re-look and alerts further improvements. The Fukushima NPP accident in Japan in March 2011 highlighted some issues in the Probabilistic Safety Assessment (PSA) methodology. PSA community is challenged to further develop the PSA methodology and suggest solutions. It is important that PSA quality need a thorough review in terms of its technical consistency of the data and assumptions, comprehensiveness of the analysis, correctness of the results etc. One of the suggested ways to improve the PSA quality is an independent review.

It is not an easy task to predict the behaviour and performance of complex man-made installations, like for example a nuclear power plant, given environmental effects (typhoon, tsunamis, etc), probabilities of failure of equipment and human errors. With the aid of software tools it has, however to a certain degree, become possible to do.

Would it, in the future, be possible to create a complete software based virtual representation of a nuclear power plant for the purpose of predicting its reliability, performance and response to external and internal disturbances?

Tools for Risk Assessment

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Probabilistic Safety Assessment, Probabilistic Risk Assessment and Quantitative Risk Assessment (PSA, PRA, QRA), have been used for many years in different industries to assess and evaluate safety and risk of hazardous activities. Probably, the nuclear industry is the one industry that has used it to its fullest. It was, in the nuclear industry initially developed to understand weaknesses and vulnerabilities in plant design, but is today increasingly used in many aspects of operational safety and for fulfilment of regulatory requirements.

PSA includes building of logical models that represent the system or installation that you wish to assess with regard to risk. It can be a nuclear power plant, a chemical plant, an oil rig, etc. With these models in place you are able to assess risk by evaluating different predefined scenarios, i.e. sequences of events that

lead to an undesired consequence. This is today, not possible to do without a software tool, given the requirements of technical adequacy and completeness of the models representing the installation.

Advanced Algorithms

RiskSpectrum PSA is the most widely used PSA software tool for assessing risk at nuclear power plants in the world. The demands are particularly high on PSA
software as they are required to provide state-of-the-art interface for modelling fault tree and event trees, store reliability data for all components and, most importantly, provide very advanced algorithms for carrying out the data intensive probabilistic calculations. These algorithms have been developed during more than 25 years now and still are being optimised to meet the ever increasing demand for quickly producing accurate predictions. A typical PSA model of today includes 10,000-20,000 logical gates that are combined in many hundred scenarios to evaluate the risk e.g. nuclear installations and calculation times vary from a few minutes to days depending on the complexity and size of the PSA model.

Risk Monitor

Risk monitor software can use the PSA model for determining the point-in-time risk based on e.g. a nuclear power plant configuration – that is, the Plant Operational Mode (power operation or one of the shutdown modes), system configurations and the components that have been removed from service, etc.

The risk monitor software is typically designed to be used by all plant personnel while PSA software requires specialist knowledge of the plant specific PSA model and modelling techniques.
There are many examples of where the PSA and risk monitors have made a difference with regard to how nuclear power plants are operated today.

Examples of PSA model applications
PSA models realized in PSA software are today used for many applications. Here are a few:

- Maintenance planning
- Risk Informed In Service Inspection (RI-ISI)
- Evaluation of Technical Specification (TS) or justifying exemptions from TS (AOT extensions)
- Evaluation of operations, precursor analysis, risk follow-up
- Emergency planning

Maintenance planning

In the U.S., PSA play an import role. The US Nuclear Regulatory Commission (NRC) requires that nuclear power plants assess and manage the increase in risk that may result from proposed maintenance activities. This assessment is typically based on the PSA, using a risk monitor.

The USNRC introduced this rule in the 1980's, as the commission became concerned about the number of unplanned shut-down of nuclear power plants, initiated as a result of problems with balance of plant systems and components. The NRC concluded that proper maintenance is essential to plant safety and noted a clear link between effective maintenance and safety as it relates to number of transients and challenges to safety systems and also associated need for operability, availability and reliability of safety equipment. For these reasons the NRC introduced the maintenance rule, 10 CFR 50.65: "Requirements for monitoring the effectiveness of maintenance at nuclear power plants". As a result, unplanned shut-downs were reduced significantly at US nuclear power plants.

Pipe Inspection

Another interesting PSA application is Risk Informed In Service Inspection of piping, RI-ISI. The fundamental idea is to identify high-risk locations, with regard to safety functions, where inspection efforts should be concentrated. Deterministic rule based ISI programmes focus on piping in high safety classed pipes, while PSA results may indicate that other systems are of equal, or even greater, importance to safety. Reduction of ISI of primary system piping of nuclear plant results in significant reductions of employee radiation doses and savings in inspection costs. RI-ISI aims at rational ISI management by taking into account the results of plant-specific risk analyses.

