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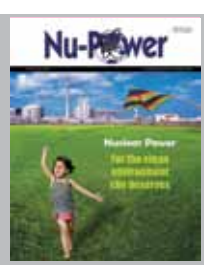
*For a pellet used in 540-MW Indian Pressurised Heavy Water Reactor (PHWR)

Nuclear Power - Clean Power, Green Power, Safe Power

Contents

Contents

Contents



Nuclear power provides emissions-free electricity for a clean environment.

Contents

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From Editor's Desk

Amritesh Srivastava

Editor

Of Light and Laureates

The beauty of science is that once in a while there comes an invention that calmly replaces an existing paradigm and brings about a profound change in the everyday life of millions... or billions.

No, you may not have guessed it right. It is neither some esoteric scientific principle nor any technological upheaval. It is not even something we deliberately notice. Yet all of us use it every day in some or other form, and you might even wonder whether you could get along without it at all. Often it is so diminutive that it comfortably fits into tiny things, and yet, with many of them packed together, it fills devices like touch screens of mobile phones, laptop/desktop displays and the ubiquitous large-screen televisions so thin that they hang like photo frames on the walls – connecting, informing and entertaining us. Blue light is also cleverly utilized in Blu-Ray optical disc recorders for far denser data storage than is possible with CDs or DVDs. And did I mention that it lights up our life, too? Now you guessed it! Yes, I am talking about the humble LED and the gentle and alluring way in which it has captivated us – much to our delight.

Three researchers won the 2014 Nobel Prize for Physics for the invention of efficient blue light-emitting diodes, which has enabled bright and energy-saving white light sources. The Nobel committee noted that light-emitting diodes, or LEDs, would be the lighting source of the 21st century, just the way incandescent bulbs illuminated the 20th century.

> **"The most important thing about blue light is how it made 'white' light possible."**

These Nobel laureates, working separately and then in two teams, made 'blue' LEDs possible in the early 1990s. However, this feat did not come easy.

The most important thing about blue light is how it made 'white' light possible. Blue light is the most energetic radiation in the visible-light spectrum. Thus, it can be converted into white light through phosphor excitation. Indeed, there is also another way in which blue light has helped create white light in a new, efficient way – by combining three primary-colored lights, i.e., red, green and blue (RGB) – to create white light. In fact, much of the early research in LEDs dates back to 1940s and '50s, and red- and green-light emitting diodes had been invented in the 1960s, but the blue-light LED was proving nastily difficult to invent. Indeed, a host of practical applications were waiting in the wings for the blue-light emitters to be invented. But no matter how hard the global scientific community tried, the 'missing' blue LED light proved stubbornly elusive for the next 3 decades.

From Editor's Desk

Then, what had begun in 1974 as an experiment to grow pure gallium nitride crystals culminated in tangible results when both teams were able to create the gallium

> **"...illumination consumes close to 25% of world's electricity."**

nitride alloys needed to create the junctions between semiconductor layers that formed the building blocks for blue LEDs. Finally, the first breakthrough came in 1994 in the form of efficient blue light, while the first blue laser was created in the following two years.

LED lamps are energy-efficiency champions. Currently, the best LED bulbs produce up to four times the light of a fluorescent bulb and nearly 20 times the light of a standard incandescent bulb for the same given amount of energy consumed. The incandescent bulb of yesteryears was a very inefficient device for producing illumination, because it wasted most of electrical energy as heat and converted only the remainder – about 10% or even less – into light. An LED bulb, in contrast, manages to covert electricity into light very efficiently, while generating very little heat. The excessive heat and the fragile heating element of the vintage incandescent bulb severely limited its lifespan to only about 1000 hours. The cool, robust solid-state LED bulb lasts 10 years.

There are other use cases that also benefit from LED's phenomenally long life and low appetite for power. For example, LED-based display screens allow our mobile computing gadgets to run longer on a single battery charge. PC monitors also consume less electricity and so also the modern versions of televisions; even those gadget watches require very less juice. However, it is in the lighting applications that the LED's potential is most enticing, especially since illumination consumes close to 25% of world's electricity. Indeed, every LED-illuminated space can reap valuable power savings: homes, offices, streets, public places – you name it. These savings alone can light up millions of 'extra' homes without setting up even a single 'additional' power plant. Every watt saved is a watt generated.

According to International Energy Agency's World Energy Outlook – 2014, about 1.3 billion people globally do not have access to grid electricity. As per recent UN data, that number is in the neighbourhood of 1.5 billion. LED lighting has the potential to transform the lives of these underprivileged people, as they now have a practical option to use

> **"Every watt saved is a watt generated."**

> **"With its ultra-low carbon footprint and emissions-free baseload power generation, nuclear electricity is already leading the charge to fight global warming."**

even low-intensity power sources like a small, and even portable, solar panel to energize these ultra-efficient, low-power LEDs for basic illumination for a few hours every day. But make no mistake – they will still need '24x7' grid electricity in order to lead a modern life – a need that can be best fulfilled by nuclear. With its ultra-low carbon footprint and emissions-free baseload power generation, nuclear electricity is already leading the charge to fight global warming.

Policymakers the world over should seize these complementary twin opportunities of the grassroots efficiencies afforded by LED lighting and the compelling merits of nuclear power – for a cleaner, brighter and more inclusive world.

I wish you all a Happy New Year 2015.

Happy Reading...

(Amritesh Srivastava)

Historic Milestone for RAPS-5

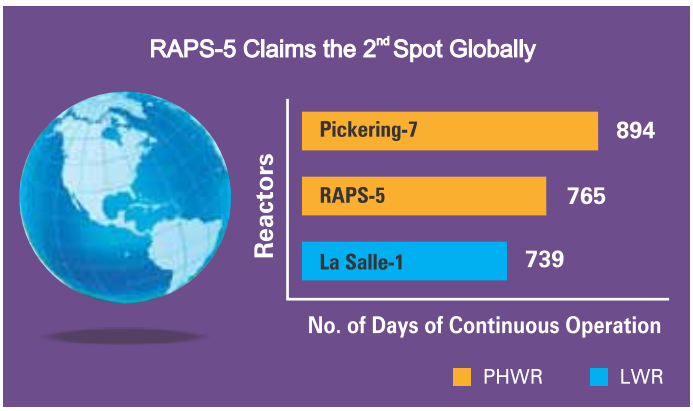
Unit Clocks World's Second-longest Continuous Operation of 765 Days

On September 6, 2014, the Rajasthan Atomic Power Station unit-5 (RAPS-5) reached a historic performance milestone by operating nonstop for 765 days at a single stretch, thereby becoming the 'second' nuclear power reactor in the world and 'first' in Asia to achieve this stellar feat. Earlier, when it crossed 739 days of continuous operation on August 11, 2014, it claimed the second place in the world for the longest continuous operation by a nuclear power reactor unit by displacing the previous second-place holder, unit-1 of the La Salle Power County Nuclear Generating Station at Illinois in the U.S., which had held this position since 2006.

By virtue of this achievement, RAPS-5 also surpassed the previous record for longest continuous operation by an Indian nuclear power reactor (590 days) held since 2011 by Tarapur Atomic Power Station unit-2 (TAPS-2).

RAPS-5, an indigenously designed 220-MW Pressurised Heavy Water Reactor (PHWR), was first synchronized to grid on December 22, 2009 and it began its commercial operation on February 4, 2010. During this period of continuous run, i.e. since its last synchronization to grid on August 2, 2012, the unit operated at full power.

The fact that RAPS-5 stands among the top nuclear power reactors globally for such long continuous run proves the country's technological maturity in nuclear power plant operation with the highest levels of safety.



- Operating Performance: Since the commencement of commercial operation, a total of 95330 million units were generated from all the 6 units of RAPS, till September 6, 2014
- During the year 2012-13 and 2013-14, the capacity and availability factor of all the five units of RAPS 2-6 were above 90% and 85%, respectively

[NPCIL HQ News Desk]

Prime Minister Visits BARC

Hon'ble Prime Minister of India, Mr. Narendra Modi, visited Bhabha Atomic Rsearch Centre (BARC) on July 21, 2014. Dr. R.K Sinha, Secretary, DAE and Chairman, AEC received the Hon'ble Prime Minister at BARC. The PM visited the Dhruva Reactor and other facilities at BARC, Trombay. This was preceded by a presentation by the Chairman, AEC on the various facets of the Indian Atomic Energy Programme. Chairman, Atomic Energy Regulatory Board, and Director, BARC were present with Chairman, AEC. At the Dhruva Reactor, the Prime Minister also saw an exhibition on various societal applications of the nuclear and radiation technologies in food and agriculture, healthcare, water resources and environmental protection.

[NPCIL HQ News Desk]

Dr. R.K. Sinha, Secretary, DAE and Chairman, AEC, briefing Hon'ble PM

Civil Works Nearing Completion at KAPP-3&4

Kakrapar Atomic Power Project-3&4 (KAPP-3&4), India's first indigenously designed Pressurized Heavy Water Reactors of 700 MW series, is progressing ahead, with civil works of main plant buildings of unit-3 and common buildings nearing completion. A major project milestone of erection and welding of Calandria and End-Shields has been completed successfully, after the receipt of Major Equipment Erection Clearance from the regulator, AERB.

So far, about 6,20,000 cu. m of concreting has been completed in the project. During the year 2014-15, civil structural works of several main plant buildings have been completed and finishing activities are in progress, with progressive release of work fronts for erection of equipment/ components. In Reactor Building-3 (RB-3), construction of last lift of Inner Containment (IC) wall, all internal structures and Steam Generator Vaults has been completed and preparatory activities for RB-3 dome erection has commenced. Reactor Building-4 has been completed up to elevation (EL) 115 m Pump Room Slab, including Calandria Vault and both Fuelling Machine Vaults.

Construction of Turbine Generator Deck for both the units has been completed. About 75% of structural steel column fabrication is completed and erection works are in full swing, while further activities for slab concreting at Turbine Building EL 111 m are in progress. Many equipment such as Turbine, Moisture Separators and Re-heaters, Condenser components, De-aerator Storage Tank, etc. have been received at the site and the balance are under advanced stages of manufacturing. Condenser erection work has commenced at the site for unit-3.

Piping work in common services system and primary piping package are in progress on multiple fronts, with about 75% pipe fabrication and 55% pipe erection for common services completed. Equipment such as ECCS Air Accumulators, Chiller units, Air Compressors, Air Dryers, Moderator Heat Exchangers, Moderator Storage Tank, Moderator Pumps, Shutdown Cooling Pumps, Fuelling Machine Bridge and Columns etc. have been erected. In addition, Primary Coolant

A view of the KAPP-3&4 main plant area under construction

Pumps, FM Supply Pumps, ECCS Pumps, Reactor Headers (5 nos.), Feeder Pipes etc. have been received at the site and are being erected progressively. Pre-assembly of End-Fittings has been completed in unit-3 as a prerequisite for coolant channel installation works.

Equipment installation, testing and commissioning for 220-kV Switchyard components has been completed successfully and both main buses charged. Civil work for 400-kV Switchyard has been completed, while tower and structure erection works are nearing completion. In main plant electrical works, Cable Tray installation, conduit installation and lighting works are nearing completion on priority routes and progressing well in other areas. Installation of all Class IV 6.6-kV and 415-V switchgears and commissioning of 415-V switchgears has been completed. Conduit and cable installation as well as junction box support erection is progressing in multiple areas. All Diesel Generator sets have been received at the site and are being erected.

The construction works of Induced Draft Cooling Tower (IDCT) is progressing well and the construction of tower frame for IDCT 3A and 3B is under completion up to EL 105 m and EL 108 m, respectively. In Natural Draft Cooling Tower (NDCT) package, raft for NDCT 3A has been completed and raker columns are under construction up to EL 109 m.

[NPCIL HQ News Desk]

Construction on Multiple Fronts at RAPP-7&8

At RAPP-7&8 site, construction activities are progressing on multiple fronts. Both End-Shields have been received at the site, while ball filling activity, which is a prerequisite before erection, has been completed. Another important milestone of erection of Fuelling Machine Bridge and Columns has been achieved in November 2014 in Reactor Building-7 (RB-7).

Inner Containment (IC) wall of RB-7 has been constructed up to 121.7m elevation (EL) and internal structures completed up to 109m EL. In Reactor Auxiliary Building-7, which is an integral part of Nuclear Building, work on peripheral walls and slabs at EL 95 m and EL 100 m is also progressing.

In Unit-8, the concreting of Calandria Vault is nearing completion and IC wall has been completed up to 101.7m EL. Construction of other structures inside RB-8 up to 100m EL is in progress. In control building, construction of unit-7 side EL 100 m slab has been completed and work on other slabs at EL 106 m and EL 111 m is in progress. Work on Waste Management Plant, Fire Water Pump House and Plant Water Pump House is also going on along with DM Water plant, Plant Water Pump House and Chlorination plant.

In Turbine Building-7, the construction of columns of Turbo Generator deck has been completed up to EL 106 m. Construction of Turbine Building-8 TG deck columns is also in progress.

Excavation work for Natural Draft Cooling Towers (NDCTs) is nearing completion. Confirmatory geo-technical investigation for NDCT-7A has been completed and plain cement work started. Construction work for Induced Draft Cooling Towers (IDCTs) is also in progress.

So far, more than 3.45 lakh cu.m of concreting has been done at the site.

Erection work of pipelines related to common service system has been started in the basements of Control Building and Reactor Auxiliary Building-7. DG Fuel Oil Storage Tanks (FOST) have been erected on the Diesel Oil Storage Pedestals of unit-7.

The 220-kV switchyard has been energized successfully. Civil work and erection of equipment structures in 400-kV switchyard is also going on.

RAPP-7 is seen on the left and RAPP-8 on the right in the foreground

Progressive delivery of equipment/components is in progress. Many equipment/components such as End-Shields, Calandria, End-Fittings, Calandria Tubes, Diesel Generators, Primary Coolant Pumps, Compressors, Chillers, Shutdown Cooling Pumps, Moderator Heat Exchangers, Moderator Pumps, Start-up Transformer, Fuelling Machine Bridge and Columns, various coolant channel components etc. have already been delivered to the site. Manufacturing of many other equipment/components by various vendors is also underway.

[NPCIL HQ News Desk]

Pre-Fabricated Ring Liner Erection at KAPP-3&4

For the first time in Indian PHWR 700-MW series reactors, carbon steel liner is provided on Inner Containment (IC) for better leak tightness. For achieving this, in earlier phase (from elevation (EL) 91.7 m up to EL 121.5 m) at KAPP-3&4, 16 panels of carbon steel liner was erected and welded in situ on IC wall panel by panel prior to concreting and the entire construction cycle for a 5m lift of IC wall took an average of 4.2 months. From 7th lift of IC wall (i.e. above EL 121.5 m) with the intent of strengthening construction technology, achieving better safety, shop-controlled quality and reducing construction cycle duration, a modular construction approach was adopted. In accordance to which, all 16 panels were fabricated in shop and assembled at ground level assembly area near Reactor Building-3 to form a full ring prior to lifting and placing on IC wall. This scheme has been successfully adopted for the balance 4 lifts of unit-3 IC wall (up to EL 139 m). The last lift of unit-3 IC wall, i.e., lift 10 was completed on December 16, 2014.

Pre-fabricated ring liner being erected

The implementation of modular scheme for PRL erection reduced the construction period cycle of 5m lift of IC wall from 4.2 months to 1.5 months.

[NPCIL HQ News Desk]

First End-Shield Arrives at RAPP-7

First End-Shield for 700-MW PHWR Rajasthan Atomic Power Project-7 (RAPP-7) arrived at RAPP-7&8 site on September 30, 2014 after traveling 808 km from M/s. L&T's Hazira plant in 60 days.

For the first time, an innovative rotating hydraulically operated fixture was used to clear the various hurdles on the way, to shorten the transportation time.

[NPCIL HQ News Desk]

End-Shield being dispatched from M/s. L&T's Hazira plant for RAPP-7

First End-Shield and Calandria Lowered at KAPP-3

Kakrapar Atomic Power Project-3&4 (KAPP-3&4), India's first 700-MW series indigenously designed Pressurised Heavy Water Reactors, achieved a major milestone recently.

End-Shield lowering in progress in RB-3

The mandatory AERB clearance for major equipment erection was received in the evening of May 26, 2014 for End-Shield erection.

In situ activities for lifting End-Shield started on May 28, 2014, and with round-the-clock working, all the pre-requisites were completed by the next-day morning. South End-Shield assembly weighing 228 MT was successfully lifted from ball-filling shed at 1000 hrs. and placed in Calandria Vault at 1130 Hrs on May 29, 2014 in Reactor Building-3.

Calandria being lowered into RB-3

On June 12, 2014, Calandria was lowered into the Calandria Vault of Reactor Building-3 at KAPP-3.

Prior to the erection, both End-Shields had been lowered in the Calandria Vault and pulled into the End-Shield cavity in the Calandria Vault wall.

[NPCIL HQ News Desk]

Indian News

National Safety Awards for Kaiga Generating Station

Kaiga Generating Station units have received recognition for their safe and reliable performance in the form of several awards in the past. On September 17, 2014, both units of Kaiga Site, i.e., KGS-1&2 and KGS-3&4 jointly received three Safety Awards at National level from Directorate General Factory Advice Service and Labour Institutes (DGFASLI), Government of India.

KGS-1&2 was declared the winner of National Safety Award for outstanding performance in Industrial Safety in achieving Lowest Average Frequency Rate for the performance in the year 2012, while KGS-3&4 was declared the runner-up in the same award category for the year 2012. Also, KGS-1&2 was declared the runner-up of National Safety Award for outstanding performance in Industrial Safety in achieving Accident-Free Year for the performance in the year 2012.

Mr. Suresh A. Patil (right) receiving 'Vishwakarma Rashtriya Puraskar' from Hon'ble Minister Mr. Narendra Singh Tomar (left), Union Minister for Labour and Employment and Mr. Vishnu Deo Sai (centre), the then Minister of State for Labour and Employment

Mr. H.N. Bhat (right), Site Director, Kaiga Site receiving the awards from Hon'ble Minister Mr. Narendra Singh Tomar (left), Union Minister for Labour and Employment and Mr. Vishnu Deo Sai (centre), the then Minister of State for Labour and Employment

These awards were received by Mr. H.N. Bhat, Site Director, Kaiga Site, at a function organised at Vigyan Bhavan in New Delhi and presented by Hon'ble Minister Mr. Narendra Singh Tomar, Union Minister for Labour and Employment and Hon'ble Minister Mr. Vishnu Deo Sai, the then Minister of State for Labour and Employment.

Also, Mr. Suresh A. Patil, an employee from Kaiga site was awarded 'Vishwakarma Rashtriya Puraskar' for the year 2012 for his outstanding contribution in Fuel Handling section activities at KGS-3&4.

[NPCIL HQ News Desk]

Environment Protection Award-2013 for RAPP-7&8

Rajasthan Atomic Power Project-7&8 (RAPP-7&8) was selected for Atomic Energy Regulatory Board (AERB) Environment Protection Award for the year 2013 in the categories of Construction and Mines Development amongst Department of Atomic Energy (DAE) units. The award was presented to Mr. B.C. Pathak, Project Director, RAPP-7&8 along with Mr. G. Nageswara Rao, Director (O), NPCIL, during the inaugural function of 31st DAE Safety and Occupational Health Professionals Meet organised at Bharat Nabhikiya Vidyut Nigam Limited (BHAVINI), Kalpakkam on October 15, 2014. AERB Environment Protection Award is presented every year to the DAE units for better contribution in tree plantation, water conservation, promotional and

Mr. S.S. Bajaj (left), Chairman, AERB, presenting the award to Mr. B.C. Pathak (center), Project Director, RAPP-7&8, along with Mr. G. Nageswara Rao (right), Director (O), NPCIL

proactive measures for environmental protection, use of green technology, encouraging paperless office, waste management, compliance of environment statutes, use of solar energy, etc.

31st DAE Safety and Occupational Health Professionals Meet at BHAVINI

The 31st DAE Safety and Occupational Health Professionals Meet was jointly organised by Atomic Energy Regulatory Board (AERB), Mumbai, and Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI), Kalpakkam, during October 15-17, 2014 at Kalpakkam. This Meet is organised annually with various themes on Industrial Safety and Occupational Health by AERB jointly with a Department of Atomic Energy (DAE) unit to promote and motivate Safety and Occupational Health aspects in DAE units. The themes for this year's three-day Meet is 'Safety and Emergency Management at Coastal Site' for Industrial Safety and 'Diabetes Mellitus and Metabolic Syndrome' for Occupational Health Safety. This Meet was inaugurated by Mr. S.S. Bajaj, Chairman, AERB. More than 200 delegates along with Chief Executives and Directors of various DAE units attended the Meet.

[NPCIL HQ News Desk]

KAPP-3&4 and TAPS-3&4 Win NSCI Safety Awards-2013

National Safety Council, India (NSCI) Safety Awards are much coveted national-level awards in the field of workplace safety, health and environment and are given in recognition of establishing effective safety management system and excellent safety and health performance by the organizations in manufacturing, construction and MSME sectors during the relevant assessment periods.

Mr. Lokesh Kumar (left), Project Director, KAPP-3&4 receiving the award from Hon'ble Union Minister Mr. Narendra Singh Tomar (center)

These awards are adjudged and declared every year by National Safety Council, an autonomous organization set up by the Minister of Labour, Government of India.

Mr. R.P.S. Tomer, the then, Station Director, TAPS-3&4 receiving the award from Hon'ble Union Minister Mr. Narendra Singh Tomar (center)

NPCIL's Tarapur Atomic Power Station units-3&4 (TAPS-3&4) won the top award in Manufacturing Sector (Group C – Power Generation); Kakrapar Atomic Power Project units-3&4 (KAPP-3&4) won top-level 'Sarva Shreshtha Suraksha Puraskar' in Construction Sector. A golden trophy and a certificate was awarded to the winners at the hands of the Hon'ble Minister of Steel, Mines and Labour & Employment, Govt. of India, Mr. Narendra Singh Tomar on October 27, 2014 at a function held in Mumbai.

[NPCIL HQ News Desk]

Performance Awards for RAPS-5&6

India Power Award-2014

Rajasthan Atomic Power Station unit-5 (RAPS-5) has continuously operated for 765 days from August 2, 2012 to September 6, 2014. RAPS-5&6 has received the India Power Award-2014 in the category of 'Best Overall Performance in Private Sector and PSU'. The award was presented by Hon'ble Railway Minister, Mr. Suresh Prabhu on November 19, 2014 to Mr. Vinod Kumar, Station Director, RAPS-5&6 at India Habitat Centre, New Delhi. The award function was organised by Council of Power Utilities.

Also, Lifetime Achievement Award was given to Dr. R. Chidambaram, Scientific Adviser to the Government of India and former AEC Chairman.

Mr. Vinod Kumar, Station Director, RAPS-5&6 (second from right), receiving the award from Hon'ble MP, Smt. Darshna Jardosh

Mr. Vinod Kumar, Station Director, RAPS-5&6 (second from right), receiving the award from Hon'ble Railway Minister, Mr. Suresh Prabhu

ENERTIA Award-2014

Rajasthan Atomic Power Station-5&6 (RAPS-5&6) has won the 8th ENERTIA Award-2014 in the category of 'Power Generation Award - Nuclear Energy'. The award was presented by Hon'ble Member of Parliament (MP) Smt. Darshna Jardosh to Mr. Vinod Kumar, Station Director, RAPS-5&6 on November 27, 2014 in New Delhi. ENERTIA foundation recognized RAPS-5 for its second-longest continuous operation by a nuclear power plant globally.

This prestigious award recognizes excellence in performance by public and private enterprises in the sector of power and energy in India and South Asian region.

[NPCIL HQ News Desk]

NPCIL Felicitated for Hindi and Urjaswi

Excellent House-Magazine Award

Nuclear Corporation of India Limited headquarters (NPCIL HQ) was bestowed Special Award for Excellence in 'Implementation of the Official Language for the year 2013-14' by Ashirwad, an NGO committed to the propagation of the official language, Hindi, in Mumbai since 1967. NPCIL HQ also received 'Excellent House-Magazine Award' from Ashirwad Foundation.

CMD, Hindustan Petroleum Corporation Limited (HPCL), Ms Nishi Vasudeva, giving away the award for Urjaswi

Hon'ble Mr. Kunwar Haribansh Singh, Member of Parliament, giving away the special award

Urjaswi, the house-magazine of NPCIL HQ, was awarded Second Prize for the year 2013-14 by PSU Town Official Language Implementation Committee (TOLIC), Mumbai.

[NPCIL HQ News Desk]

Commercial Operation for Fuqing-1

Unit-1 of the Fuqing nuclear power plant in China's Fujian province has entered commercial operation having successfully completed commissioning tests.

Plant constructor China Nuclear Engineering Corporation announced on November 19, 2014 that the 1080 MWe CPR-1000 reactor had completed a performance test while operating for 100 hours at full capacity. It said that this marked the official transition from commissioning to commercial operation.

Construction of the Chinese-developed CPR-1000 began in November 2008. The reactor achieved first criticality on July 24, 2014 and was connected to the grid on August 20, 2014.

The Fuqing plant will eventually house six Chinese-designed pressurized water reactors. The first four units of the plant are CPR-1000 reactors. For unit-2, construction of which began in June 2009, is expected to start operating in August 2015. First concrete was poured for units-3 and 4 in 2010 and 2012, respectively. Those reactor units should begin operation in February 2016 and March 2017.