To perform RI-ISI analyses, due to the complexity and the amount of data that is computed, it is necessary to use software tools.

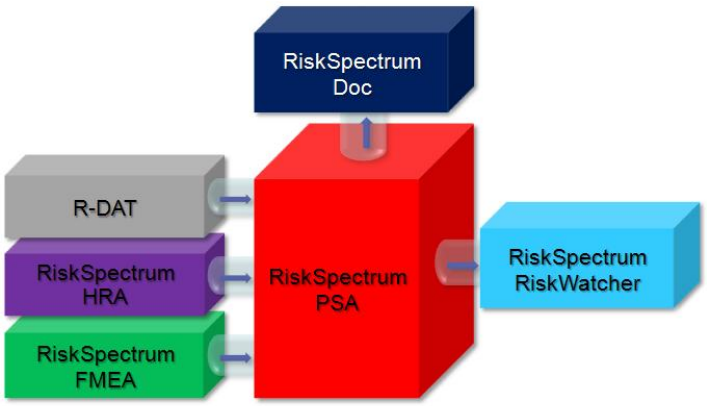
Emergency Operating Procedures

Assumptions and accident scenarios used in the development of Emergency Operating Procedures and Severe Accident Management Guidelines for nuclear power plants are traditionally based on generic investigations and analyses. Today, there are attempts to also use the PSA model to benefit from insights from the probabilistic analyses. In particular, with an integrated PSA software tool, relevant sequence paths, together with corresponding probabilities (likelihoods) could be considered in defining Severe Accident Management Guideline strategies.

Blow Out Prevention
In the aftermath of the Deep Water Horizon accident in the Mexican Gulf 2010, initiatives have been taken to develop a risk monitor for the Blow Out Prevention systems. The risk monitor will be similar to risk monitors used in the nuclear industry and there will be both qualitative and quantitative results indicating safety functions status and risk levels with regard to hazards such as a blow out. The risk monitor tool will be installed both on-shore and off-shore.

The Way Ahead
There is a clear trend to integrate more and more into software based risk and simulation models. There are many types of analyses that can be carried out and fault tree and event tree analysis are just one of them. They all are specialised at analysing different things. For example Human Reliability Analysis for predicting human errors, Plant specific reliability data update, to better reflect a particular plans performance, Failure Mode Effect & Criticality Analysis for systematic analysis of system failures and inter-dependability, etc. With the help of software, these analyses can be performed and documented in one software or database. Results from one analysis can be used in the next giving operators and planners a more complete picture.

So, will it be possible to create a complete software based virtual representation of a nuclear power plant in the future? Only time will tell, but we will certainly come very close if we keep up the pace at improving computer performance, new methods and algorithms for the prediction of future events.



RiskSpectrum PSA	Fault tree and event tree modelling and analysis
RiskSpectrum RiskWatcher	For risk monitoring
RiskSpectrum FMEA	Mapping of structures, systems and components, their failure modes and failure effects
RiskSpectrum DOC	For documentation
R-DAT	Reliability analysis

Figure. Data can be transferred seamlessly between the applications in the RiskSpectrum software platform

Mr. Johan Sörman has 18 years of experience in the nuclear industry and holds a Master of Science, Mechanical Engineering, Royal Institute of Technology, Sweden. He has worked in nuclear power plant PSA projects and various risk and reliability studies for different industries in Sweden. Since 2000, Mr Sörman has been responsible for sales, marketing, support and training of RiskSpectrum risk and reliability software. Mr. Sörman has published many scientific papers about PSA software and related topics. He has also played a significant role in the development of RiskSpectrum software.

Narayan Bhat is a Mechanical Engineer from Karnataka University (1993). He started his career in R&D institute IISc Bangalore and then joined Bhabha Atomic Research Centre in 1994 as Trainee Officer and worked as Scientific Officer at BARC before moving to private sector in 2007. He had been in the leadership roles in project management and business development as a Vice President at Rolta India Limited. His focus area of Business has been Power and Nuclear Sector. Currently he is working as Power Sector leader in Lloyd's Register Asia, based at Mumbai and responsible for business development and strategy for the growth of power sector in Asia.

New members

The society approved the following scientist/ engineers as life members of SRESA. SRESA welcomes the new members and looks forward to their valuable contribution and support.

Dr. Alok Mishra joined Westinghouse Electric Company. He has obtained his PhD in Reliability Engineering. He was working as Scientific Officer in Nuclear Corporation of Indian Ltd. (NPCIL), Department of Atomic Energy (DAE) in earlier days of his Career. His area of work includes deterministic and probabilistic safety analysis

Mr. C. P. Mungikar is working as Superintendent (Life Management & Import Substitution), Tarapur Atomic Power Station (TAPS-1&2), NPCIL. His area of expertise are Pre Service Inspection, In-service Inspection of NPPs, NDE failure analysis and RCA, Quality Assurance related to NPP components/ systems.

Dr. S.K. Chaturvedi is working as Assistant Professor in a Department of Reliability Engineering Centre, Indian Institute of Technology (IIT), Kharagpur (W.B.). He has obtained his PhD in Reliability Engineering.

UPCOMING CONFERENCES

99th Session Indian Science Congress Association

Date: January 03-07, 2012, **Venue:** Bhubaneshwar
For further details visit : http://www.sciencecongress.nic.in

International Symposium on Uncertainty & Safety Assessment and Management (ISEUSAM-2012)

Date: January 4-6, 2012
The abstract submission date has been extended to August 15, 2011.
For details see website: http://www.becs.ac.in/ISEUSAM2012/

International Conference on Progress in Nuclear Energy and Education

Date: 20-22 March 2012; **Venue:** London, UK
Deadline for abstract submission - Oct 14, 2011
For further details visit : http://mail.elsevier-alerts.com/go.asp?/bEC00001/q6LRJ92F/xQ6JJ92F

International Conference on Fatigue Damage of structural materials IX

Date : 16-21 September 2012 **Venue:** The Resort and Conference Center at Hyannis, MA, USA
Deadline for abstract submission: 9 December 2011
For more details: http://www.fatiguedamageconference.com/index.html

International Workshop on 'New Horizons in Nuclear Reactor Thermal Hydraulic and Safety'

A two-day international workshop on **'New Horizons in Nuclear Reactor Thermal Hydraulics and Safety'** is being organized by Atomic Energy Regulatory Board (AERB) in co-operation with Board of Research in Nuclear Sciences (BRNS) and Society for Reliability and Safety (SRESA) during 2-3 January 2012 at Safety Research Institute (SRI), Kalpakkam.

The objectives of the workshop are:

- advancement and dissemination of knowledge of thermal hydraulics and safety as they pertain to the steady state design, transient performance and accident behavior of nuclear power plants.
- Dissemination of the state-of-the-art thermal hydraulics and safety information on current and future generation of nuclear reactors.
- Promote effective interchange of thermal hydraulics and safety information among the many professional groups and organizations participating in the development and application of nuclear reactor technology.

Recent developments and future challenges in various areas of nuclear reactor thermal hydraulics especially on severe accident, emergency preparedness, and safety will be discussed during the conference.

Topics Covered:

- Severe Accidents, Severe Accident Management Guidelines (SAMG) and Regulatory Requirements
- Features of Severe Accident Mitigations In New Generation Reactors
- Severe Accident Phenomenon , Progression and Analysis In Water Cooled Reactors
- Steam Explosion and Hydrogen Management
- Containment Thermal Hydraulics
- Reactor Safety against External Events
- Source Term Estimation
- Emergency Preparedness
- Advances in passive safety for advanced reactors
- Challenges of Thermal Hydraulics of FBRs
- Status of Reactor Thermal Hydraulic Research In India

Launch of an International Journal "SRESA Journal of Life Cycle Reliability and Safety Engineering"

SRESA is pleased to announce the launch of an International Journal **"SRESA Journal of Life Cycle Reliability and Safety Engineering"** during the inaugural programme of the international workshop on 'New Horizons in Nuclear Reactor Thermal Hydraulics and Safety". Launching of this journal is an important milestone for SRESA. This journal provides a platform for publication of research work of scientific community in the area of reliability and safety engineering. The editors sincerely thank the authors for their valuable contributions to the inaugural issue of the Journal.

Original/ review papers ,in the area of reliability and safety engineering, may be sent for publication in this journal . Regarding details for paper submission, please visit SRESA website: http://www.sresa.org.in

Society for Reliability & Safety (SRESA)

(REG. NO. :3141/2010/G.B.B.S.D.)
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Membership Application Form

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