Fuqing-1's control room (Image: CNEC)

Inputs from WNN
(November 20, 2014)

Commercial Operation for First Fangjiashan Unit

Unit-1 of the Fangjiashan plant in China's Zhejiang province has entered commercial operation.

The 1080-MWe CPR-1000 reactor, which began full-power trial operation on December 11, 2014, officially entered commercial operation on December 15, 2014, China National Nuclear Corporation (CNNC) announced.

The Fangjiashan project – near the existing Qinshan plant – comprises two CPR-1000 reactors. First concrete for unit-1 at the Fangjiashan plant was poured in December 2008. The first fuel assembly was loaded into the unit's core on September 1, 2014 and it achieved first criticality on October 21, 2014. The unit was connected to the grid on

Earlier, on November 4, 2014, Guests and the media watch on as Fangjiashan-1 starts supplying electricity to the grid (Image: CNNC)

November 4, 2014. It is CNNC's eleventh operating power reactor.

Fangjiashan unit-2, first concrete for which was poured in July 2009, has entered the commissioning phase. Fuel loading began on December 3, 2014 and the reactor is expected to start up in October 2015.

Inputs from WNN
(December 16, 2014)

First Criticality for Hongyanhe-3

Unit-3 at the Hongyanhe nuclear power plant in Liaoning province in northeast China has achieved a sustained chain reaction, moving the unit closer to commissioning.

The 1080 MWe Chinese-designed CPR-1000 pressurized water reactor achieved first criticality on October 27, 2014, China General Nuclear Power Co (CGN) and China Power Investment Corp (CPI) announced. The milestone means "the unit officially entered the operational phase with power," said CGN.

Physical tests at zero power are currently underway at the unit to "validate core performance, nuclear instrumentation monitoring system equipment availability and correctness of core loading," CPI said.

Construction of Phase I of the Hongyanhe plant, comprising four CPR-1000 units, began in August 2009. Unit-1 began commercial operation in June 2013. Unit-2 was synchronised to the grid in late November 2013 and entered commercial operation in May 2014. Unit-3 is scheduled to begin operating later this year, while unit-4 is expected to start up by the end of 2015.

A ceremony to mark the breaking of ground for Phase-II of the Hongyanhe plant – comprising a further two

The four units making up Phase I of the Hongyanhe plant (Image: CGN)

CPR-1000 units – was held in July 2010. All six units at the site are expected to be in operation by the end of 2020.

The plant is owned and operated by Liaoning Hongyanhe Nuclear Power Co, a joint venture in which CGN and CPI each hold a 45% stake, with the Dalian Municipal Construction Investment Co holding the remaining 10%.

Source: WNN
(Published: October 30, 2014)

Russia Signs Agreement to Build up to Eight Reactors in Iran

Russia and Iran signed an agreement on November 11, 2014 for the construction of up to eight new nuclear reactor units in Iran, the country's official Islamic Republic News Agency (IRNA) said.

IRNA said the head of the Atomic Energy Organisation of Iran (AEOI), Ali Akbar Salehi, had signed the agreement in Moscow with Sergei Kiriyenko, director-general of Russian state nuclear corporation Rosatom.

Rosatom said the agreement provides for the immediate construction of two new VVER reactors at the existing Bushehr nuclear site, with the possibility of two more units to follow. It also allows for four "similar units" at another site in Iran, although that site has not been named.

Russia will produce nuclear fuel for the plants during their whole service life. Spent nuclear fuel will be returned to Russia for reprocessing and storage, Rosatom said.

Russia said it will arrange for the training of Iranian specialists in nuclear plant operation, engineering support, regulation and radiation safety.

The two countries will also look at the “expediency and feasibility” of fabricating fuel rod components in Iran, which will be used at the planned units.

AEOI spokesman Behrouz Kamalvandi was quoted as saying construction of the first two new Iranian reactors is expected to start “by the end of 2014” and take between five to seven years to complete.

The agreement is for the first two units to be built next to the existing Bushehr-1 reactor, a Russian-supplied VVER V-446 pressurised water reactor unit, which began commercial operation in September 2013. The agreement also includes the construction of two desalination plants.

Russia and Iran reached an agreement in principle on the first two units in March 2014.

The Bushehr site, in the southwest of Iran on the Persian Gulf, has room for four reactors.

Inputs from NucNet
(November 11, 2014)

Construction Starts on Third Barakah Unit

The first safety concrete has been poured for the basemat of the containment building of the third reactor at the UAE's Barakah nuclear power plant, marking the official start of the unit's construction.

A concrete pouring ceremony was held on September 24, 2014 to mark the milestone. It was attended by representatives from Emirates Nuclear Energy Corporation (ENEC), Korea Electric Power Corporation (KEPCO), Hyundai, Samsung and Doosan Heavy Industries. A total of some 1495 cubic meters of concrete was poured.

Pouring of first concrete for unit-3 is celebrated at Barakah (Image: WAM News Agency)

ENEC, which received regulatory approval for the construction of Barakah-3 and 4 on September 15, 2014, said that the pouring of first concrete at unit-3 follows 12 months of preparatory work. This included excavation work, lining the foundation pit and installing reinforcing steel bars.

Construction of the reactor containment building for unit-3 will be completed over the next three years, ENEC said. It added that unit-3 is on track to enter commercial operation by 2019.

ENEC CEO Mohamed Al Hammadi said, "The concrete pouring is yet another key accomplishment for ENEC and the UAE's peaceful nuclear energy program. ENEC is working hard to reach its construction targets on schedule and deliver safe, efficient and reliable nuclear energy to the UAE starting by 2017."

In a $20 billion deal announced in December 2009, ENEC selected a consortium led by KEPCO to build four APR-1400 reactors. First concrete for Barakah-1 was poured in July 2012, while that for unit-2 was poured in May 2013. ENEC said that unit-1 is now 57% complete, while construction of unit-2 is "also well underway." All four units at Barakah are scheduled to begin operating by 2020.

According to ENEC, once all four units at Barakah are in operation, the plant will supply about a quarter of the UAE's electricity needs and save up to 12 million tonnes of greenhouse gas emissions annually.

Source: WNN
(Published September 25, 2014)

International News

First Indigenous RPV Lifted into Place at Sanmen-2

The reactor pressure vessel (RPV) has been lifted into position at the Sanmen-2 AP1000 reactor, marking the start of the installation phase of the unit, project operator China National Nuclear Corporation (CNNC) said.

The 280-tonne RPV is China's first indigenously produced AP1000 reactor pressure vessel. CNNC said it passed all required inspections before being shipped to the construction site on August 6, 2014. The RPV was manufactured by China First Heavy Industries (CFHI) under the supervision of reactor vendor Westinghouse.

Two AP1000s are under construction at the Sanmen site in Zhejiang province, eastern China, with another two being built at Haiyang in Shandong province.

The vessels for the first units at Sanmen and Haiyang were both produced in South Korea by Doosan Heavy Industries & Construction using some forgings fabricated by CFHI.

The RPV being lifted into place at Sanmen-2

Source: NucNet
(Published: August 29, 2014)

Construction Milestone at Taishan-2 EPR

Two stills from the lifting process (Images: CNI23)

The fourth Areva EPR under construction reached a milestone with the placement of its reactor pressure vessel at the Taishan nuclear power plant in southern China.

The heavy lift operation took place on October 30, 2014 and was announced by China Nuclear Industry 23 Construction Company (CNI23) on November 5, 2014. Placing the vessel requires it to be brought through an equipment hatch horizontally and then rotated through 90 degrees and lowered into place.

CNI23 said it had developed some new techniques since doing the same thing for Taishan-1 in June 2012. It said an "innovative" way to remove aft lugs from the lifting process had made the process "more short, efficient and safe." The whole operation took eight hours, a reduction of five hours

compared with Taishan-1, which CNI23 said "greatly enhanced the efficiency of construction."

Taishan features two 1660 MWe Areva EPR units, which are being built by the 70-30 joint venture of China General Nuclear (CGN) and France's EDF that will also own and operate them. The plant is in China's Guangdong province. Other EPRs are under construction in Finland and France, and are planned for the UK as well as India.

The major components for Taishan-1 were imported: the pressure vessel from Mitsubishi Heavy Industries (MHI) of Japan and the steam generators from Areva Chalon/St. Marcel in France, but those for Taishan-2 are all made in China: the pressure vessel by Dongfang Electric Co (DEC), two of the steam generators also by DEC and the other two by Shanghai Electric. The Arabelle steam turbines and generators are being purchased separately from Alstom and DEC respectively.

Source: WNN
(Published: November 5, 2014)

Russia Signs Agreement for up to Eight Reactors in South Africa

Russian and South Africa signed an intergovernmental agreement in September 2014 that lays the foundations for the construction of up to eight new nuclear units in South Africa, Russia's state nuclear corporation Rosatom has said.

The agreement, signed on the sidelines of the International Atomic Energy Agency's general conference in Vienna, provides for the construction of Russian VVER nuclear power units with a total installed capacity of up to 9.6 gigawatts, Rosatom said. If construction goes ahead, the reactors will be the first units based on Russian VVER technology to be built on the African continent.

Apart from the joint construction of nuclear plants, the agreement also provides for "comprehensive collaboration" in other areas of the nuclear power industry, including construction of a multipurpose research reactor based on Russian technology, help with the development of nuclear infrastructure, and education of South African nuclear specialists in Russian universities.

South Africa has two commercially operational nuclear units at the Koeberg nuclear station. According to the IAEA, the units account for about five percent of the country's generated electricity.

Source: NucNet
(Published: September 22, 2014)

RPV Installed at China's Haiyang-2 AP1000 Reactor

The reactor pressure vessel (RPV) has been lifted into position and installed at the Haiyang-2 AP1000 nuclear plant in China, State Nuclear Power Technology Corp (SNPTC) said in a statement in September 2014.

The RPV was manufactured by Shanghai Electric and marks "a step forward" in China's indigenous manufacturing of Westinghouse AP1000 technology, SNPTC said.

Sanmen-2 was the first unit to use an indigenously produced AP1000 RPV. The RPV was installed at Sanmen-2 in August 2014.

China gained the rights to build its own version of the AP1000 when it agreed to buy four units from Westinghouse for the Sanmen and Haiyang plants.

Two AP1000s are under construction at Haiyang in Shandong province, northeastern China, with another two being built at the Sanmen site in Zhejiang province, eastern China.

The RPV being lowered into position (Photo: SNPTC)

The AP1000 is a 1,100-megawatt reactor designed by Westinghouse that incorporates passive safety features.

Source: NucNet
(Published: September 17, 2014)

International News

Vessel Installed at Fangchenggang-2

The reactor pressure vessel has been installed at the second unit of the Fangchenggang nuclear power plant in China's Guangxi province.

Plant constructor China Nuclear Engineering and Construction Corporation (CNECC) announced that the vessel was successfully located on its support ring within the containment building at 3:00 p.m. on September 25, 2014.

Fangchenggang is located near Hongsha village in the Guangxi Autonomous Region, about 45 kilometres from the border with Vietnam. A total of six reactors are planned to operate there. Units-1 and 2 are CPR-1000s, units-3 and 4 are planned to be the evolutionary ACPR-1000 development, and units-5 and 6 are to be AP1000s. All of these are models of large pressurized water reactor.

Units-1 and 2 are slated to begin operation in 2015 and 2016. The plant is 39% owned by Guangxi Investment Group and 61% owned by China General Nuclear (CGN).

Inputs from WNN (September 26, 2014)

The reactor vessel is lowered into place at Fangchenggang-2 (Image: CNEC)

Progress at Novovoronezh II

Dome being installed on reactor building of unit-2 of Novovoronezh II (Image: AEP)

Dome Installed at Unit-2

In November 2014, Atomenergoproekt announced the installation of the reactor containment building dome at unit-2 of the Novovoronezh II nuclear power plant.

'Coronation' of Unit-1

Earlier, in September 2014, the exhaust header structure – the first component of the passive heat removal system (PHRS) – was installed on the dome of the first reactor building at the Novovoronezh II nuclear power plant.

Both the Novovoronezh-II units will have a passive heat removal system that, in the event of loss of on-site power supply, will provide long-term heat removal from the reactor core to the atmosphere using natural circulation.

The exhaust header structure is a metal cylinder 25 meters in

diameter and 13 meters high.

Novovoronezh-II is the lead project for the deployment of the AES-2006 design incorporating a Gidropress-designed pressurized water reactor, an evolutionary development from the VVER-1000. Construction of Novovoronezh-II units-1 and 2 began in June 2008 and July 2009, respectively. The original Novovoronezh site (Novovoronezh-I) nearby already hosts three operating reactors and two that are being decommissioned.

Inputs from WNN
(November 17 and September 18, 2014)

The exhaust header being lowered into place (Image: Atomenergoproekt)

Fuel Loading at Fangjiashan Unit-2

The process of loading fuel assemblies into the reactor core of unit-2 at the Fangjiashan plant in China's Zhejiang province began on December 5, 2014.

The process involves loading 157 assemblies into Fangjiashan-2's core. This will be followed by trial operation of the CPR-1000 reactor, during which many tests will be carried out. The unit is scheduled to enter commercial operation in October 2015.

The Fangjiashan project comprises two CPR-1000 reactors with a combined capacity of 2160 MWe constructed near the existing Qinshan plant. First concrete for the unit-1 at the Fangjiashan plant was poured in December 2008, while that for unit-2 was poured in July 2009. Unit-1 was connected to the grid on November 4, 2014.

Six CPR-1000 reactors are currently operating in China, with a further 16 under construction.

Fuel being loaded into the core of Fangjiashan-2 (Image: CNNC)

With inputs from WNN
(December 5, 2014)

Westinghouse Signs 'Exclusive Negotiations' Agreement for Four Reactors in Turkey

Westinghouse Electric Company has signed an agreement with China's State Nuclear Power Technology Corporation (SNPTC) and Electricity Generation Company (EÜAŞ), the largest electric power company in Turkey, to enter into "exclusive negotiations" to develop and construct a four-unit AP1000 nuclear power station in Turkey.

Westinghouse, part of the Toshiba group, said in a statement on November 24, 2014 that the project also covers all life-cycle activities, including operations, nuclear fuel, maintenance, engineering, plant services and decommissioning.

There are eight Westinghouse AP1000 units under construction

worldwide: two each at the Vogtle and VC Summer sites in the US, and the Sanmen and Haiyang sites in China. In addition, shareholder agreements have been signed in the past few months for the development of AP1000 plants at the Moorside site in the UK and the Kozloduy site in Bulgaria.

SNPTC is the general contractor for the four AP1000 units being built in China.

Westinghouse president and chief executive officer Danny Roderick said the company is confident its partnership with SNPTC and the leadership SNPTC has demonstrated in China will provide "the greatest value" for Turkey.

In November 2013, the International Atomic Energy Agency (IAEA) said Turkey had made important progress in the development of its nuclear energy infrastructure, but needed to strengthen its nuclear regulatory body and develop a national plan for human resource development.

Turkey already has two nuclear station projects in development – the Akkuyu nuclear plant in cooperation with Russia's Rosatom, and the Sinop nuclear plant with an Areva-Mitsubishi Heavy Industries joint venture.

According to the IAEA, Turkey is aiming to produce at least 10 percent of its electricity from nuclear power by 2023.

Source: NucNet
(Published: November 24, 2014)

Sites Agreed for Four More South Korean Reactors

Two South Korean municipalities have each agreed to host two new nuclear power reactors. Ulchin County has approved construction of units-3 and 4 at the existing San Hanul plant, while Yeongdeok County has approved a new two-unit plant.

A ceremony was held on November 21, 2014, attended by Hon'ble Prime Minister Chung Hong-won, during which Ulchin County signed an agreement with Korea Hydro and Nuclear Power (KHNP) allowing the construction of two more units at Shin Hanul.

> **"Considering our poor natural resources and manufacturing-oriented economic structure, nuclear power is inevitable when considering our greenhouse gas reduction obligations."**
> ***– Prime Minister Chung Hong-won***

Under the agreement, in exchange for hosting the new units, KHNP will provide the county with KRW 280 billion ($250 million), mainly to be used for improving local infrastructure, with the remainder for building new schools and hospitals.

Six reactors are already in operation at the Hanul/Ulchin plant in Ulchin County, having started up between 1988 and 2005. A further two units are under construction at the nearby Shin Hanul plant and should both be in operation by April 2018.

With the signing of the agreement, KHNP can now prepare for construction of Shin Hanul units-3 and 4, two further APR1400s. Construction of these will start in 2017 at the earliest, with both expected to be operating by 2022.

Prime Minister Chung said, "Understanding the national energy policy, we thank the county for their cooperation in providing a nuclear power plant site." He described the signing of the agreement as a "win-win milestone" for the country and the local area.

Mr. Chung noted, "Considering our poor natural resources and manufacturing-oriented economic structure, nuclear power is inevitable when considering our greenhouse gas reduction obligations."

South Korea currently has 23 nuclear power reactors in commercial operation with a combined generating capacity of 20,656 MWe. Nuclear accounts for about one-third of the country's electricity production.

Meanwhile, Yeongdeok County in North Gyeongsang province in western Korea has also signed an agreement for the siting of a new two-unit plant. Yeongdeok has been designated as a potential site for a nuclear power plant comprising up to four large reactors.

Inputs from WNN
(November 21, 2014)

Rostov-3 Gears Up

Unit-3 of the Rostov nuclear power plant (Image: Rostov NPP)

The third reactor at Russia's Rostov nuclear power plant was brought to the minimum controlled power level on December 7, 2014, moving it a step closer to starting commercial operation.

The loading of 163 fuel assemblies into the VVER-1000 pressurised water reactor was carried out between November 14 -19, 2014 and hydrotesting of the primary and secondary reactor loops started on November 25, 2014.

Rosenergoatom, the Rosatom subsidiary that operates all of Russia's civil nuclear power plants, said last month in a statement that construction and commissioning of the unit is ahead of schedule. Hot testing of the unit was completed on October 24, 2014 and additional pre-start due diligence work was conducted until October 31, 2014.

With Inputs from WNN
(December 8, 2014)

Core Catcher Delivered to Belarusian Plant

The core catcher for unit-2 of the nuclear power plant at Ostrovets in Belarus was delivered to the construction site, Atomenergomash said on November 19, 2014.

A core catcher is a device provided to catch the molten core material – corium – of a nuclear reactor in case of a nuclear meltdown and prevent it from escaping the containment building.

Inputs from WNN
(November 19, 2014)

The core catcher was transported by ship and by road on its journey to Ostrovets (Image: Rosatom)

Russia Ships Third Generator for Tianwan-3 to China

Russian heavy equipment manufacturer ZiO-Podolsk has shipped the third of four steam generators intended for unit-3 of the Tianwan nuclear power plant in China.

ZIO-Podolsk is a subsidiary of Atomenergomash (AEM), which is part of Russian state nuclear corporation Rosatom.

The PGV-1000M steam generator has a diameter of just over 4 meters, a height of 5 meters and a length of 16 meters. It weighs 378 tonnes and has an operating life of 40 years.

AEM said last month that construction of the reactor building at unit-3 in Jiangsu province is nearing completion.

The third steam generator en route to Tianwan-3 (Image: Rosatom)

Tianwan-3 will be an AES-91 VVER-1000 unit designed by Gidropress and supplied by Russian state firm Rosatom. AtomStroyExport is the main contractor, supplying the nuclear island. First concrete for the unit was poured in December 2012. It is scheduled to begin operating February 2018. Two similar units began operating at the site in 2007, while construction of a fourth began in September 2013. Each of the VVERs is rated to produce 1060 MWe

Source: WNN
(Published: December 3, 2014)

Shin Wolsong-2 Fuel Loading Completed

South Korea's Shin Wolsong-2 has been loaded with its first core of nuclear fuel as it prepares for commissioning.

Fuel loading began at the 1050-MWe OPR-1000 reactor on November 14, 2014 after South Korea's Nuclear Safety and Security Commission (NSSC) issued an operating licence to Korea Hydro and Nuclear Power (KHNP) for the reactor on November 13, 2014. Fuel loading of the OPR-1000 reactor began the following day. The unit is scheduled to begin commercial operation in July 2015.

Inputs from WNN
(November 21, 2014)

KHNP staff celebrates the completion of fuel loading at Shin Wolsong-2 (Image: KHNP)

Vietnam Making Progress with Nuclear Power Programme, Says IAEA

An International Atomic Energy Agency mission reviewing Vietnam's nascent nuclear power programme found that the country has implemented some of the agency's earlier recommendations on siting, stakeholder involvement, environmental protection and industrial involvement, and is aware of what more needs to be done.

A team of experts, assembled at Vietnam's request by the IAEA to see how recommendations from an Integrated Nuclear Infrastructure Review (INIR) mission in 2012 are being implemented, carried out a follow-up INIR mission in November 2014.

INIR missions are designed to help IAEA member states assess the status of their national infrastructure for the introduction of nuclear power.

The review team noted the progress Vietnam has made since the previous mission. For example, there is now an approved national project on stakeholder involvement and many activities have been carried out in the last two years.

According to the IAEA, Vietnam concluded an intergovernmental agreement with Russia in 2010 and an intergovernmental arrangement with Japan in 2011, for the construction of nuclear power plants at different sites in Ninh Thuan.

Vietnam is planning to build four nuclear units in the southeastern province of Ninh Thuan.

Inputs from NucNet
(November 19, 2014)

'Major Turning Point' for Japan as Governor Approves Sendai Restarts

The governor of Japan's Kagoshima Prefecture on November 7, 2014 approved the restart of the Sendai-1 and 2 nuclear reactor units after they became the first in the country to meet new safety standards imposed after the March 2011 Fukushima-Daiichi accident, the Japan Atomic Industrial Forum (JAIF) said.

Yuichiro Ito's approval to restart the two pressurised water reactor units, owned and operated by Kyushu Electric Power Company, follows approvals announced last week from the mayor and the local assembly.

Various legal and technical procedures remain, with actual restarts expected at the beginning of 2015 at the earliest, JAIF said. "The decision nevertheless marks a major turning point."

In July 2014 Japan's Nuclear Regulation Authority (NRA) gave Kyushu Electric preliminary approval to restart the two units, pending local consultation and approvals.

The NRA said the station, in southwest Japan, met new safety standards designed to protect against everything from terrorist attacks to tsunamis like the one that led to meltdowns at Fukushima-Daiichi.

The new nuclear safety standards cover three main areas:

The Sendai nuclear station in Japan

design basis safety standards, severe accident measures and safety standards for earthquakes and tsunamis.

All of Japan's 48 operational reactors are offline while they undergo inspections to make sure they comply with new safety standards.

Sendai-1 and Sendai-2 are both 846-megawatt PWRs. Sendai-1 began commercial operation in July 1984 and Sendai-2 in November 1985.

Source: NucNet
(Published: November 7, 2014)

First Steam Generator for Leningrad-II

Installation of the first of the four steam generators at the Leningrad-II nuclear power plant in western Russia will be completed within the next few days, general designer of the new plant Atomenergoproekt (AEP) said on September 3, 2014.

Leningrad Phase II is a new nuclear power plant adjacent to the existing Leningrad nuclear plant site. Two AES-2006 design nuclear units are being built there, which should begin operation in 2016 and 2018 respectively. Two further AES-2006 units are planned for the site. Each AES-2006 unit will employ four steam generators.

Steam generators are used in pressurized water reactors to transfer heat from the reactor's primary coolant circuit to a secondary circuit – turning water into steam that goes on to drive turbines and generate electricity.

The steam generator is maneuvered into place (Image: AEP)

Inputs from WNN
(September 3, 2014)

International News

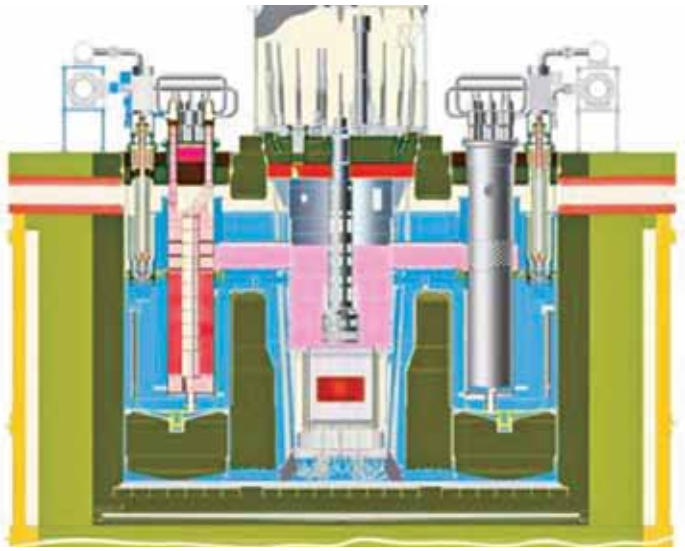
Design Completed for Prototype Fast Reactor

Russian power engineering R&D institute NIKIET has completed the engineering design for the BREST-300 lead-cooled fast reactor.

According to NIKIET parent Rosatom, more than 25 divisions of NIKIET plus 35 other nuclear industry organizations and companies have been involved in the two-year project to complete the technical design for the prototype reactor.

The BREST reactor – standing for bystry reaktor so svintsovym teplonositelem (fast reactor with lead coolant) – is seen as a potential successor to the BN fast reactor series. In 2012, Rosatom announced plans to build a demonstration BREST-300 unit and associated fuel facilities at the Siberian Chemical Combine in Seversk, near Tomsk. Construction of the pilot fuel production plant began at the site earlier this year, and work on the reactor is penciled in to begin in 2016.

The 300 MWe demonstration unit will use dense nitride uranium-plutonium fuel with lead as the primary coolant. The inherently safe reactor would be part of a closed nuclear fuel cycle, recycling used fuel indefinitely using on-site reprocessing and associated facilities. Longer-term plans foresee the 300 MWe unit as the forerunner to a 1200 MWe version for wide deployment as a commercial power generation unit. The development program is part of an Advanced Nuclear Technologies Federal Program 2010-2020 that seeks to exploit fast reactors as a way to be vastly more efficient in the use of uranium while 'burning' radioactive substances that otherwise would have to be disposed of as waste.



Design work on the BREST-300 has been completed (Image: NIKIET)

Fast reactors feature in long-term Russian plans which envisage moving to a closed fuel cycle. The BN-series of fast reactors includes the currently operating BN-600 Beloyarsk 3 unit and Beloyarsk 4, a BN-800 which started up in June and is expected to enter commercial operation in 2015. Design work is underway on the next in the series, the BN-1200.

Source: WNN
(Published: September 2, 2014)

Chinese Fast Reactor Completes Full-Power Test Run

China's experimental fast neutron reactor has been successfully operated at full capacity for the first time.

The Chinese Experimental Fast Reactor (CEFR) was brought to full power at 5.00 p.m. on December 15, 2014 and operated at this level continuously for three full days, China National Nuclear Corporation (CNNC) said on December 18, 2014.

The sodium-cooled, pool-type fast reactor was constructed with Russian assistance at the China Institute of Atomic Energy (CIEA), near Beijing, which undertakes fundamental research on nuclear science and technology. The reactor has a thermal capacity of 65 MW and can produce 20 MW

The CEFR (Image: CNNC)

in electrical power. The CEFR was built by Russia's OKBM Afrikantov in collaboration with OKB Gidropress, NIKIET and Kurchatov Institute.

The CEFR project was approved by the Chinese State Council in 1992, with final approval given in 1995. The China Experimental Fast Reactor is one of the major energy projects under the national high-tech research and development program of China's "National 863 Program". The China Institute of Atomic Energy (CIAE) is the organizer of the project's construction.

First concrete for the CEFR was poured in May 2000 at CIAE's Beijing site. The reactor achieved first criticality in July 2010 and was connected to the grid at 40% capacity a year later. Since then, various commissioning tests on the reactor, the turbines and of the sodium pumping system have been carried out at increasing power output levels. Materials and fuel irradiation tests have also been conducted over this period. So far the reactor has accumulated 438 hours of operation. CNNC said it expects "the first phase of testing" to be completed in the first half of 2015.

Xu Dazhe, head of the China Atomic Energy Authority and the State Administration of Science, Technology and Industry for National Defence (SASTIND), attended a ceremony to mark the end of the full-power trial operation of CEFR. He was quoted by the Xinhua news agency as saying, "The achievement has laid a solid foundation for fast reactor technology development, commercialization and nuclear fuel cycle technology development."

Source: WNN
(Published: December 19, 2014)

Russia Makes Fast Neutron Reactor Progress

Russia has announced two new milestones in its 'Proryv', or Breakthrough, project to enable a closed nuclear fuel cycle. The ultimate aim is to eliminate production of radioactive waste from nuclear power generation.

Siberian Chemical Combine (SCC), based in Tomsk, said yesterday it has completed testing of the first full-scale TVS-4 fuel assembly containing nitride fuel. The assembly is intended for the BN-600 fast neutron reactor, which is the third unit of the Beloyarsk nuclear power plant.

Vladimir Troyanov, chief production engineer of the Breakthrough project, said the materials used for the TVS-4 fuel assembly "possessed higher radiation stability that permits a substantial increase in its service life and, in turn, the efficiency of fast neutron reactors." The product that is to follow – TVS-5 – is being designed for the pilot demonstration reactor BREST-OD-300, which will built at the SCC site, Troyanov said. BREST-300 is a lead-cooled reactor system developed by the N A Dollezhal Research and Development Institute of Power Engineering (NIKIET).

Meanwhile, Krasnoyarsk-based Mining and Chemical Combine (MCC) said on September 16, 2014 it has produced the first industrial batch – 10 kg – of mixed-oxide (MOX) fuel. MOX is a mixture of plutonium and uranium dioxides. Tablets of the MOX fuel will enter serial production for use at the BN-800 fast neutron reactor, or unit-4 at the Beloyarsk plant, which is in the Sverdlovsk district.

TVS-4 fuel assembly (Image: SCC)

A MOX production line, now undergoing start-up and adjustment, was assembled in a mine 200 meters underground at the MCC site and is expected to become fully operational by the end of 2014.

SCC and MCC are both subsidiaries of Russian state nuclear corporation Rosatom.

Inputs from WNN
(September 19, 2014)

International News

Regulator Grants Russia's Kalinin-1 Life Extension Until 2025

Russia's nuclear regulator Rostechnadzor has approved the life extension of unit-1 of the Kalinin nuclear power station and has issued a new 10-year licence for the unit, Russian state nuclear corporation Rosatom has said.

This is the first time a modernisation and lifetime extension of a nuclear unit has been carried out in Russia and will see the Russian-designed VVER unit continue commercial operation until at least 2025, Rosatom said.

Kalinin nuclear power station (Source: Rosenergoatom)

The life extension project began in December 2009 and included modernisation and maintenance operations over five years.

The last set of repairs was carried out during an outage in early 2014, which completed the process for the issuing of a licence for extended operation until 2025.

Rosatom is now working on extending the lifetime of Kalinin-2, a project which is expected to be completed in 2016.

Kalinin nuclear power station has four commercially operational pressurised water reactors with a power capacity of 950 megawatts each. It is in the Tver region, about 170 kilometres northwest of Moscow.

Kalinin-1 and 2 began commercial operation in 1985 and 1987 and Kalinin-3 and 4 began commercial operation in 2005 and 2012.

Source: NucNet
(Published: July 2, 2014)

First US On-site Emergency Equipment Facility Completed

Construction has been completed of a "beyond design" dome at Dominion's North Anna nuclear power plant in Virginia. The dome – which will house emergency equipment and supplies – is the first of its kind in the USA.

The steel-reinforced concrete dome – with a diameter of 36.5 metres and a height of 11.5 metres – covers an area of 965 square metres. It features two hardened equipment doors. The building was designed by Engineering System Solutions (ES2) and constructed by American Business Continuity Domes (ABC Domes) and Dome Technology.

In response to the March 2011 accident at Japan's Fukushima Daiichi plant, the US Nuclear Regulatory Commission issued an order with specific requirements for mitigation strategies for beyond-design-basis external events. The "diverse and

The new domed storage facility at North Anna (Image: ABC Domes)

flexible coping capability" (or FLEX) strategy was an industry initiative announced in February 2012 to implement the NRC's Fukushima task force recommendations. The initiative includes the purchase of additional on-site portable equipment at every nuclear facility in the USA. The new equipment is to be stored at diverse locations and protected to ensure that it can be used if other systems that comprise a facility's multi-layered safety strategy are compromised.

Dominion's director of nuclear engineering Eric Hendrixson explained, "The concept of the FLEX program is assume everything is broken and have flexible equipment that you can tie into the various points in the plant."

"The dome shape means it is a blunt object, so that if there's heavy winds or storms or tornado, it has the tendency to flow off the round sides of the dome, as opposed to a flat surface," Hendrixson said. The dome is claimed to be capable of withstanding winds of up to 360 mph (580 km/h), "event driven missiles" and earthquakes.

A Dominion spokesman told World Nuclear News, "North Anna unit-2 is the first facility in the US to complete all required FLEX modifications, storage building, procedures and training."

Similar facilities are nearing completion at Dominion's other operating nuclear power plants. The dome at the Millstone plant in Connecticut is due to be completed by the end of this month, while that at the Surry plant in Virginia should be finished in December.

ABC Domes said it was working on seven more such domes for two other US nuclear utilities.

Source: WNN
(Published: October 27, 2014)

Core Catcher for Akkuyu

Russia has designed an advanced core melt trap, or core catcher, for the Akkuyu nuclear power plant that is specific to conditions in Turkey, Atomenergoproekt (AEP), the principal designer for the project, said on September 30, 2014.

A core catcher is a device provided to catch the molten core material – corium – of a reactor in case of a meltdown and prevent it from escaping the containment building.

Alexander Sidorov, head of AEP's integrated design bureau, introduced the design to Turkish workers on the Akkuyu project.

The core catcher for the Akkuyu project has features that include greater seismic robustness and easier installation than core catchers installed at other Russia-designed plants, Sidorov said, according to a statement by Rosatom. The "upgraded design" enables the reactor to withstand "greater safe shutdown earthquake loads" and to run without electricity supply for up to 72 hours, he said. It also has a "more efficient cooling system".

The new design will be 15% lighter than the core catcher installed at Novovoronezh nuclear power plant II in Russia. It will also take one month less to install.

Rosatom installed its first core catcher at Tianwan nuclear power plant in China and Kudankulam nuclear power plant in India. Leningrad II and Baltic nuclear power plant also have core catchers.

The devices are made by the Volgodonsk branch of AEM-Technology.

Rosatom signed an agreement in 2011 to build and operate a four-reactor plant in Mersin province on Turkey's Mediterranean coast, with the aim of having the plant fully operational by the Turkish republic's 100-year anniversary in 2023.

Construction work is currently expected to begin on the first of Akkuyu's four 1200 MWe Gidropress-designed AES-2006 VVER pressurized water reactors in 2015 or 2016. The first unit is to start operations in 2020.

Source: WNN
(Published: September 30 , 2014)

International News

South Africa and France Sign Nuclear Accord

South Africa has signed a civil nuclear cooperation agreement with France, opening the door to the possible deployment of French nuclear technology as South Africa looks to expand its nuclear power program.

The inter-governmental framework agreement signed by South African energy minister Tina Joemat-Petterson and French foreign minister Laurent Fabius covers areas including skills development, localisation of nuclear technology as well as research and development in South Africa. Ms. Joemat-Petterson signed a similar agreement with Russia in September, and an agreement with China is also due to be signed.

South Africa's two operating nuclear power plants at Koeberg, operating since the mid-1980s, were built by French company Framatome (now Areva). Ms. Joemat-Petterson said that South Africa was pleased to continue its long-standing cooperation with France. "This paves the way for establishing a nuclear procurement process," she said, adding that South Africa intends to sign similar agreements with "the remaining nuclear vendor countries" as it prepares for a program to build up to 9.6 GWe of new nuclear capacity.

France also pointed to the two countries' joint experience at Koeberg. A statement issued by Fabius's ministry said the nations shared the "common goal" of allowing South Africa to meet its energy needs while sharing French expertise.

In a statement, French nuclear company Areva welcomed the agreement, describing it as an "important factor" for future South African nuclear projects. "Areva is ready to support this development, notably through its Generation III+ EPR reactor technology," the company said.

Nuclear energy features heavily in South Africa's long-term plans to secure a sustainable energy mix. The country's 2010 Integrated Electricity Resource Plan envisages up to 9.6 GWe of new nuclear capacity by 2030, and earlier this year the country allocated ZAR850 million ($81 million) – over 10% of its energy ministry's budget – to nuclear research and development.

Source: WNN
(Published: October 14, 2014)

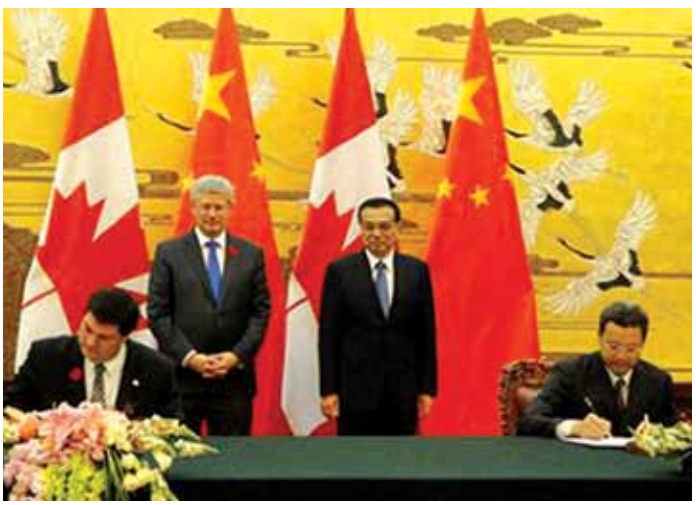
China and Canada Expand Cooperation

China and Canada have signed an expanded memorandum of understanding on nuclear cooperation, while the China National Nuclear Corporation (CNNC) and Candu Energy have agreed to cooperate on nuclear fuel development.

The expanded memorandum of understanding was signed in Beijing by Hon'ble Canadian Prime Minister Stephen Harper and Hon'ble Chinese Premier Li Keqiang on November 8, 2014.

According to the Canadian prime minister's office, it "underscores" the two countries' commitment to "broadening cooperation in a wide range of nuclear activities, including nuclear energy policy, research and development, and resource utilization for civilian purposes." The agreement aims to facilitate the joint development of "new markets and alternative fuel cycles using CANDU technology and resources such as thorium."

Mr. Harper and Mr. Li then witnessed the signature of



Hon'ble Prime Minister Stephen Harper and Hon'ble Chinese Premier Li Keqiang witness the signature of the CNNC-Candu Energy joint venture (Image: CNNC)

the agreement between CNNC and Candu Energy, which according to CNNC will see the companies work together to build Advanced Fuel CANDU Reactor (AFCR) projects in China and develop global opportunities for the technology.

An expert panel hosted by the China Nuclear Energy Association had previously made a positive recommendation on the AFCR technology, praising the reactor's safety characteristics and highlighting the role it could potentially play in a closed fuel cycle, reusing used fuel from light water reactors.

Candu Energy president and CEO Preston Swafford said the company looked forward to working with CNNC on AFCR technology.

"Taken together, the MOU, framework JV and positive recommendation by a Chinese expert panel represents a new level of cooperation between Canada and China in the next wave of nuclear energy innovation," he said.

Source: WNN
(Published: November 10, 2014)

Nuclear Park Generates 19.7% of Spain's Electricity

Spain's seven commercially operating power reactors generated 19.7 percent of the country's total demand for electricity in 2013 and had an average availability factor of 89.4 percent, industry group Foro Nuclear said.

Foro Nuclear said nuclear's 19.7 percent share of generation compared to 14.7 percent for coal, 11.8 percent for hydro and 19.3 percent for wind.

The seven units generated a total of 56.7 terawatt hours. Nuclear's installed capacity of 7.86 gigawatts accounted for 7.3 percent of the country's total installed capacity, according to Foro Nuclear.

In terms of nuclear fuel, Spain exported 60 percent of the 351.5 tonnes of uranium (tU) it produced in 2013 and Spanish reactors consumed 178 tU. The main destinations for exported fuel were France, Belgium and Sweden.

Nuclear fuel in Spain is produced by Enusa at its production facility in the province of Salamanca.

Foro Nuclear said the internationalisation of Spain's nuclear industry is a trend that has taken hold in recent years, helped

Santa María de Garoña nuclear power station

by the growth of the global market, regulatory certainty and regulatory stability.

Foro Nuclear president Antonio Cornadó said nuclear energy helps achieve long-term security of supply with reliable fuel supply at "competitive and predictable prices".

Inputs from NucNet
(July 16, 2014)

Polish Public Supports Nuclear Plan

Public support for the construction of Poland's first nuclear power plant has soared to 64%.

The Polish Institute of International Affairs' (PISM's) findings are based on quantitative research it carried out earlier this year, based on data gathered through face-to-face interviews with a random, representative sample of 1000 Polish citizens. Of the 64% supporting Polish plans for a nuclear power plant, 57% cited its potential for providing increased energy independence for the country as a reason for their support. Economic benefits were less frequently cited: 42% of pro-build respondents cited employment opportunities, while 26% and 24% respectively cited technological progress or the involvement of Polish companies in the project.

The PISM report describes the increasing recognition of the

importance of energy independence as "understandable" given the country's "over-reliance on Russian energy resources, i.e., oil and gas." Relatively low support for the development of shale gas extraction and the development of coal-based technologies as potential options to ensure energy security "may signify that Poles are persuaded that regardless of Warsaw's diversification efforts, continued reliance on fossil fuels will inevitably perpetuate energy dependence on Moscow," it notes. Some 63% of those in favour of the nuclear option said they would support investment in nuclear capacity for Poland even if the country could meet its energy demand by buying low-priced power from its neighbours.

The study found that the most prominent group among those supporting the construction of a nuclear plant was young, highly-educated individuals with higher incomes living in the largest cities. The study also found a clear regional pattern, with the highest support for nuclear coming from those in the east of the country.

Poland's energy policy plans include operating nuclear power plants from about 2025 as it moves away from its current heavy dependence on coal and imported gas. Utility Polska Grupa Energetyczna (PGE) plans to install around 3000 MWe of nuclear capacity at one of three potential sites, with the first unit coming online by 2025.

Inputs from WNN
(August 26, 2014)

Low-Carbon Displaces Coal in Poland's Plan

Poland will reduce dependence on brown and black coal by introducing nuclear power and renewables, according a draft energy policy to 2050 released for consultation.

The Polish government put forward two main scenarios for future energy supply. Both see nuclear power introduced in 2020 and expanding to become "an important element of the energy sector after 2025", along with renewable sources.

One forecast has nuclear power producing 50 TWh per year from 2035 – in line with the government's ambition to build two nuclear power plants with capacity of 3000 MWe each. At the same time, renewables grow to about 60 TWh per year in 2035 and on to about 75 TWh by 2050.

Another scenario has nuclear growing more quickly and by 2050 producing 74 TWh per year, while renewables expand more gradually to 49 TWh in 2050.

What both scenarios have in common is that the total low-carbon generation from nuclear and renewables reaches around 125 TWh per year in 2050, and the consumption of coal drops by close to 40%.

Poland's plan for new nuclear is being taken forward by PGE EJ1, a project company of Polska Grupa Energetyczna (PGE), which owns 70% of the shares on its own and through a nuclear subsidiary. Equal 10% stakes in PGE EJ1 are held by copper miner KGHM (Kombinat Górniczo-Hutniczy Miedzi), and power utilities Tauron Polska Energia and ENEA.

Presently brown and black coal fuels over 90% of Polish

Belchtow coal mine and power plant (Image: Greenpeace Polska - Bogusz Bilewski)

electricity, and the country suffers some of the worst air quality in Europe. According to the European Environment Agency, concentrations of damaging PM_{10} particulates, which can cause cardiovascular and respiratory problems, regularly exceed daily and annual limits in cities.

The Polish government published the draft energy policy to 2050 on August 14, 2014 and the consultation runs until September 1, 2014.

Source: WNN
(Published: August 21, 2014)

IPCC Calls for Zero Carbon by 2100

The world needs to take stringent action to move to a low-carbon economy before the end of the century to avoid severe impacts from warming of the climate, according to the final installment of the fifth assessment report from the Intergovernmental Panel on Climate Change (IPCC).

The Synthesis Report released by the IPCC on November 2, 2014 draws together the findings of the fifth assessment report released in stages over the past 13 months. With over 800 lead authors and editors from over 80 countries drawing on more than 30,000 scientific papers, the IPCC describes it as the most comprehensive assessment of climate change ever undertaken.

The report notes that multiple mitigation pathways are available that could limit warming to below 2°C relative to pre-industrial levels, all of which would require substantial emissions reductions over the next few decades and near-zero emissions of CO_2 and other long-lived greenhouse gases by the end of the century.

> **"It is technically feasible to transition to a low-carbon economy. But what is lacking are appropriate policies and institutions."**

Most of the scenarios offered up to achieve this goal require the global share of low carbon options for electricity supply – nuclear, renewables and carbon capture and storage (CCS) – to increase from current levels of 30% to reach 80% by 2050, with fossil fuel generation without CCS almost entirely eliminated by 2100. There is no single solution: to be most cost-effective, mitigation needs to use a combined approach including measures to reduce energy use, reduce net emissions and enhance carbon sinks in land-based sectors as well as decarbonizing energy supply. However, the report does acknowledge that excluding certain mitigation technologies – such as nuclear – from the mix would lead to substantial increases in mitigation costs.

The IPCC documents note that virtually all energy options have related issues affecting their uptake or implementation, including those related to public perception. The primary issues highlighted for nuclear energy are anxieties focusing on health, safety and proliferation.

There is no time to waste: delaying additional mitigation until 2030 will substantially increase the challenges associated with limiting warming over the 21st century to below 2°C. "It is technically feasible to transition to a low-carbon economy. But what is lacking are appropriate policies and institutions," said co-chair of IPCC Working Group III Youba Sokona. "Compared to the imminent risk of irreversible climate change impacts, the risks of mitigation are manageable," Sokona added.

Options are available to keep climate change impacts within a manageable range while allowing for continued economic and human development, according to IPCC chair Dr. R. K. Pachauri. "All we need is the will to change, which we trust will be motivated by knowledge and an understanding of the science of climate change," he said.

Adaptation and mitigation are seen as complementary strategies for reducing and managing the risks of climate change. As well as reducing climate risks, limiting emissions over the next few decades will also increase the prospects for effective adaptation to climate change and reduce the costs and challenges of mitigation in the longer term, the report notes. Without additional mitigation efforts beyond those in place today, even allowing for adaptation, warming by the end of the 21st century will lead to high risk of severe, widespread, and irreversible global impacts.

The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP), endorsed by the United Nations General Assembly, and is the world body for assessing the science related to climate change. Its mission is to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

Source: WNN
(Published: November 3, 2014)

Nuclear Industry Shares IEA Concern

The World Nuclear Association (WNA) "shares the concern" of the International Energy Agency (IEA) that urgent action will be needed to steer the world's energy system onto a safer, low-carbon path.

In the 2014 edition of its World Energy Outlook (WEO) issued in London on November 12, 2014, the IEA said that nuclear power is one of the few options available at scale to reduce carbon dioxide emissions while providing or displacing other forms of base load generation. It has avoided the release of an estimated 56 gigatonnes of CO_2 since 1971, or almost two years of total global emissions at current rates.

The WEO incorporates all the latest data and developments to produce a comprehensive and authoritative analysis of medium- and longer-term energy trends. The latest edition includes a special focus on nuclear energy.

"...the IEA said that nuclear power is one of the few options available at scale to reduce carbon dioxide emissions while providing or displacing other forms of base load generation. It has avoided the release of an estimated 56 gigatonnes of CO_2 since 1971..."

WNA Director General Agneta Rising said: "The IEA's central scenario would set us on a path of a dangerous increase in global temperatures. We must act to switch to cleaner and more affordable energy sources. Nuclear is a cost-effective way of producing reliable low-carbon electricity on a large scale and must form an increasing part of the world's energy supply if we are to get serious about addressing climate change."

Policies concerning nuclear power will remain an "essential feature" of national energy strategies, even in countries which are committed to phasing out the technology and that must provide for alternatives, the WEO said.

Global nuclear power capacity increases by almost 60% in the IEA's central scenario, from 392 GW in 2013 to over 620 GW in 2040. However, its share of global electricity generation that peaked almost two decades ago rises by just one percentage point to 12%.

Of the growth in nuclear generation to 2040, China accounts for 45% while India, Korea and Russia collectively make up a further 30%. Generation increases by 16% in the USA, rebounds in Japan (although not to the levels prior to the accident at Fukushima Daiichi) and falls by 10% in the European Union.

"Despite the challenges it currently faces, nuclear power has specific characteristics that underpin the commitment of some countries to maintain it as a future option," it said. "Nuclear plants can contribute to the reliability of the power system where they increase the diversity of power generation technologies in the system. For countries that import energy, it can reduce their dependence on foreign supplies and limit their exposure to fuel price movements in international markets."

Annual emissions avoided in 2040 due to nuclear power (as a share of projected emissions at that time) reach almost 50% in Korea, 12% in Japan, 10% in the USA, 9% in the European Union and 8% in China. The average cost of avoiding emissions through new nuclear capacity depends on the mix and the costs of the fuels it displaces, and therefore ranges from very low levels to more than $80/tonne.

Paris-based IEA is an autonomous organization, which "works to ensure reliable, affordable and clean energy for its 29 member countries and beyond".

Inputs from WNN
(November 12, 2014)

Special Article

Dr. Ratan Kumar Sinha, Chairman, Atomic Energy Commission, and Secretary, Department of Atomic Energy, addressing the delegates during IAEA conference

International Atomic Energy Agency 58th General Conference, Vienna

September 24, 2014

Statement by Dr. Ratan Kumar Sinha

Chairman, Atomic Energy Commission
and
Secretary, Department of Atomic Energy

Mr. President, Excellencies, Ladies and Gentlemen,

It gives me great pleasure to congratulate you, Mr. President, on your election as the President of the 58th General Conference. Under your able leadership, I am sure the current General Conference will accomplish all the tasks laid before it.

India welcomes the four new Members to the IAEA, and I take this opportunity to congratulate Union of Comoros, Republic of Djibouti, Cooperative Republic of Guyana, and Republic of Vanuatu on the occasion of their joining the IAEA family.

Mr. President,

The current year marks several important milestones for the Indian atomic energy programme. The Department of Atomic Energy (DAE), established on August 3, 1954, completed sixty years of service this year. The year 2014 is also the Golden Jubilee year of India's first reprocessing plant called 'Plutonium Plant', which was the first step in the second stage of Indian nuclear power programme, that uses plutonium based fuel in Fast Breeder Reactors. At the beginning of this year, we reached the milestone of the fortieth anniversary of the commissioning of ISOMED, India's first gamma radiation processing plant for sterilisation of medical products. This plant was set up at BARC, Mumbai with the help of UNDP and the IAEA.

On August 6 this year, the Unit No. 5 of the Rajasthan Atomic Power Station (RAPS 5) achieved a record of 765 days of continuous operation, the highest in the world in the last two decades, and the second highest in the entire history of nuclear power. I would like to inform you that with the sale of electricity produced by this plant in approximately four and half years of commercial operation, it has already recovered its cost of construction. RAPS-5 has avoided about 4.25 million tonnes of carbon-dioxide emission, in its dream run.

The first unit of the Kudankulam Nuclear Power Plant which achieved its first criticality in July last year is now operating at close to its full rated power of 1000 MWe. The second unit is in an advanced stage of commissioning.

The construction of the 500 MWe Prototype Fast Breeder Reactor (PFBR) is nearing completion at Kalpakkam. The erection of all critical, permanent in-core components has been completed. The reactor is now expected to achieve first criticality in about six months from now.

Next month, at Indira Gandhi Centre for Atomic Research, India will be hosting the IAEA Technical Meeting on the Construction and Commissioning of Fast Reactors.

India continues to attach high priority for R&D on all aspects of Thorium-related reactor technologies and allied fuel cycle. The process of selection of a site for construction of AHWR is in an advanced stage.

The performance of several Indian fuel cycle facilities reached their highest levels last year. Thus, PHWR fuel production achieved an increase of 18% over the previous year, and the highest ever production of heavy water was achieved with the lowest specific energy consumption.

A protocol additional to the agreement between India and the IAEA for the application of safeguards to Indian civilian nuclear facilities entered into force on July 25, 2014.

Mr. President,

As part of India's commitment to

implement the highest standards for the safety of Indian nuclear power plants, several steps have been taken in the recent past to organise peer reviews at national and international level. I wish to inform you that a 'follow up mission' of the IAEA Operational Safety Review Team (OSART) to India for Rajasthan Atomic Power Station (RAPS) units - 3&4, took place during February 3 - 7, 2014. The team assessed that in many cases the station has done much more than what was intended in the OSART observations.

A visit of a preparatory team of IAEA's Integrated Regulatory Review Service (IRRS) for peer review of India's nuclear regulatory system is planned during October 7-8, 2014. Earlier, the Indian Atomic Energy Regulatory Board (AERB) held a Workshop in March 2014, involving the participation of experts from the IAEA, for planning the compilation of documents and allied requirements for receiving the IRRS mission to India, envisaged early next year (March 2015).

India appreciates the significant progress made by International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) over the years. The INPRO methodology for assessment of innovative nuclear reactors and fuel cycles provides an opportunity for developing acceptance criteria for new designs, inter alia, addressing innovative capabilities for enhanced safety.

Mr. President,

India is pleased to note that the Director General has chosen to organise the Scientific Forum this year on the important topic of "Radioactive Waste: Meeting the Challenge". In this connection, I would like to reiterate that the Indian policy of employing a 'closed nuclear fuel cycle' not only ensures better utilisation of the nuclear fuel resources, but also greatly minimises the quantity of nuclear waste. The 2014 Scientific Forum will provide an opportunity for countries to share their experience in this important area, which will also go a long way in allaying one of the major concerns of nuclear energy.

The commissioning of Actinide Separation Demonstration Facility of BARC at Tarapur, has taken India to be one of the two advanced nuclear countries who could demonstrate separation of minor actinides from the High Level Waste (HLW). This approach would help in reducing substantially the life of the radioactive waste, from around 1000 years to about 300 years, as well as the volume of HLW requiring long-term storage. Furthermore, technology has been developed and demonstrated for the removal of highly radioactive Caesium-137 and its conversion to vitrified pencil source, usable for blood irradiator and similar low dose rate radiation applications. Removal of actinides and Caesium-137 addresses several technical issues on the storage of high level waste in a cost-effective and sustainable manner.

In this context, I would like to draw your attention to the exhibition set up by India on our technological advances in the area of nuclear waste management. I cordially invite all Delegations to visit the exhibition.

Mr. President,

Non-power applications of nuclear and radiation technologies in the area of health-care, water, industry and environmental protection continue to expand, delivering important benefits to the society. We have been a strong supporter and contributor to the Regional Cooperation Agreement (RCA) initiative right from its inception, and India is the RCA Lead Country in the area of industrial applications and cancer treatment for the past several years.

Complemented with irradiation as a quarantine treatment, a chemical dip treatment has been developed by BARC for extended preservation of Lychee fruit (which has only a short shelf-life otherwise) and this technology has been transferred to traders in India and to one party in Madagascar.

As a part of continuing efforts towards development of cost effective and efficient modalities for early diagnosis and treatment of cancer, the Tata Memorial Centre (TMC), an autonomous institution under DAE, in collaboration with BARC, has established techniques, using commercially available monoclonal antibodies, to deliver radioisotopes to specific sites for imaging and also for treatment of tumors.

This practice has, in particular, been found to be very effective in cases of Non-Hodgkin's Lymphoma in reducing the duration of treatment from 9 months to 1 month.

India appreciates the IAEA's sustained efforts to support cancer management, and in particular through the Programme on Action for Cancer Therapy (PACT). India looks forward to continuing expansion of activities under the PACT initiative.

India also appreciates the efforts of the IAEA Director General to mobilise support for the proposed modernisation of the nuclear applications laboratories of the IAEA.

In addition to the activities related to nuclear energy and non-power applications, India continues to make good progress in developing high technology in many important areas, including nuclear fusion and accelerator related technologies.

Mr. President,

As part of implementation of the Arrangement with the IAEA concerning India's voluntary contribution to the Nuclear Security Fund, the services of an Indian cost-free expert in information security are being provided to the Division of Nuclear Security of the IAEA.

In the same context, and under the auspices of the Global Centre for Nuclear Energy Partnership (GCNEP) initiative, a Regional Training Course on 'Vulnerability Analysis of Physical Protection Systems', was held last week in Mumbai.

As a measure to further enhance preparedness to address radiological emergencies, a high throughput 'Quick Scan-type Whole Body Monitor (WBM)' has been developed to quickly measure internal contamination in human beings. With a counting time of one minute, the system can detect inhaled or ingested gamma emitters delivering less than 10 micro-Gray effective dose. With a rate of monitoring fifty individuals per hour, this system will serve as a valuable tool for quickly screening potentially affected individuals in case of a radiological emergency in public domain. For the prevention and response to radiological emergencies, including threat of Radiological Dispersal Device (RDD - 'Dirty Bombs'), a 'Quad-rotor based Aerial Radiation Monitoring System (QARMS)' has been developed. This system can be used for search of 'Orphan Radioactive Sources' and assessment of any spread of radioactive contamination, following radiological emergencies, by flying at low altitudes of five to fifty metres and can be remotely controlled from a distance of five hundred metres.

Mr. President,

In my address to the IAEA General Conference last year, I had pointed out on the role that nuclear energy is destined to play in meeting the electricity as well as non-electricity needs of the mankind, and made a plea to make a concerted effort to pool and support the international knowledge resources and research to arrive at safe, economic and sustainable solutions, when the time comes.

In a similar context, in 2006, while I was chairing the Meeting of the INPRO Steering Committee, I made the following observation, which was also published in the IAEA - NENP newsletter.

I quote:

"Four decades from now, in any country of the world, it should be possible to start replacing fossil fuelled power plants, at the same urban or semi-urban sites where these are located, with advanced NPP that would, more economically, deliver at least twice the power that was being produced by the replaced plants."

Unquote

There is no doubt that the modern reactor technologies would meet the required standards of safety, environmental releases and economics, for achieving the above objective. However, to realise such a vision, it will be also necessary to consider, in parallel, the need for the development of scientifically validated basis for radiation protection regime.

Decades of studies on populations exposed to high radiation, and recent advanced research in radiobiology carried out in different parts of the world provide evidence that radiation-induced damage and repair mechanisms are distinctly different at cellular and tissue levels, and for low dose and high dose rates. With the current status of development and availability of advanced research tools, I am sure, given the required resources and priority to address any residual doubts through advanced research, a science-based, firm recommendation can be made to remove any undue conservatism in radiation protection limits.

The human population living in Kerala coast in South west India is continuously exposed to natural background radiation emanating from the monazite-bearing sand, with the dose varying up to a high of 45 mGy per year in the High Level Natural Radiation Areas (HLNRA), compared to less than 1.5 mGy per year in some other places in the same area (that is similar to Normal Level Natural Radiation Areas, NLNRA). As a part of on-going research of screening newborns in these areas in India, the studies have now exceeded 160,000 newborns; these studies did not reveal any statistically significant difference in the frequency of any type of malformations and stillbirth after adjusting for the confounding factors such as maternal age at birth, consanguinity, ethnicity, etc., and frequency of Down syndrome. Adaptive response studies are in progress using end points such as chromosome aberration, micronuclei and gene expression pattern.

An accelerated and conclusive scientific research, on the matter of health effects of radiation, would allay the perceived or misplaced concerns on nuclear energy in some sections of the society, as well as lead to more wide-spread use of life saving radiation-based diagnostic modalities at affordable costs, as for example, nuclear medicine procedures such as PET imaging.

The IAEA should take the lead in this direction, along with other international bodies like UNSCEAR, ICRP and WHO, by organising an international symposium for scientific discussions and to arrive at a consensus on the current state of understanding on the effect of low dose radiation on human health, and identify any residual gap areas that need further scientific research.

Mr. President,

Before concluding, I wish to share with great pride the news that India's maiden Mars mission, Mangalyaan, successfully entered the planet's orbit today, in a historic moment for India's space programme.

Thank you, Mr. President.

Non-destructive Testing of Aluminum Alloy Casting Fan Blades for 700-MW PHWR Primary Recirculating Pump Motors

Dipankar Bej, SEE, NPCIL HQ, Kolkata QA Office

Introduction

Primary recirculating pump (PCP) is the main pump for the primary heat transport system, used to transfer the heat from reactor core to steam generator when reactor is in on-power mode of operation. These pumps are driven by 6.6-kV heavy-duty motors.

Figure 1: Blades mounted on rotor

These motors are squirrel cage type electric motors, and to keep the inside of the motor cool, driving-end and non-driving-end fan blades are mounted on the fan hub of the rotor at the respective sides. The rotor rotates with the fan blades and air circulation takes place.

The fan blades are manufactured from aluminum-alloy die-casting process and subsequently machined to the required shape. When aluminium alloys are cast, there are many potential sources of defects that can harm the quality of the part cast. All aluminium alloys are subject to some volumetric defects like shrinkage cavities, gas porosity, gas holes, etc. and some surface defects like surface porosity, surface crack, hot tears, cold shut, blow holes, etc. Different non-destructive testing (NDT) methods are applied to identify the volumetric and surface discontinuity. The volumetric discontinuities are identified by the radiography NDT method and surface discontinuities are identified by the liquid penetrant (LP) test NDT method. Depending upon the size and severity of discontinuity, the defects are identified, and as per acceptance standard the cast product is considered as accepted or rejected.

Manufacturing of Fan Blades

The composition of the fan blade material is mainly Al and 10% to 13% of Si, along with Cu 0.1%, Mg 0.1%, Fe 0.6%, Mn 0.5%, Ni 0.1%, Zn 0.1%, Pb 0.1%. This type of aluminum alloy is called LM6 alloy. Pure aluminium melts at 660.4°C. It is not suitable for casting and is only used for electrical applications (where high conductivity is essential) and a few other special applications. Most casting alloys contain silicon as the major alloying element. Silicon forms a eutectic with aluminium at 11.7% Si at 577°C temperature. Silicon additions improve casting characteristics by improving fluidity, feeding and hot tear resistance. The silicon-rich phase is hard, so the hardness of the alloy is increased with Si content but ductility and machinability are reduced. The eutectic alloys have the highest fluidity for a given casting temperature, and having a short freezing range, they solidify with primary shrinkage. They are good for thin-section castings. The fan blades being a thin section, items are manufactured by gravity die-casting. The molten metal is poured under gravity into a refractory-coated permanent mould or die. The technique is sometimes known as “permanent mould” or “chill” casting. The dies are made of a fine-grained, pearlitic cast iron or low-alloy steel. Simple retractable cores may be made of high-grade alloy steel, but resin-bonded sand cores are used to produce complex internal shapes. The LM6 alloys are very much suitable for the die-castings. A gravity or low-pressure die-casting must be metallurgically sound, have good surface finish and be easily and rapidly produced. To achieve this, the die must be coated. After die-casting, the cast blades are machined by different machining process to give required shape and finished blade profile.

Possible Discontinuities during Manufacturing

When aluminium alloys are cast, there are many potential sources of defects

that can harm the quality of the cast part. All aluminium alloys are subject to:

Shrinkage defects: Aluminium alloys

Figure 2: Cast and machined blade

shrink by 3.5–6.0% during solidification (depending on alloy type).

Gas porosity: Molten aluminium readily picks up hydrogen, which is expelled during solidification, giving rise to porosity.

Oxide inclusions: Molten aluminium exposed to air immediately oxidises forming a skin of oxide, which may be entrained into the casting.

In addition to the above common defects, the aluminium alloy castings are subject to some surface defects like Surface porosity, surface crack, cold shut, hot tears, blowholes, etc.

The process has, in principle, all the features necessary to produce castings of good quality, both metallurgically and dimensionally. The metal is drawn from the bottom of a bath of molten alloy, avoiding the contaminated surface layer. The mould is filled gently without turbulence, thus avoiding oxide/Gas entrapment. Solidification is directional, enabling constant feeding of the casting. Mechanical casting extraction avoids damage to the die so as to maintain dimensional accuracy throughout the life of the die.

Quality Checks of Fan Blades

During casting and subsequent machining of blades, discontinuity may occur on the surface and inside the surface of the cast. The dimensional accuracy also depends on casting process and subsequent machining. The dimensional accuracy is ascertained by checking the dimension of blades and comparing it with drawings. The surface discontinuities are checked by liquid penetrant test method. The subsurface and inside discontinuities are checked by Radiography (X-Ray) of the blades. The chemical composition of the blade is found out by mass spectrometry and the mechanical strength is found out by testing the test bar at UTM.

Radiography (X-Ray) of Cast Blades

Radiography of aluminum casting products is done to find out the internal discontinuities presents inside the casting. ASTM E-155 Standard reference radiographs are used for the inspection of aluminum casting. These reference radiographs illustrate the types and degrees of discontinuities that may be found in aluminum-alloy casting. The castings illustrated are in thicknesses of ¼ in and ¾ in. In the following example, X-Ray was used here as the source of radiography of aluminum cast blades. The focal spot dimension was 2 mm x 2 mm, and rated

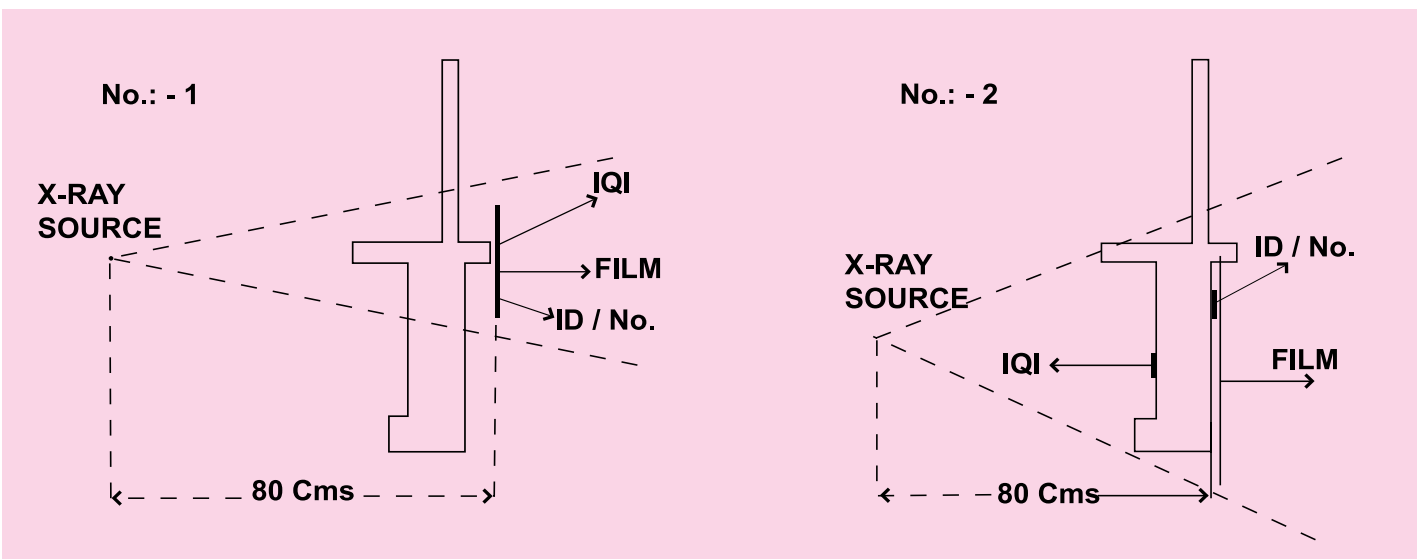


Figure 3: Shooting sketch, film and source position for thick portion

capacity up to 250 kV—5 mA. The film used was AGFA D4 ASTM-CL-1. The shooting sketches are given below.

The geometrical un-sharpness (Ug), calculated as 0.04 mm, was well below the maximum permissible limit of 0.5 mm as per standard. The wire-type image quality indicator (IQI) was used as per ASME SE-747 for material group no. 02 and set A & B. The exposure given was 180 kV, 10mA-minutes for single wall single image on average. The film density was minimum 1.5 on interested area. The sensitivity, calculated as 1.14%, was better than the allowable 2%.

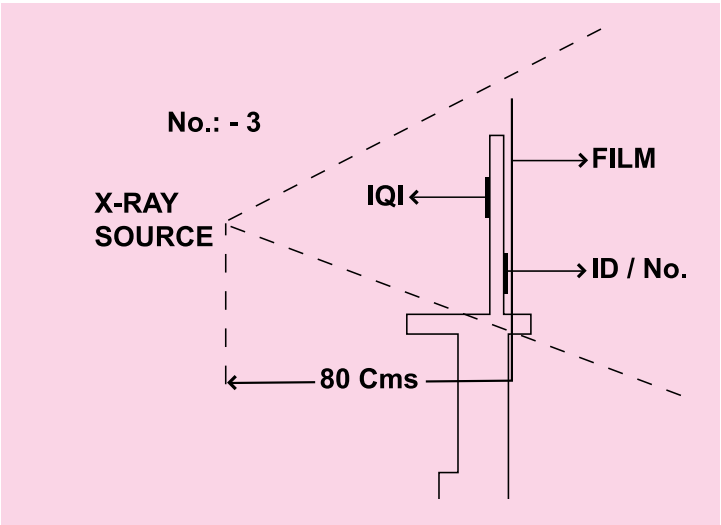


Figure 4: Shooting sketch, film and source position for thin portion

Some discontinuities and the corresponding radiographs are mentioned here.

Foreign material: Appear as isolated, irregular or elongated variation of film density. They may be due to the presence of slag, sand or metal. The appearance of foreign material on blade and the corresponding radiographic film are shown in Figure 5.

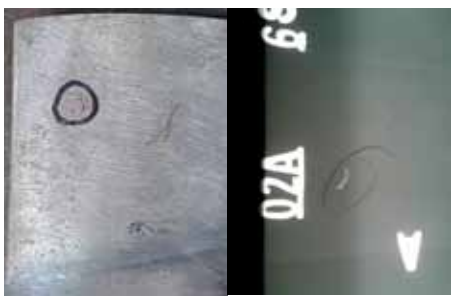


Figure 5: Foreign material on blade and the corresponding radiographic film

Gas porosity: Represented by round or elongated dark spots corresponding to minute voids usually distributed through the entire casting. The appearance of gas pore on blade and the corresponding radiographic film are shown in Figure 6.

Figure 6: Gas pore on blade and the corresponding radiographic film

Gas holes: Appear as round or elongated, smooth-edged dark spot occurring individually, in clusters or distributed throughout the casting. The appearance of gas holes on blade and the corresponding radiographic film is shown in Figure 7.

Figure 7: Gas holes on blade and the corresponding radiographic film

Shrinkage cavity: Appears dendritic, filamentary, or jagged darkened area. The appearance of shrinkage cavity on blade and the corresponding radiographic film is shown in Figure 8.

In all, more than 2700 X-Ray films were reviewed to complete the job of manufacturing of blades.

Liquid Penetrant Test of Cast Blades

Liquid penetrant testing is carried out to find out the surface defects (defects which are open to the surface) of the cast blades. Colour-contrast solvent-removal liquid penetrant is applied on the surface to be examined and allowed to enter into the discontinuities. Excess penetrant is removed by solvent cleaner. A non-aqueous developer is applied over the surface. The developer functions both as a blotter to absorb penetrant that has been trapped in discontinuities and as a

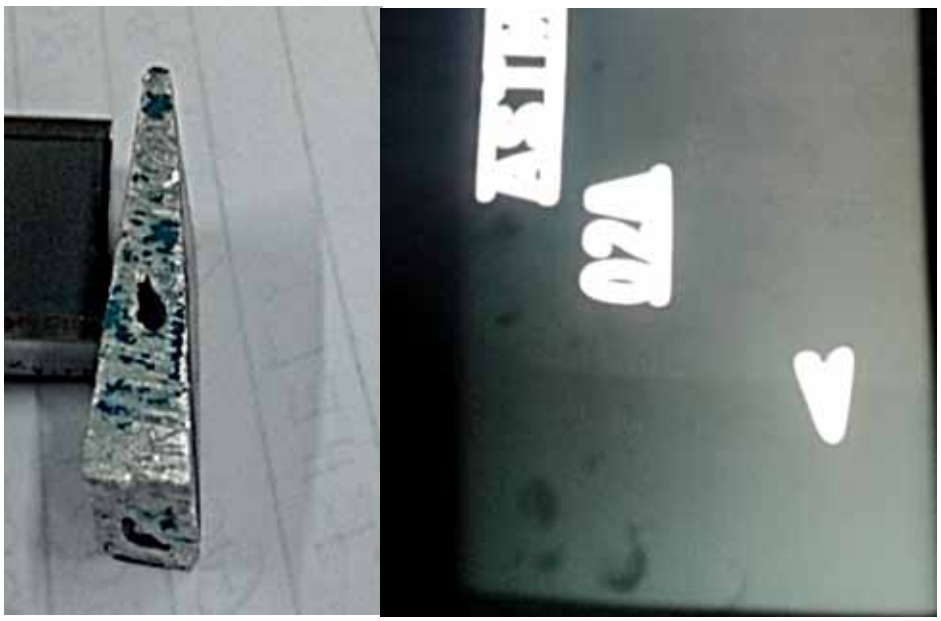


Figure 8: Shrinkage cavity on blade and the corresponding radiographic film

contrasting background to enhance the visibility of penetrant indications. The surface of the blade is prepared as per procedure before liquid penetrant test. Suggested penetration time for this type of penetrant for aluminum casting blades is 5 to 10 minutes for defects like porosity, cold shut, cracks, etc. The indications are categorised into three types:

a) **Circular indications:** These are more or less elliptical, with major axis not more than three times the minor axis,

b) **Linear indications:** Those with length in excess of three times the average width, and

c) **In-line indications:** Those that are in a group of three or more indications aligned side by side in line with intervening gaps of less than 2 mm, measured edge to edge.

The evaluation of indication is done according to acceptance criteria laid out in procedure.

Acceptance Criteria for Discontinuities

During NDT, many relevant and non-relevant indications come. They are distinguished, and the relevant indications that come from discontinuities are evaluated for acceptance or rejection as per severity levels. In this specific case of Aluminum alloy cast blades:

For radiography evaluation, as per acceptance criteria of procedure and specification, any indication coming from the discontinuities and above ASTM E-155 severity level III is unacceptable and considered as defect.

Figure 9: DP indication from a blowhole

For liquid penetrant test evaluation, as per acceptance criteria of procedure and specification, any indication coming from the discontinuities and above severity level II as stated in respective specification is unacceptable and considered as defect.

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Implementation of Wear Particle Analysis (Ferrography Technique) at Indian NPPs for Proactive Maintenance

V.N. Konda, SEE (M), NPCIL HQ, **Jyoti Thakur,** SEE (E), NPCIL HQ, **A.K. Sinha,** CE (M-NS) H+, NPCIL HQ

Introduction

The purpose of the plant predictive maintenance (PdM) programme is to improve plant safety and reliability through early detection and diagnosis of equipment problems and prevent degradation, prior to equipment failure. Of the many techniques available for predictive maintenance, ferrography wear particle analysis (WPA), or ferrography, is one such technique.

Condition monitoring techniques and predictive maintenance programme allow detection, identification and evaluation of the deviating parameter at the very incipient stage, so that degradation is attended and timely mitigatory actions can be initiated. Non-destructive examinations play a key role in the health assessment and aging management of nuclear power or process plants.

Ferrography is a branch of tribology. Tribology is the science concerned with the design, friction, lubrication and wear of contacting surfaces that move relative to each other.

Ferrography is a state-of-the-art technology for proactive maintenance for industries, where large number of rotating and reciprocating machineries is in operation. Though wear is an accepted part of running machinery, and each machine produces a definite range of wear particles during normal wear but some wear mechanism are abnormal and accelerating, which may lead to machine failure. Accelerated wear takes place due to excessive speed, load and shock. For example, overloading of air filters can lead to premature failure of oil-wetted parts.

Ferrography is a diagnostic predictive maintenance tool that is available to alert problems early in rotator and reciprocating machinery. The particles of abnormal and accelerated wear generated by each of the mechanisms can easily be recognized by their shape, size and texture, size distribution, concentration and appearance. Thus, WPA can avoid failures well in advance and pin-point the root cause of problem.

This technique is capable of indicating the rate of wear, severity of wear, type of wear, wear mechanism and exact location of wear for the equipment well in advance.

An effective WPA programme of tribological components such as bearings gears, piston and seals can reduce operating cost of maintenance and minimize unscheduled machine downtime.

Similar to blood testing

This process is similar to blood sampling. The way a small sample of blood is taken, 12-15 ml of lube oil sample is similarly taken and thereafter a ferrogram (slide) is prepared that is similar to a blood sample slide.

The ferrogram is then examined under the ferroscope just like blood sample slide is examined under the microscope. Finally, the health status and further course of action is recommended.

Evolution of ferrography at Indian NPPs

Ferrography was started for the first time in Indian Nuclear Power Plants (NPPs) at Narora Atomic Power Station (NAPS) in December 1996 and thereafter at Kakrapar Atomic Power Station (KAPS), Madras Atomic Power Station (MAPS), and Rajasthan Atomic Power Station units-1&2 (RAPS-1&2) and later on at all other NPCIL stations. For initial 10 years, analytical results of all station were monitored and trended at the NPCIL headquarters (HQ) and were used to ensure timely corrective action. All stations are now doing this independently.

During this period, failure of a large number of equipment could be avoided based on the trending of wear particle analysis and due to timely corrective action.

HQI (Headquarter Instruction)

HQI-452 – Guideline for ferrography method of wear particle analysis (WPA)– has been issued and is revised every three years.

2.0 Techniques for Used Lube Oil Analysis

The concept of wear is:

i) Every lubricated wear surface generates particles.

ii) There is a gradual build-up of small particles in a normal system.

iii) When abnormal wear begins, there is a sharp instantaneous increase in the concentration of large size particles present in the system.

Used Oil Analysis

Used oil analysis is carried out to determine lubricant condition. In other words, wear particles are captured from the used oil and analysis is carried to determine equipment condition.

The following three prominent techniques are available for analysis for used lube oil.

2.1 Chemical Analysis

This gives change in viscosity of oil, concentration of moisture in ppm, contamination in the oil, flash point, dielectric dissipation factor and neutralization value, etc. When these values reach certain limits, then analyses and replacement are needed.

2.2 Wear Particle Analysis

2.2.1 Spectrography Oil Analysis Procedures (SOAP) for Wear Particle

In spectrography oil analysis, wear particles are vaporised in an analyser, which gives actual element contents, but it can measure particle size up to a maximum of 10 microns only and does not identify the generation mode.

2.2.2 Ferrography Technique:
Explained in section 3.0

3.0 Ferrography Technique and Wear Particle Analysis

The name 'ferrography' comes from the ferromagnetic action of a permanent strong rare earth magnet attached to the testing instrument which extracts and arranges wear particles for preparing a ferrogram.

Ferrography is a lube oil analysis tool, using which it is possible to detect, measure and analyse wear particle ranging from 1 to 250 microns in size. It provides an accurate insight into the condition of the various lubricated components inside a machine by examining the wear particles contained in the lubricant.

3.1 Strength of Ferrography

Though the severitiy of wear is usually correlated with the presence of large particles, there are a few wear mechanisms that are exceptions to this concept because all particles are not wear particles. The strength of ferrography technique is to differentiate between real wear and corrosive/ abrasive wear.

3.1.1 Corrosive Wear and Abrasive Wear

In corrosive wear and abrasive wear, there is a massive build-up of particle concentration, but there is no significant change in the particle size, whereas in wear mechanism, size of wear particle as well as concentration of wear particle increases along with time (Figure-1). This means, increase in both particle size and quantity will be generated when severe wear occurs.

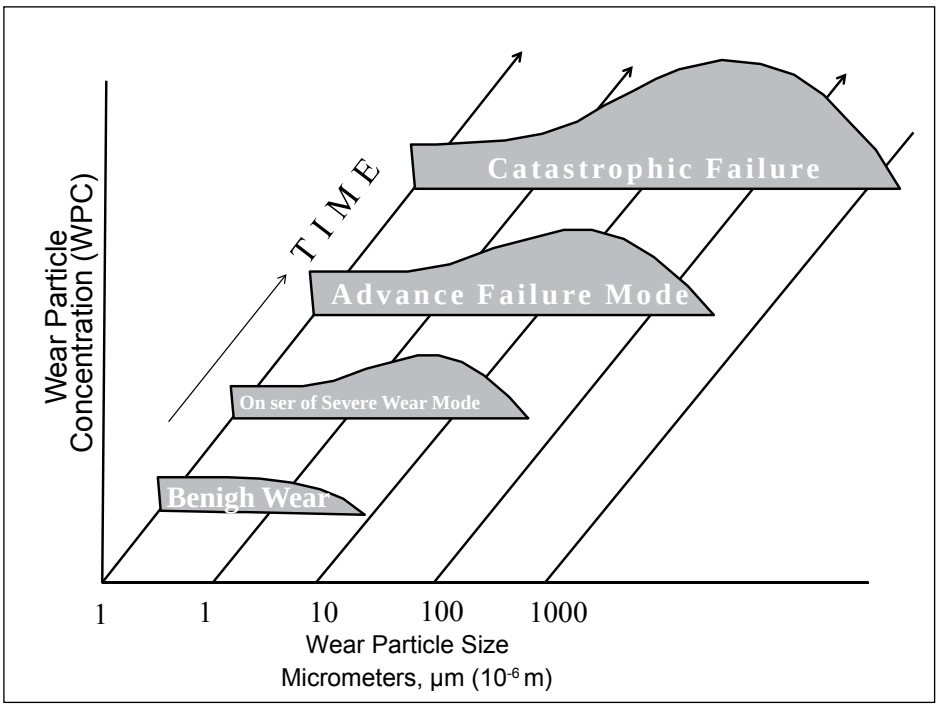


Figure 1: Due to the magnetic fluid, the ferrous particles align themselves in chains along the length of the slide, with the largest particles being deposited at the entry point. Nonferrous particles and contaminants, unaffected by the magnetic field, travel downstream and are randomly deposited across the length of the slide.

3.1.2 Trapping of Non-ferrous Particles

A magnetic separator is used to remove ferrous and non-ferrous wear particles. Non-ferrous materials like copper alloys, babbit materials, etc. also get trapped on ferrogram.

4.0 Applications of Ferrography Technique

4.1 The ferrogrpahy technique is very useful for the types of lubricants listed below:

i) Hydrodynamic and boundary lubricated equipment

ii) Grease-lubricated equipment

iii) Light-water and heavy-water lubricated equipment

iv) Very much useful for bearings, gears, pistons, bushes etc.

v) Reciprocating machines, where vibration analysis does not give much information, and

vi) Specially identifies for low-rpm machines

5.0 Ferrography Examination Process

Ferrography examination (wear particle analysis) is conducted in two stages:

i) Quantitative (Stage-I)

ii) Qualitative Analytical (Stage-II)

5.1 Quantitative Analysis (Stage-I)

The first stage involves the monitoring and trending of wear particles, the most important parameter in the early detection of abnormal wear.

In this process, a lube oil sample is allowed to pass through a tube over a strong magnetic field generated by the rare earth magnets of the test equipment. The photo sensors measure the change in transmitted light, which is proportional to the amount of refraction (in effect, blockage), due to wear particles.

The digital readout is a number indicating the total quantity of metal particles of large as well as small size (DL and DS) in the oil. This is trended for further evaluation.

Direct reading (DR) ferrography is used to obtain numerical baselines of wear particle concentration. The DR ferrograph monitor is a quantitative trending tool that permits condition monitoring through examination of fluid samples on a scheduled, periodic basis.

Wear particle concentration (WPC) is a measurement for quantitative trending. This is an empirical value and has no units. Different equipment have their own quantitative baselines based on the type of wearing components.

If total WPC is much higher compared to the previous sample, then these samples are further analysed under a ferroscope for identifying the composition of wear particles and indicating the source of wear, i.e. qualitative analysis. It is interesting to point out here that even in the very first sample, abnormal wear can be detected if results of similar equipment are compared.

The lubricants are also tested against their physical and chemical properties to know their further usability or deterioration at this stage.

Thus, the following analyses are carried out at stage-I

i) Wear Particle Concentration (WPC)

ii) Large Particle Concentration (LPC)

iii) Percentage Large Particle (PLP)

Thus, in stage-I, abnormal wear is identified by trending the concentration of wear particles. The quantitative measuring instrument used is Direct Reading Ferrograph (DR-III).

For each machine there is a limit for the WPC, and whenever the WPC value approaches the allowable limit, necessary recommendations are cited based on the analysis of the shape and texture of wears.

5.1.1 Wear Particle Index

Quantifying the amount of wear debris present in the lubricating oil is also known as 'Wear Index'. The magnitude of the 'Index' value is directly related to the amount of ferromagnetic debris present in it. This index is trended over a period of time for samples taken at regular intervals to monitor the progress of wear mechanism. Abnormal wear condition can be detected by a sharp rise in wear particle concentration.

5.1.2 Severity of Wear Index

The ratio DL/DS is a measure of wear condition. A rapid increase in DL/DS shows abnormal wear.

Where

DL = Density of large wear particles. i.e. 5 > micron

DS = Density of small particles. i.e. < 5 micron

Total wear Q = DL + DS and Severity Terms S = DL-DS.

Sharp rise in DL - DS indicates increased generation of large particles, leading to sudden increase in total wear, indicating imminent catastrophic failure is indicated. Detailed examination of wear particles on ferrogram is a must for locating the wear process.

- Severity of wear index= Q x S

  =(DL+DS) x (DL-DS)=DL2-DS2

- Percentage of large particles (PLP)

$$= \frac{DL - DS}{DL + DS} \times 100$$

An increase in both the wear particle concentration and percentage of large particles is an indication abnormal wear condition.

Classification of wear particle is indicated in Table-1.

5.2 Qualitative Ananlysis (Stage-II)

The debris of the lubricant is separated through a linear or rotary particle deposit on a glass slide called ferrogram. The slide is examined by watching under a powerful microscope, wherein the rate, size and concentration of different categories of wear are quantified and finally the condition of the machine is adjudged.

5.2.1 Preparation of Ferrogram

As mentioned earlier a ferrogram is similar to a blood-sample slide, used in a medical examination, which is examined under microscope/ferroscope.

Special Sticky Fluid

A special sticky fluid is put on the slide so that all particles get stuck and cannot

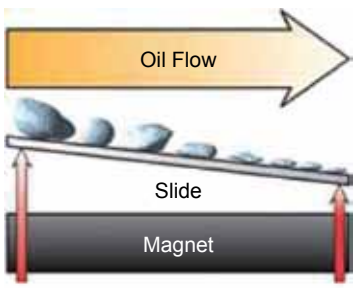


Figure 2: Ferrogram maker

escape. The captured particles may be ferrous, non-ferrous or other particles.

The following two types of ferrograms are prepared:

(i) **Rotary Particle Depositor (RPD):** Ferrogram is prepared under the influence of both centrifugal and magnetic field.

(ii) **Standard Ferrography Analyzer (LINEAR):** Ferrogram is prepared under the influence of magnetic field only.

KAKRAPAR ATOMIC POWER STATION
KAKRAPAR, GUJARAT

NORMAL

SAMPLE ID	: NPCIL-K/RB-OSU TANK#101 (UNIT-1)/18522.	SAMPLE DATE	: 24/06/14
SAMPLE DESC	: RB-OSUTANK#101 (UNIT-1) 1-33110-TK-101.	REC'D DATE	: 07/08/14
COMPONENT	: TANK SAMPLE	REPORT DATE	: 13/08/14
MANUFACTURER	: NOT AVAILABLE	1st SAMPLE	: 12/01/12
LUBRICANT	: SERVO PRIME-68	PREV SAMPLE	: 22/03/14
		NO. SAMPLES	: 9
		PROGRAM	: 1

RECOMMENDATIONS:
Wear Particle Concentration (WPC) is acceptable.
Maximum allowable WPC is 15.0.

Discussion of Results:
The wear particle concentration (WPC) is 1.8

DL: 1.0 DS: 0.8 DILUTION: 1:1

PERCENTAGE OF LARGE PARTICLES: 11%

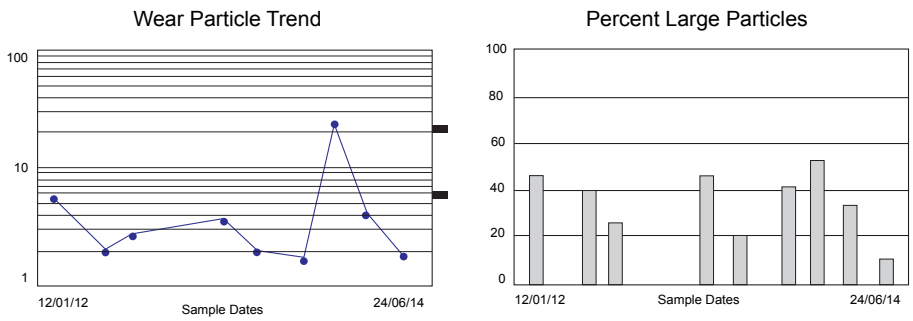


Figure 3: WAP test report example-1 (Normal wear)

The 'Rare earth magnet' used is powerful enough to supersaturate any metallic debris – ferrous or non-ferrous (Figure 2).

Ferrograms are placed on a hot plate at 330 °C to observe the colour change to distinguish between low-alloy, medium-alloy and high-alloy steels, babbitt material and organic material.

We get significant information by heating the ferrogram slides due to change in appearance and colour of the wear particles.

5.2.2 Computerised Ferrographic Analysis System

It features a computer system and FAST (ferrographic analytical software technology)

i) Faster storage and retrieval data, reports, images

ii) Automatic comparative displays for more accurate trending

iii) Extensive database

Finally, equipment condition reports provide:

i) Colour images of actual wear particles

ii) Graphical representation of trends

iii) Detailed analysis of quantitative and qualitative trends and

iv) Basis for recommendations for further maintenance

5.2.3 Analysis carried out under Stage-II

i) Wear particle composition

ii) Types of wear

iii) Identification of the source (component), cause and severity of wear

That is why stage-II is also known as diagnostic stage.

The instruments FM-III (ferrograph) separates the particle by size and the Ferroscope-IV is used to evaluate the separated wear particles.

6.0 Wear Rating

Based on the analysis, the wear rate is normally specified under the following categories:

i) **Normal:** Indicates that the equipment is generating expected amount of wear debris material with regard to size, shape, composition and concentration of wear particles, oxides and contaminants (Figure 3).

ii) **Marginal:** Indicates that the wear patterns are not within the expected levels. Marginal ratings may accompany recommendations of minor maintenance action. Minor action is defined as an oil change or filtration with an external portable filter system. Change of filter or breather element, or verification of operating conditions (Figure 4).

ii) **Critical:** Indicates a serious wear condition and usually accompanies a recommendation for definite maintenance action. This action may be in the form of comparison of past performance data to the current information, conducting a visual inspection without the removal or shutdown of the equipment. Increased sampling frequency for closer monitoring is often recommended. Recommendations for equipment overhaul may be made if a resample analysis shows increasing trend (Figure 5).

KAKRAPAR ATOMIC POWER STATION
KAKRAPAR, GUJARAT

MARGINAL

SAMPLE ID	KAPS/FM SUPLY PUMP 2-3525Q-P002/18010	SAMPLE DATE	30/06/14
SAMPLE DESC	FM SUPLY PUMP	REC'DDATE	07/08/14
COMPONENT	PUMP	REPORT DATE	13/08/14
MANUFACTURER	NOT AVAILABLE	1st SAMPLE	29/09/11
LUBRICANT	OMEGA 60	PREV SAMPLE	19/03/14 (M]
		NO. SAMPLES	7
		PROGRAM	1

RECOMMENDATIONS:
Wear Particle Concentration(WPC) is high.
Maximum allowable WPC is 15.0.

Discussion of Results:
The wear particle concentration (WPC) is 25.6

DL: 15.7 DS: 9.9 DILUTION: 1:1

PERCENTAGE OF LARGE PARTICLES : 23%

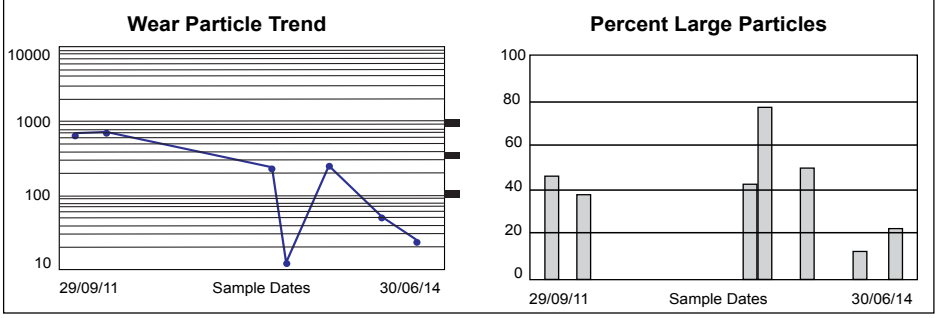


Figure 4: WAP test report example-2 (Marginal wear)

7.0 Wear Mechanism

Ferrography is also capable for indicating type of wear mechanism from the presence of the ferrous/non-ferrous particles, by measuring the length and thickness ratio of the particle generated by rubbing, cutting and laminar wear as indicated in Table-2.

Specific type of wear generates distinctive characteristic that reveals the wear mechanisms at work. For example, in rubbing wear, flat platelets typically between 5 and 15 microns in size are found, which indicates wearing of the shear layer.

Types of wear:

i) Normal rubbing wear

ii) Severe sliding wear

iii) Cutting wear

TEST REPORT

Used Oil Analysis Report for Predictive maintenance

Report No.	:	140825036 / 1408250112	Report Date	:	20-09-2014
Sample ID	:	1408250112	Sample Date	:	23-08-2014
Equipment Name	:	Gear Box	Received Date	:	25-08-2014
Equipment No.	:	7141 - P - 4, GEAR BOX LUBE	1st Sample Date	:	06-05-2013
			Reservoir Capacity	:	10 Liters
Equipment	:	Gear Box	Lubricant	:	Servo Gear - 90
Equipment Location	:	CWPH			

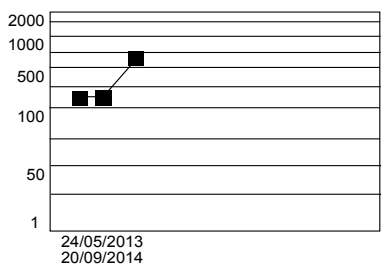
CRITICAL

QUANTITATIVE FERROGRAPHY ANALYSIS TEST RESULTS:

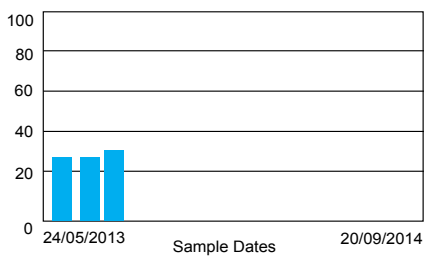
Maximum allowable WPC applicable for 7141-P-4 (G.B.Oil)	:	500

Spectro's Expert Observation of Quantitative Ferrography Test Results:

The Wear Particle Concentration (WPC)	:	856.5
Large Particles (> 5 microns)	:	572.3
Small Particles (< 5 microns)	:	284.2
Dilution Factor	:	Nil
Percentage of Large Particles	:	33.63%
Wear Severity Index	:	246757.65



Wear Particle Trend



Percentage of Large Particles

i) Percentage of Large particles =(DL-DS)/(DL+DS) x 100=(572.3-284.2)/(572.3+284.2) x 100=33.63%

ii) Wear Severity Index=Q x S=(DL+DS) x (DL-DS)=DL2-DS2=(572.3)2-(284.2)2=327527.29-80769.64=246757.65

Figure 5: WAP test report example-3 (Critical wear)

iv) Bearing wear

v) Gear wear

vi) Sphere wear

8. Selection of Equipment

Following criteria may be applied for the selection of the equipment for wear particle analysis.

8.1 Choosing Equipment for WPA depends upon

i) How critical the equipment is to a process/production

ii) Maintenance history

iii) Prohibitive cost of repair and/or replacement

iv) Age of equipment

8.2 In nuclear power plants, the selection of equipment for the purpose of ferrography is done based on the criticality of equipment. At NPCIL plants, the following equipment have been selected for the wear particle analysis and ferrography.

1) Turbo Generator (TG) sets

2) Emergency Diesel Generators (EDGs) sets

3) Boiler Feed Pump (BFP)

4) Air compressor

5) Chiller compressor

6) Primary feed pump

7) Condensate extraction pump

8) Shutdown cooling pump

9) Process water pump

10) Primary Heat Transport (PHT) pressurizing pumps

11) Moderator pumps

12) Switchyard compressor

13) Fire fighting pumps

14) Transformers

15) Condensate pump (BWR)

16) Reactor clean-up recirculation pump (BWR)

17) Circulation water pump (BWR)

18) Oil supply units

19) Fuel pool cooling pump (BWR)

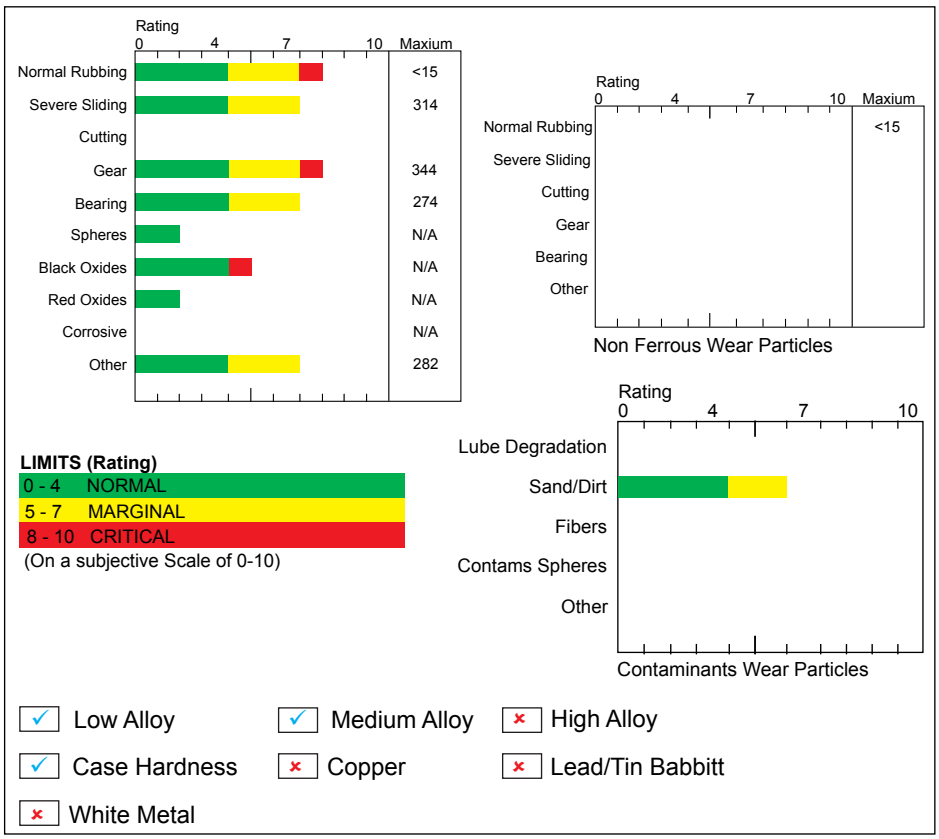


Figure 6: WAP test report example-4

Lubrication oil from 40 to 50 equipment of each Indian NPP is sampled quarterly for ferrography.

9.0 Sampling Technique

9.1 Throughout Sampling

Since particulate matter exists as a separate phase in the fluid, it cannot be assumed that a uniform distribution exists throughout the lubricant.

i) A true representative oil sampling is an absolute must for proper analysis and diagnosis.

ii) Sampling procedure must be followed step by step.

iii) Taking highly contaminated oil from the bottom of a bearing oil sump or from a standpipe, where the oil has been stagnant, will most likely to lead to an incorrect diagnosis and recommendations.

The lubricants in critical equipment in nuclear power plants are not easily accessible for sampling. Samples are collected either from existing drain-point or main oil tank. However, a sample should always be taken before in-line filter and also the sample must always be taken from a single location in the system.

9.2 Sampling Frequency

Basis for deciding the sampling frequency is determined by the nature of the machine, age of the machine and its use and how important is the early wearing of the machine is to the users.

Experiments in various plants have shown that taking a quarterly sample ensures that onset of abnormal wear is detected in time to minimise the consequences. However, this can be reviewed based on the operating condition and review of analysis results after some time. Presently, samples are collected every three months from the equipment at the operating power plants of NPCIL to closely monitor machine health and rate of wear. It is proposed to set up an in-house ferrography facility.

9.3 Re-sampling

When an increase in contaminates/ wear particles is detected in the regular quarterly samples, additional samples are required to be sent at greater frequency. Sometime re-sampling is also required on urgent basis.

For equipment rated 'marginal' and 'critical', 're-sampling' is requested. Re-sampling is required for the Machine Condition Analyst to verify his analysis or modify recommendations if the new samples show an increasing trend.

Response Time: Response Time is very much crucial in giving the analysis report to the user in time.

10.0 Type of Particles that Ferrography can Detect

a. Ferrous Wear Particle

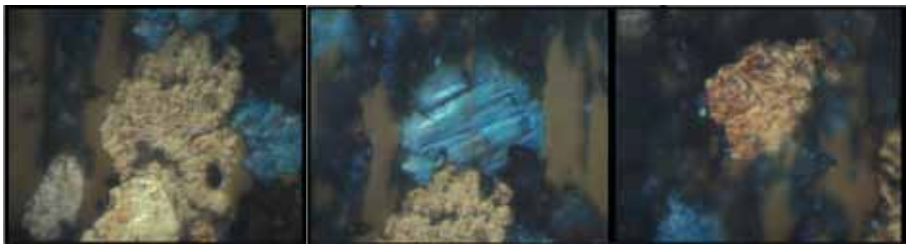
i) Low-alloy steel

ii) Medium-alloy steel

iii) High-alloy steel

These particles come from the following: (Also see Figure 7 and 8)

- Normal rubbing wear
- Severe sliding wear
- Cutting wear



Medium Alloy Steel Wear (Image 1, 400X Magnification) | **Gear Wear (Image 2, 400X Magnification)** | **G.W. Pitting Particles (Image 3, 400X Magnification)**

Expert Observation of test results

Normal rubbing wear particles are observed in marginal quantities

Low alloy steel severe sliding wear particles of size ranging up to 314 microns are observed in near large quantities. Medium alloy steel wear particles of size ranging up to 282 microns are observed in near large quantities. Case hardness steel wear particles of size ranging up to 390 microns are observed in large quantities. Bearing wear particles of size ranging up to 27 microns are observed in near large quantities. Gear wear particles of size ranging up to 344 microns are observed in large quantities. Gear wear pitting particles of size ranging up to 390 microns are observed in large quantities. Gear wear pitting particles of size ranging up to 378 microns are observed in large quantities. Gear wear laminar particles of size ranging up to 362 microns are observed in large quantities. Sand / dirt particles are observed in marginal quantities. Red oxides particles are observed in small quantities. Black oxides particles are observed marginal quantities. Spheres particles are observe in small quantities. Wear particles observed on the ferrogram indicate critical operating condition of the equipment.

Recommendation / Interpretation

Wear Debris Analysis tests report is rated critical due to the presence of large quantities of Gear wear (Fatique, Laminar & Pitting), Case hardness steel wear particles, Marginal quantities of Low alloy steel severe sliding wear, Medium alloy steel wear, Bearing wear, Black oxides and high wear particles concentration. The Wear observed in the components contains major quantity of gear particles, which may lead to failure over a period of time. Increase in wear concentration indicates excessive rubbing of sliding contacts. Based on the above observations and interpretations, it is recommended that the lubricant be changed within three months from the date of last sampling done, if the equipment is in a running state from that date, otherwise not and Inspection of the related components. If abnormal condition exists, Please inform laboratory.

Figure 7: Wear particle images under high magnification

- Bearing wear
- Gear wear
- Sphere wear

b. Ferrous oxides

i) Black oxides

ii) Red oxides (Rust)

c. Lube degradation

i) Corrosive

ii) Friction polymers

d. Contaminates

i) Sand

ii) Dirt

iii) Fibres (Filter materials)

iv) Contaminant spheres

11.0 Particle Identification

Particle composition is first broken down into six categories: (i) white nonferrous (ii) copper (iii) babbitt (iv) contaminants (v) fibers, and (vi) ferrous wear. In order to aid the identification of composition, the analyst heat-treats the slide for two minutes at 600 °F.

White nonferrous particles, often aluminum or chromium, appear as bright white particles both before and after the heat treatment of the slide. These are deposited randomly across the slide surface, with larger particles getting collected against the chains of ferrous particles. The chains of ferrous particles typically act as a filter, collecting contaminants, copper particles and babbitt.

Copper particles usually appear as bright yellow particles, both before and after heat treatment, but the surface may change to verdigris after the heat treatment. These are also randomly deposited across the slide surface, with larger particles resting at the entry point of the slide and gradually getting smaller towards the exit point of the slide.

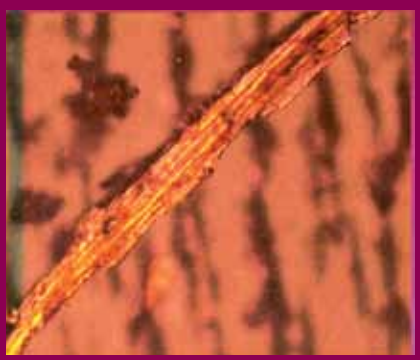
Babbitt particles consist of tin and lead. They appear gray, sometimes with speckling before the heat treatment. After the heat treatment of the slide, these particles still appear mostly gray, but with spots of blue and red on the mottled surface of the object. Also, after heat treatment, these particles tend to decrease in size. Again, these nonferrous particles appear randomly on the slide, not in chains with ferrous particles.

Contaminants are usually dirt (silica), and other particulates which do not change in appearance after heat treatment. They can appear as white crystals and are easily identified by the transmitted light source on the microscope, as they are somewhat transparent. Contaminants appear randomly on the slide and are commonly dyked by the chains of ferrous particles.

Fibers, typically from filters or outside contamination, are long strings that allow the transmitted light to shine through. They can appear in a variety of colors and usually do not change in appearance after heat treatment. Sometimes these particles can act as

Severe Sliding Wear

Ferrogram



Description

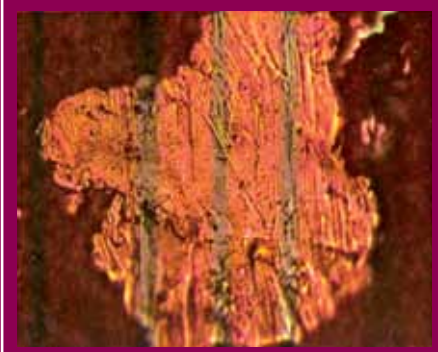
- Flat elongated particles with striations
- Greater than 20 microns in major dimension

Causes

- Excessive load
- Excessive speed on sliding surface

Bearing Wear

Ferrogram



Description

- Laminar platelets

Causes

- Rolling contact failure

Corrosive Wear

Ferrogram

Description

- Heavy concentration of fine particles at exit of ferrogram

Causes

- Oil additive depletion

Cutting Wear

Ferrogram

Description

- Long curled strips

Causes

- Misalignment
- Abrasive contaminant in the lubricant

Figure 8: Examples of some wear types

a filter, collecting other particles. They can appear anywhere on the ferrogram. However, they tend to be washed towards the exit end.

Ferrous particles can be broken down into five different categories: high alloy, low alloy, dark metallic oxides, cast iron and red oxides. Large ferrous particles will be deposited on the entry end of the slide and often clump on top of the other. Ferrous particles are identified using the reflected light source on the microscope. Transmitted light will be totally blocked by these particles.

- **High-alloy steel** particles are found in chains on the slide and appear gray-white before and after heat treatment. The distinguishing factor in the identification between high alloy and white nonferrous is position on the slide. If it is white and appears in a chain, it's deemed to be high alloy. Otherwise, it's considered white nonferrous. The frequency of high alloy on ferrograms is rare.
- **Low-alloy steel** particles are also found in chains and appear gray-white before heat treatment, but then change color after heat

treatment. After heat treatment they usually appear as blue particles but can also be pink or red.

- **Dark metallic oxides** deposit in chains and appear dark gray to black both before and after heat treatment. The degree of darkness is indicative of the amount of oxidation.
- **Cast iron** particles appear gray before heat treatment and a straw yellow after the heat treatment. They are incorporated in chains amongst the other ferrous particles.
- **Red oxides (rust)** are readily identified by polarized light.. Sometimes they can be found in chains with the other ferrous particles and sometimes they are randomly deposited on the slide surface. A large amount of small red oxides on the exit end of the slide is generally considered to be a sign of corrosive wear. It usually appears to the analyst as a "beach" of red sand.

11.1 Non-ferrous Wear Particles

i) White non-ferrous metals like aluminium alloys

ii) Copper alloys

iii) Babbitt lead/tin alloys

12.0 Case Study

Trending of Data and Analysis of Result

It has been experienced that failures on a number of equipment could be averted because of the advance warning available from ferrography reports. Based upon the reports, the equipment were taken up for maintenance and defects rectified in time. Some prominent equipment for which

Table-1: Classification of Wear Particles

Particle Type	Size Major Dimension	Shape Length and Thickness
Normal rubbing wear	< 15 microns	< 10:1
Severe wear particles	> 15 microns	> 05:1 but < 30:1
Chunks	> 5 microns	< 05:1
Laminar particle	> 15 microns	> 30:1

Table-2: Wear Mechanism

Particle Type	Description	Significance
Rubbing wear	Flat platelet typically	Indicates wearing of the shear layer
Severe sliding wear	Particles measure > 15 micron in size	Indicates abnormal sliding contact possibly due to deteriorating lubricant film
Cutting wear	> 15 microns and resemble	Indicates either misaligned components (bearing and shaft)
Fatigue spalling	From 15 microns and up. Similar to severe sliding	Scuffing of the gear teeth possibly due to contamination or misalignment
Laminar wear	> 15 microns in size	An abnormal rolling contact
Spherical wear	Measure < 5 microns in diameter and are spherical	Early indication
Black oxide	Reddish brown (Fretting)	Could also indicate fretting of a surface
Corrosive wear	0.1 to 1 micron in size	Indicates an acidic presence
Lubricant degradation	Amorphous residue containing metallic particles	Indicates stress on lubricant possibly
Fibers	Natural and synthetic	Indicates possible filter rupture

failure could be avoided is as in the table 3:

Table-3: Some prominent equipment for which failure could be avoided

1. HP Compressor-2, Boiler Feed Pump (BFP)-1 at MAPS-2
2. Boiler Feed Pump (BFP)-2 at MAPS-1
3. Non-active High-pressure Pump (NAHP) and Non-active Low-pressure Pump (NALP) at KAPS-2
4. Chiller-2 at NAPS
5. DG-1 at RAPS-2
6. 7141-PM-4, Gear Box at NAPS-1

Records of result are trended and recommendations are archived for retrieval as and when required.

No need to maintain bulky records

There is no need to keep large amounts of hard copies and old records, as all old data are trended and accommodated in a few pages as in the examples shown in Figures 3, 4, 5 and 6.

All reports contain recommendations of the analysis.

13.0 Latest Developments

This system may also be coupled with vibration analysis, effective in detecting and diagnosis the faults.

Software has been developed integrating WPA and vibration analysis. Online direct condition monitoring by using navigator is now in use.

It has been observed that sometimes vibration data does not indicate any immediate abnormalities.

14.0 Benefits

i) Provides early warning

ii) Identifies lubricant contamination

iii) Identifies specific failing components

iv) Helps in monitoring component deterioration

Thus, WPA prevents catastrophic equipment failure through the timely and accurate prediction.

15.0 Conclusions

i) Ferrography reduces downtime by allowing timely scheduling of necessary repairs.

ii) It eliminates the risk of costly secondary damage and helps in reducing equipment failure rate.

iii) When wear particle analysis indicates that a machine is in good operating condition, periodic maintenance may not be necessary. Therefore, based on the results, maintenance may be deferred or, the periodic frequency adjusted. For example, bearings, gear etc. need not be replaced periodically as is being done presently, but only when they begin to show early signs of wear.

iv) Ferrographic analysis provides early warning of failure of components and also is helpful in pinpointing specific failing components to help reduce the cost of repairs as well as downtime by allowing timely scheduling of necessary repairs.

V. N. Konda, *a mechanical engineer, joined NPB in 1985. He has participated in inspection and rehabilitation programmes at several reactor units. He is also a Member of SG Task Force. He has received Group Achievement Award for successful organization of WANO BGM and for successful sludge lancing of all SGs at KAPS-1 using indigenously developed (by BARC) sludge lancing equipment (SLE).*

Jyoti Thakur, *SEE, is working with NPCIL in the Directorate of Operations. She is a B. Tech. graduate in electrical engineering. She joined NPCIL's 10th batch of trainee engineers in the year 2001. Thereafter, she was involved in the commissioning of the 540-MW PHWR units at TAPS-3&4 and gained experience in commissioning of transformers and switchgears. She joined NPCIL HQ in 2010 in operations directorate and is now involved in performance review of electrical systems and implementation of design improvements.*

A. K. Sinha, *CE (MS), SO/H+, is a mechanical engineer. He joined NPCIL in 1983. He has wide-ranging expertise in complex rehabilitation of reactor and major maintenance work of PHWR and BWR plants and has contributed to several such programmes. Apart from this, he has been involved in implementing many innovative techniques of advanced maintenance in NPPs, including ferrography, thermography and trending of maintenance performance indicators (MPIs).*

Development of Standalone Video Inspection System for Eddy Current Testing during Steam Generator ISI

Jocy Varghese, SO/D (QA), KGS (1-4), **Sunil Gadgil,** QAS, KGS (1-4)

Introduction

Kaiga Generating Station (KGS) consists of four units of PHWR-type reactors with rated capacity of 220 MW each. During the biennial shutdown of Kaiga Generating Station unit-4 (KGS-4) in 2013, eddy current testing (ECT) of four steam generators was carried out using standalone video inspection system developed by Quality Assurance (QA) section. The testing was carried out during an in-service inspection (ISI) programme.

Steam Generator Eddy Current Testing Manipulator System

The steam generator (SG) U-tubes were inspected by eddy current testing for healthiness/or any possible thinning. The testing was carried out by remotely operated robotic manipulator system. This system consisted of:

- Robotic arm to locate the tube to be tested
- Pusher-puller to insert the eddy current testing probe in to the U-tube
- Two SG-Bowl camera focusing to tube sheet on either side of the SG-man hole to view the 1830 tube holes
- Control room set-up out side the reactor building to operate the system remotely

Challenges Faced

- The correct installation of the manipulator could be ascertained only after the completion of installation and deployment of the system
- The image output on 4 small independent TV systems had a lot of wire connections which were obstructing testing activities
- Viewing at four different TV images along with ECT signal simultaneously was creating inconvenience to the ECT operator during ISI. There was a possibility of missing small indications during online monitoring of tube ECT data
- The bullet cameras installed originally for inspection of tube sheet inside the SG bowls were non-focusing. Hence, achieving good tube sheet images needed position adjustment of these cameras manually inside the congested SG manhole during the initial installation and whenever it got disturbed during the conduct of ECT
- Glare in images due to interaction of SG bowl lighting and camera lenses
- While probing, the loose crud coming out from the SG-tubes was falling on X-Z robotic arm light and camera lens, blocking the images completely. This resulted in the frequent halting of inspection

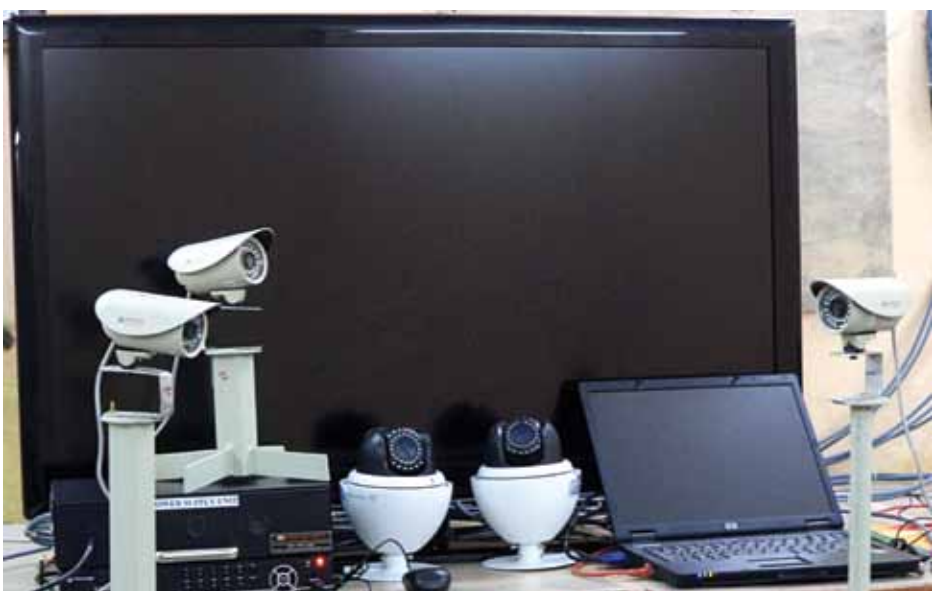


Figure 1: Camera and PC set-up developed for the SG ISI system

activities and cleaning of the camera manually

Action Taken

A detail study was initiated to resolve the problem. It was decided to develop an independent video system that overcame the abovementioned challenges and identified constraints. The required modifications were done step by step and the results were validated in last two ISI campaigns.

As a result of these modifications, an independent system namely 'Steam Generator ECT-ISI Video display Standalone System' was developed at KGS. The newly-developed system comprised of:

- High-intensity infra-red (IR) lighting, effective image viewing facilities
- Special cameras with auto-focus/ adjustment
- Data recording arrangement
- Facilitation of easy marking of reference tube inside SG, which is required for installation and setting up of ECT manipulator

Figure 2: Camera display from field

Material and Equipment for the System

1. A laptop/desktop computer
2. A big screen TV-cum-monitor
3. An 8-channel DVR (Digital Video Recorder) with 2TB recording for SG-ISI-period
4. Two SG-BOWL-IR (Infrared)-PTZ (Pan-Tilt-Zoom) cameras
5. Three IR-bullet camera with stand (one at 8" height for Pusher-Puller, one height adjustable (2 ft. to 5 ft.) for SG-manhole view and one at 5 ft height for total field view)
6. 100 m LAN cables with modem switch SG-DVR to ECT control room
7. An IR-Mini bullet (10 IR-LEDs, with a size 30mm in diameter and 76mm in length) for X-Z arm

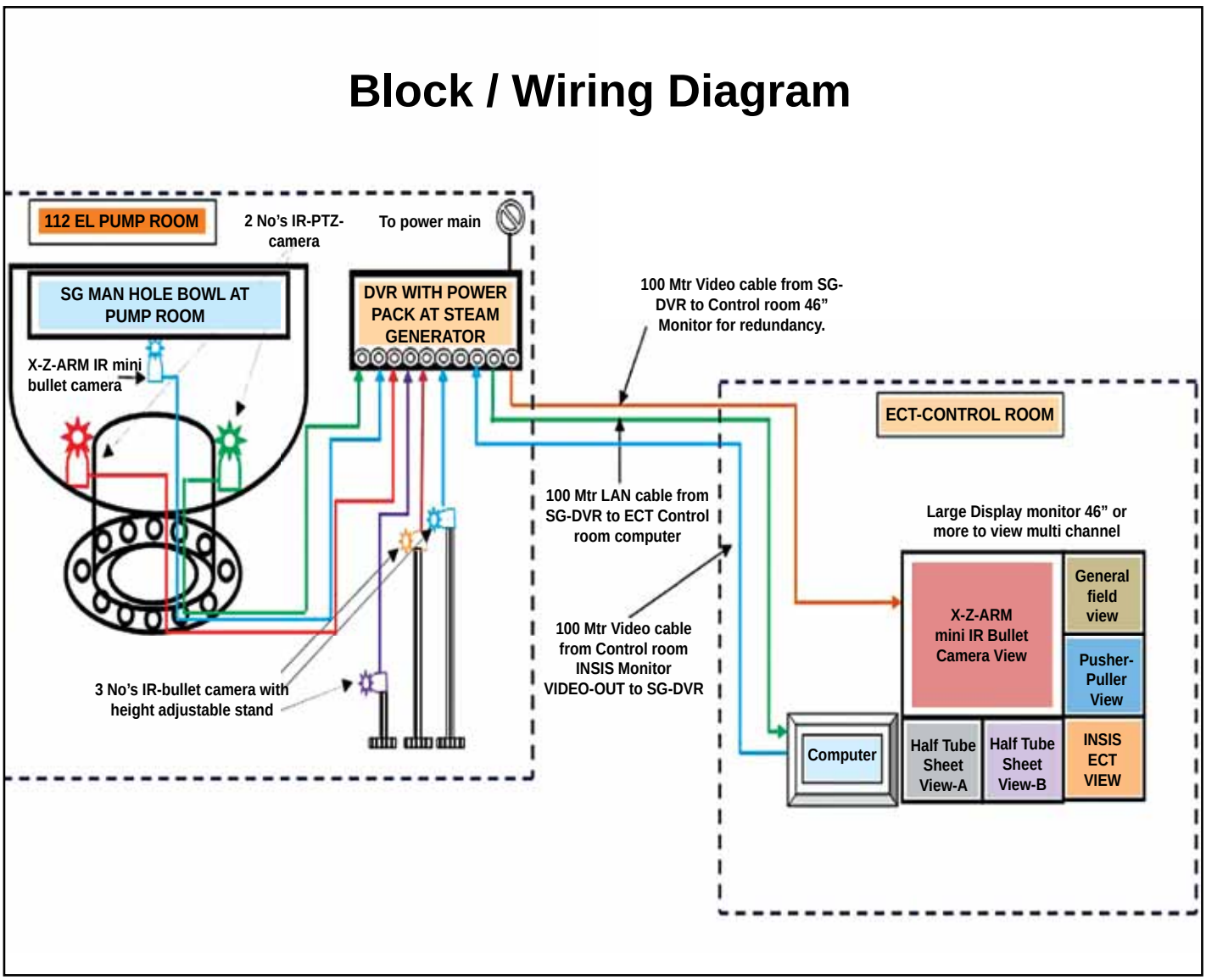


Figure 3: Block diagram of the inspection system developed for SG ISI

8. Approximately 60 m CCTV camera coaxial cable (4+1) and related 5-pair power/signal (BNC/RCA) cables connectors

The camera–PC setup, camera display from field and block diagram are shown in Figure 1, Figure 2 and Figure 3, respectively.

Results Achieved

The standalone video inspection system had several unique advantages and made the workflow simpler and easier. Hence, later this system was implement at other NPCIL stations also. Following are the improvements achieved by implementing new system.

Tangible:

- The new independent standalone display system provides total information around the SG area during ECT activities such as installation of manipulator, alignment, calibration, changing of probes during tube scanning.

- The requirement of additional lighting arrangement inside the SG-bowl is eliminated by placing of IR-PTZ cameras in SG bowl and focusing of these cameras can be controlled from the ECT control room. This has eliminated the requirement of manual adjustment of these cameras inside the SG bowl, thereby reducing inspection time, contamination as well as manrem. Indeed, a dose reduction by 40% could be achieved as a result of these modifications.
- The IR-Mini bullet camera replaced a bunch of LED lights on X-Z arm and it is less affected by powder, as the IR lighting partially passes through the powder particles. Hence frequent cleaning of the camera is reduced.
- All the 6 (six) images are viewed on a single TV monitor in ECT control room (2 field IR bullet cameras, 1 X-Z arm IR bullet camera, 2SG-bowl IR-PTZ cameras and 1 INSIS-ECT output image). Thus, the inspection efficiency of ECT operator is increased.

Intangible:

- The new system totally eliminated the external 24-volt AC 220-volt AC power supply for lighting.
- The visual output from the field can be recorded remotely in DVR through IP system and keeping permanent records of images/video.
- A video cable connected from SG-DVR Video-OUT to ECT control room large TV-IN will give an all view/images of camera connected to DVR by changing the TV mode from VGA-IN to RCA-IN. This gives an adequate redundancy of the system in case of LAN-failure and avoids the need for the operator to physically visit SG area.
- The system provides real-time information about all the ECT activities performed at different locations on different components/ equipment along with the INSIS-ECT machine operation information.
- As this system is IP-based, the total information/progress of work can be viewed from different locations through the LAN system without interfacing with the ECT-control room personnel.

Conclusion

Organizations are responsible for providing a safe and healthy workplace/ environment for their employees by setting up and enforcing high standards, providing training and encouraging continual improvement in limiting menrem to remain within stipulated limits. The use of the above system was found very helpful in minimizing radiation dose, which in turn contributed effectively to reduce the station collective dose at KGS and also at other stations, in line with ALARA (as low as reasonably achievable) policy. This system has helped to eliminate the tedious work of setting-up of the camera and light where it would have otherwise involved major doses. As the system stores all the information, including the ECT machine operation, it is useful for future reference also.

Sunil Gadgil, *B.E (Mechanical), joined 32nd batch of BARC training school in 1988. After the completion of his induction training, he was posted to TAPS-1&2 (1989 to 1995) and subsequently to Kaiga Generating Station. He has 25 years of experience in operation, commissioning, maintenance and quality assurance functions of PHWRs and BWRs. At present, he is Quality Assurance Superintendent at the KGS site.*

Jocy Varghese *joined Quality Assurance section of Kaiga project as SA/B in 1989. He is associated with eddy current in-service inspection activities at Kaiga Generating Station. He helped standardize a method for carrying out ECT of all heavy water heat exchangers, which significantly reduced the station radiation dose and inspection time. He promulgated the idea of development of the standalone video inspection system for eddy current testing of steam generator ISI. He is currently working as SO/D in QA section of KGS (1-4).*

Online Purification and Degassing of Transformer Oil: Innovative Approach Adapted at TAPS-3&4

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Abstract

Transformer oil purification under vacuum is an effective technique for improving the physical properties of transformer oil. The commonly adopted method is to carry out oil purification after electrically isolating the power transformer from network. This method results in significant revenue loss if offline work is required to be executed in the generator transformers that are used for power evacuation to electrical grid. In this article, we have discussed an innovative approach adopted at TAPS-3&4 for the first time at any NPCIL unit, for improving the properties of transformer oil. In this process, the generator transformers remained in service during the process of oil purification. By incorporating various protection interlocks and logics for ensuring the safety of transformers, it was possible to carry out "online purification and degassing" of transformer oil. This technique resulted in significant savings of revenue. Further, the results of "online purification and degassing" have revealed that the time required to achieve the desired properties of transformer oil is quite less as compared to offline purification and degassing technique.

Introduction

In India, Tarapur Atomic Power Station Unit-3&4 (TAPS-3&4) is the first twin-unit module of 2x540-MW capacity. The generation voltage at turbo generator in each of these units is 21 kV. There are three oil-filled single-phase generator transformers in each unit, which are used for power evacuation to the grid through 400-kV SF_6 gas-insulated switchyard. Generator transformers are required to step up the voltage from generating voltage (21 kV) to transmission line voltage (420 kV). Each single-phase generator transformer of TAPS-3&4 is rated for 210 MVA. Some important specifications of generator transformer are mentioned in Table-1.

Table-1: Specifications of Generator Transformer

S. No.	Description	Specifications
1)	Name of manufacturer	TELK
2)	Manufacturer's type designation	Core type
3)	Type of construction	1-phase, core-type, two-winding, outdoor
4)	Full-load rating	210 MVA (per phase)
5)	Rated HV no-load voltage	420 kV/√3
6)	Rated LV no-load voltage	21 kV
7)	Type of cooling	ONAN, ONAF and OFAF
9)	Frequency	50 Hz
10)	HV winding connection	Star
11)	LV winding connection	Delta
12)	Vector group	YN d11
13)	Tapping on winding	Off-circuit
14)	Range of tapping steps	+2.5% to -7.5% in steps of 2.5%
15)	Taps provided on	HV winding

Problem Encountered in the Generator Transformers and Action Taken

During the initial loading of these transformers to full power in the year 2006, high temperature hot spots were observed during thermal imaging on the LV turret portion flange bolts, transformer tank body below LV turret and transformer body flange bolts near pump inlet lines. This hotspot problem in generator transformers appeared to be inadequate magnetic shielding and/or less clearance between core and transformer structural parts. To rectify this hotspot problem temporarily, copper shorting links were provided on the LV turret flange bolts and on transformer body flange bolts. Additionally, vortex

coolers were also provided for localized cooling on transformer body below LV turret portion. High concentrations of dissolved gases were observed during the full power operation of unit-3 in the year 2008 and these high concentrations were reduced by carrying out offline hot-oil circulation. Subsequent to these activities, both units were operating at low power level, hence hotspot temperatures were also observed to be towards the lower side.

Both the units achieved their full power (FP) level in the year 2012 and 2013, respectively. Subsequent to operation at full-power level for 4-5 months, high concentrations of dissolved gases were observed during dissolved gas analysis (DGA) of transformer oil. The problem was aggravated with increase in power level. Due to high concentration of individual gases as well as total dissolved combustible gases (TDCG) in DGA results, generator transformers of both units were taken offline and filtration of transformer oil was carried out. Offline filtration of transformer oil was necessary in order to maintain the dielectric properties of transformer oil, which could have degraded due to increased concentration of dissolved gases. After this in the month of March 2014, reactor power of TAPS-4 was also reduced to 80% FP in order to limit the rate of rise in the dissolved gases. There was also the question of imminent revenue loss to the organization for the period during the offline oil purification and degassing activity and due to a reduction in the power level.

Importance of Periodic Analysis of Transformer Oil for Dissolved Gases

Much in the same way that analysis of a patient's blood determines certain health problems, analysis of transformer oil for dissolved gases can detect problems within the transformer. Early detection of incipient faults in transformers is extremely cost effective by reducing unplanned outages. The most sensitive and reliable technique used for evaluating the health of oil-filled electrical equipment is DGA.

Insulating oils under abnormal electrical or thermal stresses break down to liberate small quantities of gases. The qualitative composition of the breakdown gases is dependent upon the type of fault. By means of DGA, it is possible to distinguish faults such as partial discharge (corona), overheating (pyrolysis) and arcing in a great variety of oil-filled equipment. Typical gases analysed during DGA are H_2, CH_4, C_2H_6, C_2H_4, C_2H_2, CO, CO_2, N_2, O_2. Data from DGA can provide

1. Advance warning of developing faults
2. A means for conveniently scheduling repairs
3. Monitor the rate of fault development

IEEE Guideline for Operator Action Based on Measured Concentrations of Dissolved Gases

A four-condition DGA guide to classify risks to transformers has been developed by the Institute of Electrical and Electronics Engineers (IEEE). The same was taken as reference at TAPS-3&4. The guide uses combinations of individual gases and total combustible gas concentration. Table-2 reflects the four conditions based upon individual as well as total combustible gas concentrations, and Table-3 explains the sampling frequency and recommended actions by operator.

Table-2: Four Conditions Based Upon Gas Concentrations

Status	H_2	CH_4	C_2H_2	C_2H_4	C_2H_6	CO	CO_2	TDCG
Condition 1	100	120	35	50	65	350	2,500	720
Condition 2	101-700	121-400	36-50	51-100	66-100	351-570	2,500-4,000	721-1,920
Condition 3	701-1800	401-1000	51-80	101-200	101-150	571-1400	4,001-10,000	1,921-4,630
Condition 4	>1800	>1000	>80	>200	>150	>1,400	>10,000	>4,630

CO_2 is not included in adding the numbers for TDCG because it is not a combustible gas.
All concentrations are in parts per million (ppm).

The four conditions are defined below:

Condition 1: Total dissolved combustible gas (TDCG) below this level indicates the transformer is operating satisfactorily. Any individual combustible gas exceeding specified levels in Table-3 should have additional investigation.

Table-3: Four Conditions Based Upon Gas Concentrations

Conditions	TDCG Level or Highest Individual Gas	TDCG Generation Rates (ppm/day)	Sampling Intervals and operating Actions for Gas Generation Rates	
			Sampling Interval	Operating Procedure
Condition 1	720 ppm of TDCG or highest condition based on individual gas from Table-2	<10	Annually to 6-monthly for EHV transformer	Continue normal operation
		10-30	Quarterly	
		>30	Monthly	Exercise caution. Analyse individual gases to find cause. Determine load dependence
Condition 2	721-1,920 ppm of TDCG or highest condition based on individual gas from Table-2	<10	Quarterly	Exercise caution Analyse individual gases to find cause. Determine load dependence
		10-30	Monthly	
		>30	Monthly	
Condition 3	1,941-2,630 ppm of TDCG or highest condition based on individual gas from Table-2	<10	Monthly	Exercise caution. Analyse individual gases to find cause. Plan call manufacturer other consultants for advice
		10-30	Weekly	
		>30	Weekly	
Condition 4	>4,630 ppm of TDCG or highest condition based on individual gas from Table-2	<10	Weekly	Exercise extreme caution. Analyse individual gases to find cause. Plan outage. Call manufacturer and other consultants for advice
		10-30	Daily	
		>30	Daily	Consider removal from service. Call manufacturer and other consultants for advice

Condition 2: TDCG within this range indicates greater than normal combustible gas level. Any individual combustible gas exceeding specified levels in Table-3 should have additional investigation. A fault may be present. DGA samples should be taken at least often enough to calculate the amount of gas generation per day for each gas.

Condition 3: TDCG within this range indicates a high level of decomposition of cellulose insulation and/or oil. Any individual combustible gas exceeding specified levels i n Table-3 should have additional investigation. A fault or faults are probably present. DGA samples should be taken at least often enough to calculate the amount of gas generation per day for each gas.

Condition 4: TDCG within this range indicates excessive decomposition of cellulose insulation and/or oil. Continued operation could result in failure of the transformer.

Notes

1. Either the highest condition based on individual gas or total dissolve combustible gas can determine the condition (1, 2, 3 or 4) of the transformer. For example, if the TDCG is between 1,941 ppm and 2,630 ppm, this indicates condition-3. However, if hydrogen is greater than 1,800 ppm, then transformer is in condition-4, as shown in Table-2.
2. When the Table says 'determine load dependence' this means, if possible, find out if the gas generation rate in ppm/day goes up and down with load. Perhaps the transformer is overloaded. Take samples every time the load changes; if load changes are too frequent, this may not be possible.
3. To get TDCG generation rate, divide the change in TDCG by the number of day between samples that the transformer has been loaded. Down-

days should not be included. The individual generation rate ppm/day is determined by the same method.

Requirement of Transformer Oil Purification and Degasification

The insulation system of high-voltage power transformers consists of oil, paper and other cellulose-based solids. Transformers under operation are always subjected to thermal and electrical stresses, which cause degradation of both oil and paper insulation. Degradation of the insulation system is an ongoing process, but is substantially accelerated by elevated temperature and the presence of moisture, oxygen and degradation products. The degradation process also produces moisture and dissolved combustible gases such as H_2, CO, CH_4, C_2H_4, C_2H_6, C_2H_2 etc. Apart from these gases, O_2, N_2 and CO_2 are also present due to exposure of transformer oil. Moisture may also enter the transformer from atmosphere due to improper breathing, exposure of oil and winding during maintenance, etc. Dissolved oxygen present in transformer oil along with moisture causes acidity of oil to increase and sludge formation. All these result in the deteriorating of electrical, chemical and physical properties of the oil. Similarly, combustible gases produced/generated due to abnormal thermal and electrical stresses in the transformers result in the degradation in dielectric properties of oil and cellulose insulating material. In order to extend the transformer life, we must prevent the accumulation in oil of compounds primarily responsible for the chemical changes that culminate in deterioration of the insulation system, as useful life of transformers is determined by the residual strength of the cellulose insulation. Moreover, if concentrations of dissolved gases are allowed to increase for long time, most of the gases get saturated in oil. At this stage, it is recommended to degas the transformer oil, since further gas generation will lead to operation of Buccholz relay and any air bubble inside the transformer will damage the solid insulation.

Principle of Transformer Oil Purification and Degasification

Oil purification is a process that eliminates or reduces physical contamination by means of physical processes (filtration, dehumidification, degasification, etc.) Typically this means a combination of mechanical filtration and vacuum degassing. It can be done both offline and online. The effect is normally an efficient removal of particles larger than 0.2 micron and removal of most of the dissolved water and gases in the oil.

Essential components of an oil purification and degaassing system are:

1. Oil inlet and outlet pumps
2. Coarse and fine filters
3. Heaters
4. Degassing/Vacuum chamber
5. Vacuum pumps
6. Oil trap
7. Oil flow meters, vacuum gauge
8. Control panel

Initially vacuumm is generated in the degassing chamber. Transformer oil is drawn into the system with the help of inlet pump. Oil temperature is increased by electrical heaters and suspended impurities are removed by coarse and fine filters. Hot oil is sprayed from the top into the vacuum chamber where moisture and dessolved gases are extracted. Oil outlet pump at the downstrem of degassing chamber sends the oil back into the transformer. In this way, close-loop circulation of transformer oil is continued till desired properties of transformer oil are achieved.

Action Plan Prior to Online On-Load Transformer Oil Purification and Degassing

The problem of high hotspot temperature and consequent increase in the concentrations of dissolved gases are related to each other. This problem will prevail till some permanent design modifications are carried out in the generator transformers. To resolve this problem permanently, the following jobs are planned to be carried out in near future:

1. Shifting of one single-phase generator transformer from TAPS-3&4 to factory site of original equipment manufacturer (OEM) and back to TAPS-3&4
2. Necessary engineering, design modification and validation for existing transformers at OEM site and implementation of modified design on shifted generator transformer
3. Replacement of one existing transformer with modified transformer during biennial shutdown (BSD) and its re-commissioning

4. Fabrication of six modified transformer tanks at OEM location and their transportation to TAPS-3&4

5. Replacement of old transformer tank with modified tank, shifting to location and its re-commissioning at site

Although works has been started for above mentioned activities, these activities of design modification will take some years to complete, as the quantum of work is large and the jobs can only be done in a sequential manner. If generator transformers continue to remain in service, then regular oil filtrations will be required for these transformers at an interval of 3-4 months. Transformer oil filtration after taking outage of transformer in frequent manner will result into revenue loss and cannot be justified for any operating power station. Definitely an alternative option was required so that the target was achieved seamlessly. Online on-load purification and degassing of transformer oil provided the solution to this problem.

Evaluation of Online On-Load Transformer Oil Purification and Degassing Activity

To avoid outage of plant for repetitive requirement of transformer oil purification/degassing and consequent revenue loss and to provide extra cushioning time for design modifications in existing generator transformers, feasibility of online-onsite transformer oil purification and degassing was explored. It became know that online-onsite transformer oil purification and degassing was possible and that it had been performed at a few locations in India. To understand the technical specifications, safety features and practical aspects of this system, a meeting was held with a specialized party. The necessary documents submitted by the party in support of their past completed works were also checked. The party was able to clear many doubts and demonstrated their expertise in carrying out online transformer oil purification. Further to evaluate the practical requirement and for experience sharing, a site visit to a plant where this job was under progress was carried out. And only after being fully assured about safety provisions and technical aspects of the online system, it was decided to start the activity of online on load transformer oil purification and degassing activity at TAPS-3&4.

Offline VS. Online Purification and Degassing System

The process of removal of moisture, suspended particles and dissolved gases is similar in both online and offline techniques. However, some additional and mandatory safety features are required in online on-load purification and degassing system. These provisions include:

1. Continuous monitoring of transformer oil level and logics incorporated to box-up the transformer if oil level changes beyond predetermined high and low level set point

2. Design that ensures that vacuum is drawn only in the purification and degassing equipment and not in the transformer. Special valves at the discharge of pumps so as to avoid the transformer getting exposed to vacuum during entire activity

3. Arrangement for air venting from the purification/degassing plant and oil hoses so as to avoid air ingress inside transformer prior to the start of work

4. Automatic control of entire purification/degassing activity such as programmed logic circuit (PLC) control so automatic safety provision are incorporated and no manual intervention required for starting and stopping of activity

5. Speed control of inlet and outlet pumps so as to maintain optimum oil level inside degassing chamber

6. Provision of foam/bubble control inside degassing chamber

7. Provision of oil leak detection inside purification/degassing plant and automatic stooping of activity and box up of transformer

8. Provision of other process-related alarms similar to offline purification and degassing activity

Description of Activities Performed during Online Purification and Degasification at TAPS-3&4

The most important aspect of online–on-load purification and degassing activity was to ensure that equipment as well as personnel safety was not compromised. At the same time, it was compulsory to ensure that transformer was not getting tripped, so as to avoid any undesired transient towards the reactor side.

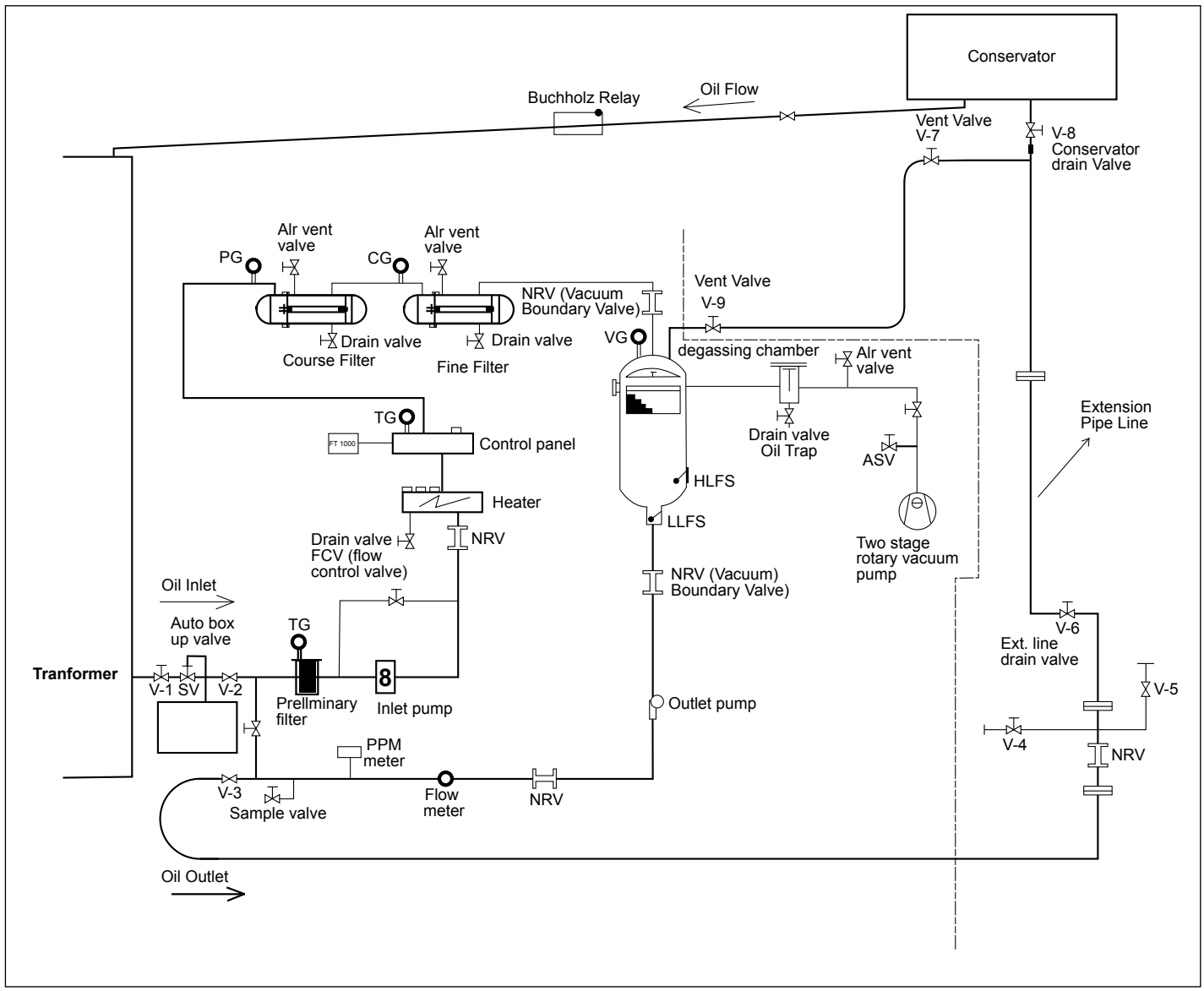


Figure 1: Schematic of online–on-load purification and degassing system

1. Measures taken to ensure personnel and equipment safety

I. Online purification plant along with oil pipelines and connecting oil hoses were flushed for sufficient duration with transformer oil provided by TAPS-3&4. This was necessary to avoid any cross contamination to generator transformers.

II. During online purification/ degassing, oil outlet from the machine is connected to the drain valve provided at the bottom of conservator. In order to eliminate the requirement of person going up for opening and closing the drain valve, an extension pipeline with valve was prepared and connected to the drain line of conservator. This arrangement ensured the start-stop of activity from ground as well as rapid box-up of transformer in case of any emergency situation. These extension pipelines were pressure-tested and flushed with fresh transformer oil for sufficient duration prior to installation.

III. Functional checks of all safety

provisions provided in the purification machine were completed. These safety provisions included:

- Complete stopping of purification activity and automatic box-up of transformer in case of oil leakage from transformer or inside purification plant
- Transformer tank or oil hoses not getting exposed to vacuum during starting and running of degassing activity. Vacuum was developed in degassing chamber only
- Automatic level control of degassing chamber with the help variable frequency drives provided for inlet and outlet pumps
- Continuous level measurement

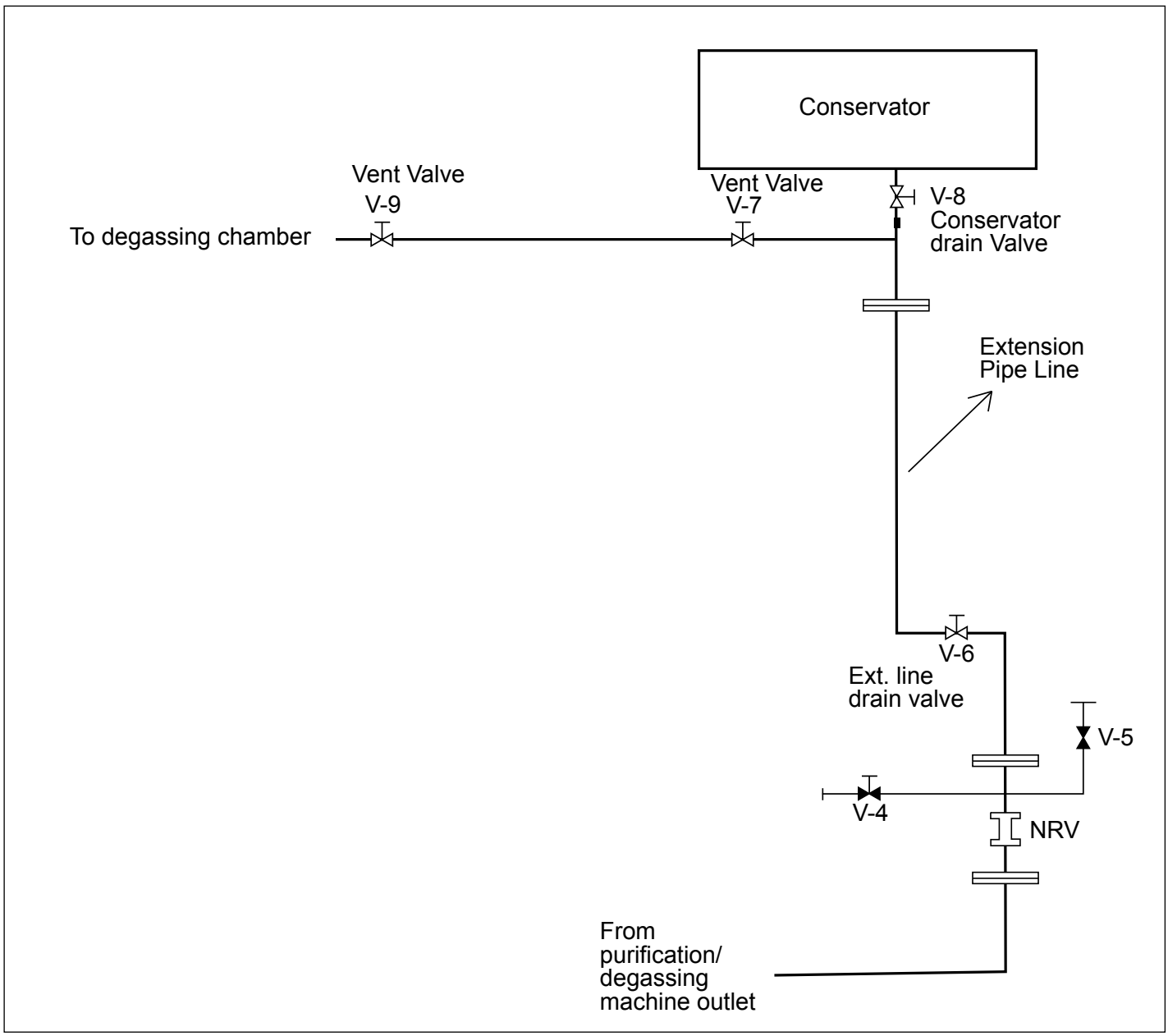


Figure 2: Venting arrangement

for transformer oil inside tank. Logics for automatic box-up and stopping of filtration plant if oil level changes beyond the high- and low-level set points

- Other alarms provided for other system equipment such as high heater temperature, pump-motors overload and high DP across filters
- Foam control in degassing chamber with the help of foam-control valve

IV. To avoid any undesired accidental situation due to any fire, fire extinguishers, especially CO_2-type were made available. Proper grounding of all electrical equipment was ascertained.

2. Measures taken to avoid undesired outage of plant and transients towards reactor side

I. In order to gain the full confidence on the system, to establish base data, to check the operation of transformer protective relays and to carry out the functional checks of logics and equipment provided in the purification and degassing system, the whole activity mockup was fist performed on a spare generator transformer.

II. During the activity, flow of oil has to be from conservator to transformer tank. By continuous monitoring of alarm and trip contacts of Buchholz relay in the spare generator, it was established that oil flow of 1200 LPH would not actuate the trip contacts and there would be no air bubbles which actuate the alarm contact of Buchholz relay.

3. Importance of air venting before start of work

The most important precaution that needs to taken during online–on-load purification and degassing of any power transformer is to prevent ingress of air inside on-load transformer. This is important because a large volume of air is initially present inside oil hoses, extension pipeline and filter machine equipment. Ingress of air inside electrically charged transformer can:

I. Cause bubble formation, badly affect the heat-removing capability of oil, which in turn can generate hotspots on windings

II. Degrade the insulating properties of oil

III. Oxygen and moisture present in air can change the physical and chemical properties of oil

It was mandatory to have the necessary arrangement of effective venting prior to the start of work along with step-by-step procedure for carrying out venting of air. A special arrangement as mentioned in Figure 2 was prepared, which in conjunction with vacuum developed in the degassing chamber and manipulation of valves and operation of oil pumps, was used for complete venting of air.

4. Completion of online—on-load transformer oil purification and degassing activity

After successful completion of mockup activity on spare transformer, oil purification and degassing plant was shifted to GT-4 "Y" phase location. Necessary set points for oil level low and high interlocks were incorporated for GT-4 "Y" phase. Air venting from purification plant and oil hoses was done and purification and degassing activity was started keeping an

Table-4: Concentrations of Dissolved Gases (in ppm)

Dissolved gas / Activity	Hydrogen		Carbon Monoxide		Methane		Carbon Dioxide	
	GT-4 "R" phase	GT-4 "Y" phase	GT-4 "R" phase	GT-4 "Y" phase	GT-4 "R" phase	GT-4 "Y" phase	GT-4 "R" phase	GT-4 "Y" phase
Before degassing	2241	2190	69	66	332	374	2870	2696
After degassing	4	5	2	4	1	2	46	87

optimum oil flow of around 1200 LPH. Concentrations of dissolved gases were reduced to significantly low level within three passes of oil circulation.

In a similar manner, purification and degassing activity was completed for GT-4 "R" phase also. During the entire activity, important parameters such as winding temperature indicator (WTI) and oil temperature indicator (OTI) temperatures, heater temperature, degassing chamber oil level, transformer oil level, and alarm on filter machine panel and transformer local panel were closely monitored.

Online–on-load transformer oil purification and degassing activity was completed without any abnormality/ transient.

Comparison of Results

Performance of online–on-load purification and degassing activity was excellent and concentrations of all the

Table-5: Concentrations of Dissolved Gases (in ppm)

Dissolved gas / Activity	Ethane		Ethylene		Acetylene		TDCG	
	GT-4 "R" phase	GT-4 "Y" phase	GT-4 "R" phase	GT-4 "Y" phase	GT-4 "R" phase	GT-4 "Y" phase	GT-4 "R" phase	GT-4 "Y" phase
Before degassing	111	114	350	435	0.5	0.5	3104	3179
After degassing	1	2	4	6	0	0	12	19

Table-6: Oil Parameters

Dissolved gas / Activity	BDV of oil (in kV)		Moisture in oil (ppm)	
	GT-4 "R" phase	GT-4 "Y" phase	GT-4 "R" phase	GT-4 "Y" phase
Before degassing	83	84	6.1	8
After degassing	86	92	5.2	7

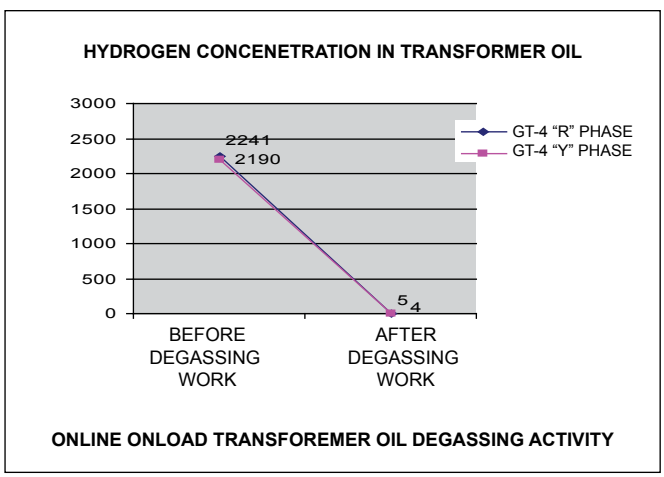


Figure 3: Hydrogen concentration

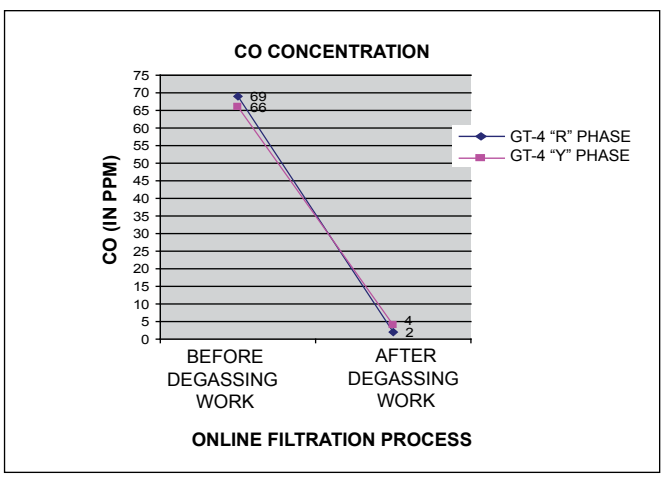


Figure 4: Carbon monoxide concentration

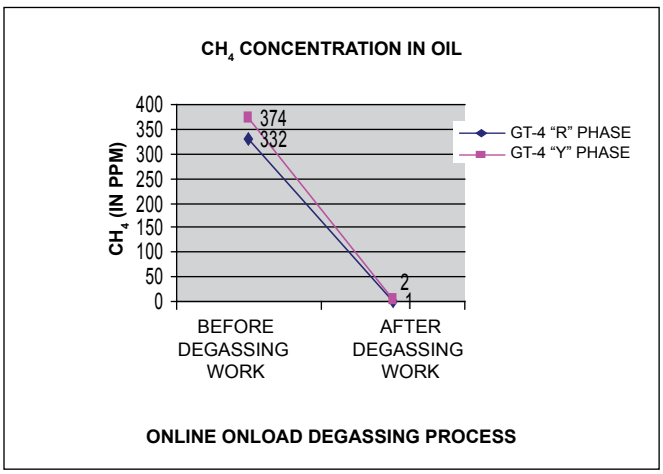


Figure 5: Methane concentration

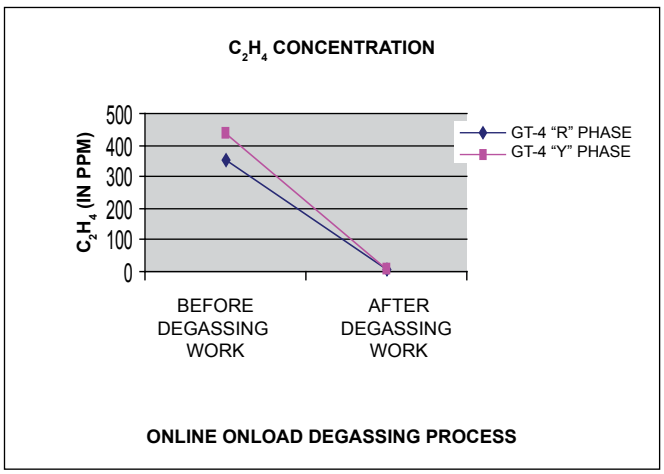


Figure 6: Ethylene concentration

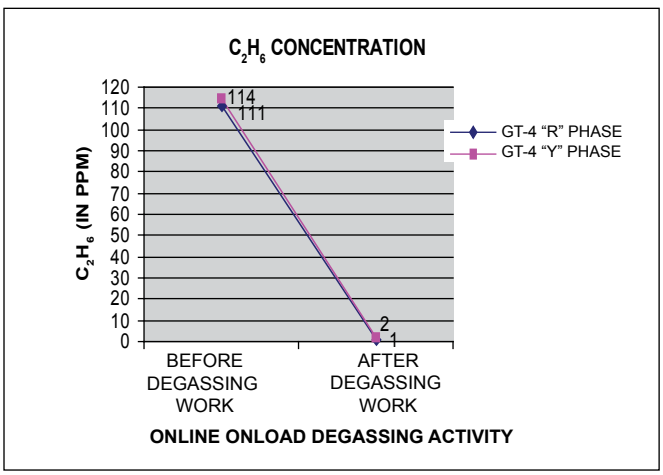


Figure 7: Ethane concentration

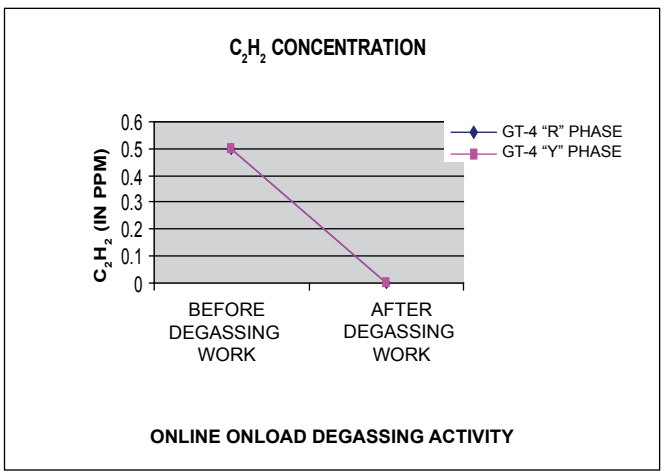


Figure 8: Acetylene concentration

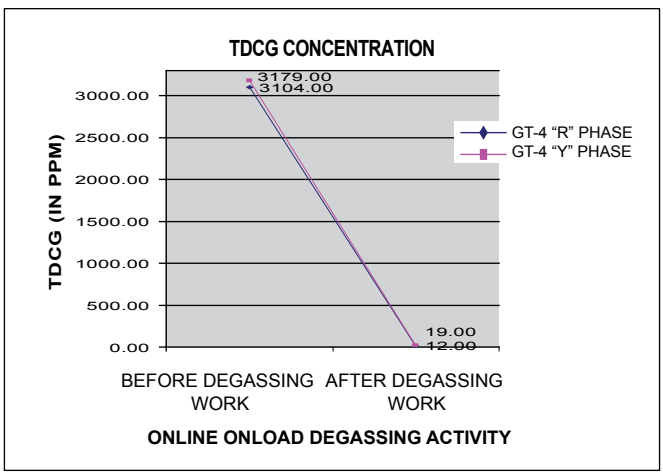


Figure 9: TDCG Concentration

dissolved gases were significantly reduced. Improvement in breakdown voltage and reduction in moisture level in oil were also observed, although before the start of activity itself, breakdown voltage (BDV) and moisture in oil values were better than their recommended value.

Conclusion

Offline transformer oil purification, commonly referred to as hot oil circulation (HOC) work, is routinely performed at many power utilities, including NPCIL. However, for the first time in an NPCIL (Nuclear Power Corporation of India Limited) unit, the activity of online on-load transformer oil purification and degassing activity was completed successfully at TAPS-3&4. The work precluded revenue loss that would have occurred due to outage and power reduction, which was otherwise imminent if offline oil purification had been carried out. At the same time, it also provided an extra cushioning time for getting the generator transformer design suitably modified.

Acknowledgement

This work is a perfect example of an efficient teamwork. It is necessary to acknowledge the valuable support and involvement of Mr. A.P. Phadke (TS), Mr. S.K. Mishra (SE, QA section), Mr. Randhir Kumar (STE, E&I), Mr. Akash Chopra (SME, Mech.) and their teams at TAPS-3&4. Without them, the successful completion of this work would not have been possible. We are also thankful to electrical design and transmission group at NPCIL, HQ for their support and NPCIL top management for their guidance.

Rishi Pal Singh Tomer, *Outstanding Scientist and Site Director (Tarapur Maharashtra Site), after completion of B.E. (Electrical) from IIT, Roorkee, joined the 21st batch of BARC Training School in the year 1977. After completion of the induction training, he was posted at RAPS-1&2 and later at KAPS in various capacities. Subsequently, he was Station Director, TAPS-3&4. Some of the highlights of his career include establishment of the process for removal of SPND from VFU/HFU and Inconel SPND installation in place of Cobalt SPND at TAPS-3&4, resolution of intake channel water flow issue prior to near-full-power operation of TAPS-3&4 and online-onsite purification of transformer oil for power transformers of TAPS-3&4. He has also guided various measures for permanent resolution of high hotspot temperatures pertaining to generator transformers of TAPS-3&4.*

Sunil Kumar Roy *completed his B.E. degree in Mechanical Engineering, in the year 1985 and joined the 29th batch of BARC Training School for his induction training. He has functioned as Project Engineer (M) at RAPS-5&6, Senior Maintenance Engineer (M) at RAPS-3&4 and Maintenance Superintendent at RAPS-1&2. Presently, he is Maintenance Superintendent at TAPS-3&4.*

Some of the highlights of his career are his role in the commissioning of NAPS, where "Anti-Burp" plugs in SSS valves were introduced, as well as in the commissioning of steam generator lancing equipment for the first time in an Indian PHWR. He was instrumental in the introduction of online-onload transformer oil purification.

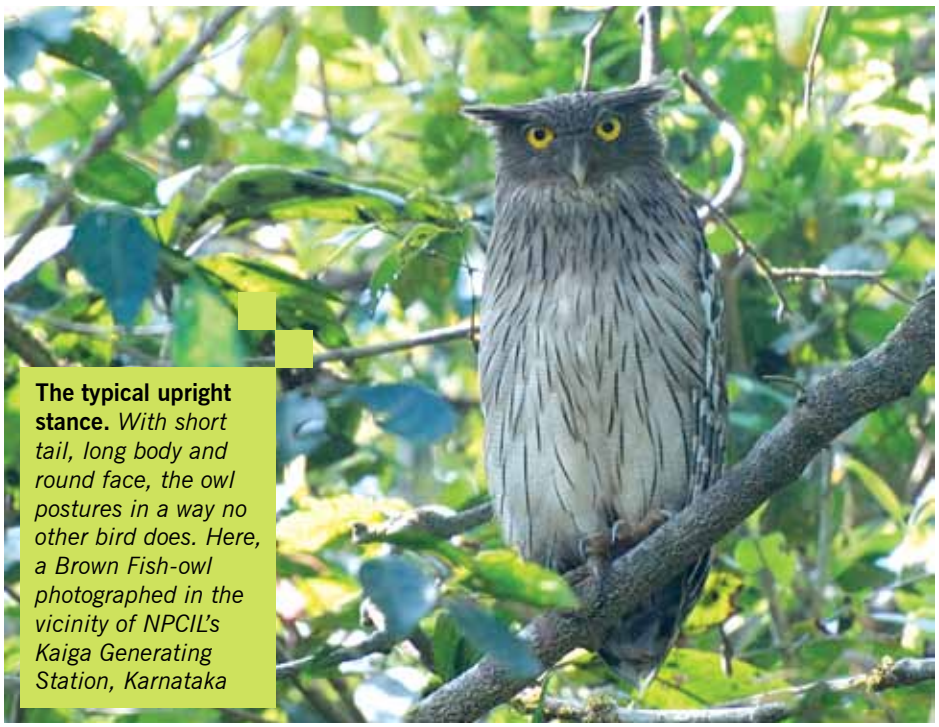
A.N. Thakur, *SME (E), is an electrical engineer. After the completion of his one-year induction training, he joined NAPS in the year 1992. There, he was involved in the commissioning and maintenance of various systems and equipment. Since 2006, he is Senior Maintenance Engineer (Electrical) at TAPS-3&4. He has made significant contribution during first synchronization of TAPS-3. He has largely contributed in identifying and resolving electrical issues at TAPS-3&4 at that time.*

Rahul Kumar Mishra, *after completing B.Tech., joined NPCIL in the year 2007. Following his one-year induction training at MAPS Training School, he was posted at TAPS-3&4, where he is part of the electrical maintenance section team since year 2011 and has been assigned the maintenance responsibility of power transformers, switchyard, ESCADA, and process water system.*

ESP (Know This Species)

Brown Fish-owl

Scientific Name: *Ketupa zeylonensis*



The typical upright stance. *With short tail, long body and round face, the owl postures in a way no other bird does. Here, a Brown Fish-owl photographed in the vicinity of NPCIL's Kaiga Generating Station, Karnataka*

Physical Characteristics

There are about 200 species of owls in this world. They are in different sizes, from 12 to 71 cm. Nevertheless, any owl species can be recognised as an owl easily, as all of them have a common distinctive shape.

The Brown Fish-owl is a large bird, about 61 cm in size. It has a long body and a disk-like face that are densely covered with feathers. With fine vertical streaks throughout, the bird is brown overall. But the underparts are paler. It has prominent ear tufts above its head. Like other fish-owls, the Brown Fish-owl too has those characteristic large straight-looking yellow eyes. The eyes of the owl have limited field of view, only about 110° compared to 180° view for humans. But what makes them exceptional is their remarkably flexible neck. They can invert their heads and can look directly behind, an action which humans would never be able to do. Besides, most owls are nocturnal and they have better vision in dark.

Distribution

The Brown Fish-owl is a resident bird found throughout the year. It is distributed in India and its nearby countries like China, Sri Lanka, Pakistan and Bangladesh. In India, it is one of the common birds and found almost all over the country. While all the seven nuclear power plant sites in India comes under its distribution range, the Brown Fish-owl is abundant in the environs of Kaiga Generating Station, which is located amidst the Western Ghats.

Ecology

The bird is seen mostly in singles, roosting in large trees amidst the dense foliage. They prefer the trees that are close to lakes or streams or any other waterbodies. They occur well-wooded areas, lowland forests and ravines.

Food

Owls are predators, and hunting in the dark is their specialty. They do so to avoid competition with other daytime predators like eagles, kites and hawks. However, the Brown Fish-owl is a semi-diurnal that hunts even during the day. It prefers dim settings like the dawn or dusk or cloudy hours. Fish is the main food of the Brown Fish-owl. It also feeds on frogs, crabs, rodents, reptiles and small birds.

Breeding

It breeds in the natural tree hallows or at the rocky clefts or in the abandon nests of other birds. December to March is its breeding season. However, this varies locally depending upon the climatic conditions. The bird lays one or two white eggs that are smooth and roundish.

Text and Photograph:
J. Devaprakash
The Author is Manager (Corporate Communication) at NPCIL, Mumbai. He is also a bird watcher and amateur wildlife photographer.

Around Kudankulam

At the crack of dawn, I awake to the spirited cacophony of birds. In the whole orchestra that has cuckoos, robins, sparrows, bulbuls and many other birds, a Peacock's call "pia-ow" is louder and nearer. I quietly open the window of my room on the second floor of a guesthouse at Kudankulam township to glimpse the scene. It is still dark outside. There is a female Peacock on a tall compound wall of a temple next-door making calls every few minutes and waking up everyone around. The other birds are inconspicuous and vocalising from all corners. I stand there mesmerizingly, listening to these nature's musicians. My spirits go high, too.

Later in the morning, down in the reception area of the guesthouse, I join the other two members of a team formed to study the wetlands and waterbirds in and around Kudankulam. They are, Dr. Bala, a renowned ornithologist and an ace bird ringer from Bombay Natural History Society and Mr. Rajeev, an active member of the nature club established by the Kudankulam Nuclear Power Plant. The study is a part of NPCIL's (Nuclear Power Corporation of India Limited) Environment Stewardship Programme, a voluntary initiative that helps conserve nature.

Kudankulam doesn't need much introduction. It is 25 km northeast of Kanyakumari, where India's mainland ends and the endless sea begins. More than its proximity to this world-popular tourist destination, it is the nuclear power project that brings fame to Kudankulam. The two nuclear reactors, being set up here in technical collaboration with the Russian Federation, are the largest-size power-generation units (1000 MW each) of any kind in India. With this distinction, this tiny village brings an enduring glory not only to itself but to the entire region as well. Besides the nuclear power plant, the region is also known for wetlands and birdlife. In the winter months, when birds tend to migrate, the region's bird population swells, as it gets numerous migratory avian beauties that visit from across the world.

It is a pleasant February morning, and a brief drizzle a moment ago has brought forth that signature fragrance of fresh wet soil. We quickly set out for the day, heading to survey the wetlands and waterbirds in that area.

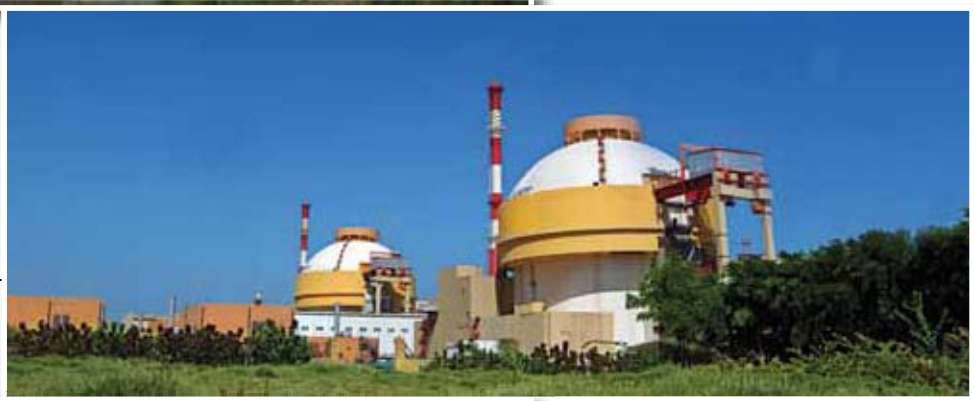
The role of wetlands in the ecosystem is undoubtedly crucial. Among its numerous features, three are commendable: It acts as a habitat for wildlife, controls erosion, and conserves and purifies water. As a habitat, it supports a great variety of species of plants, birds, animals, and myriad aquatic living things. Almost, every living thing in this world is, in a way, dependent on water. "By studying wetlands, we humans can understand their status and learn about the species that are dependent thereupon", explains Bala.

The region has wetlands everywhere. Almost every single village or town in this region has at least one wetland in the form of a pond, lake or backwater. At some places, there are more than two. Interestingly, the names of most villages in this area have suffixes that indicate a waterbody: they end with either "kulam" (meaning pond) or "eri" (meaning lake) – Kudankulam (Kudan + kulam), for instance. Similarly, there are several other nearby villages like Chetti kulam, Koonthan kulam and Kadan kulam that follow this prevalent nomenclature pattern. "There were more than 3000 wetlands, from ponds to lakes, in the Kanyakumari District alone, once," says Bala, whose hometown, called Agateeswaram, is also located in the very same region.

The study begins right from Kudankulam township, which has a long canal that drains water from the nearby villages to the sea. We collectively decide Dr. Bala to lead the survey and the other two to assist him. I take the job of writing down the field observations and Rajeev agrees to support in the counting of the birds. As soon as we reach the canal, every one of us springs into action and concentrates on our respective assignment. When on field, Dr. Bala moves around curiously like a child. With his overwhelming enthusiasm, he

ESP (Environment Stewardship Programme)

The Kudankulam township with abodes at the backdrop of looming mountains and tall windmills



The two 1000MW Light Water Reactors of Kudankulam Nuclear Power Project are the country's largest-size power generation units

The canal in the Kudankulam township is home to several resident and migratory birds

The Chettikulam lake is just minutes away from Kudankulam. Among several birds that visit this place every winter from across the world, the Garganey (the birds on their wings) and Northern Pintails (the birds in the foreground) are seen in the picture

A flock of Bar-headed Goose in the Kudankulam lake. Bar-headed Goose is one of the world highest-flying birds that fly above the Himalayas during their migration

starts counting the birds at such a pace that I can only grasp half of what he says. "Sir, can you please repeat what you just said?" I request him, blaming myself for choosing the scribbling work. Rajeev grins at me teasingly. "This canal is home to at least 25 species of birds, including many threatened species like painted storks, spoonbills and spot-billed pelicans," repeats Bala. As we stroll, he continues to list down the names of each species he sees in the canal as well as on its banks. I continue jotting down his observations. He stops walking on the spur of the moment and cries out "look at there..." pointing to a small tributary of the canal, where a bird is wading in the shallow water. He then adds, "it is a Green Sandpiper, and it comes from Palearctic countries like Russia, Denmark and Iceland". "Russia?" I exclaim and then add, "That means Kudankulam has now two classes of visitors from Russia". As I say this, my colleagues look at me surprisingly. I go on to make it clear, "I mean, we already have people from Russia (who help set up the nuclear power plant here) and now these Russian birds". The surprise on their faces now morphs into smile.

Hours later, we reach the nearby village Chettikulam, where there is a freshwater lake. It is about one km long and a few hundred meters wide. Inside the lake, we see a large group of Spot-billed Ducks that swim effortlessly on the water surface and a flock of Painted Storks that roost peacefully. With enough light, as the sky has opened up now, I take out my photo gear to shoot them. I hand over the work of writing notes to Rajeev and wink at him happily. He smirks back and grabs the booklet hastily. While I begin to photograph the birds around, Dr. Bala starts narrating the scene at his usual pace, and it is now Rajeev's turn to struggle with the notes.

It is noon when we completed the survey at Chettikulam. From here we now drive to the Koonthankulambird sanctuary, which is about 60 km northeast of Kudankulam. With convincing bird data, Koonthankulam has been designated as Important Bird Area. It is a village that has set an example for community-based nature conservation. The visiting birds enjoy peace and dwell safely, thanks to the dedicated protection by the villagers. Conservation of birds is everyone's job here, for which they sacrifice many a thing. To an extent, the village witnesses noiseless Diwali every year, as they have stopped using crackers during the celebrations since long back. Even during weddings and other ceremonial functions they never play noisy musical instruments that can perhaps disturb the birds.

We reach the village late afternoon and meet Mr. Paulpondi, the caretaker of the birds and the sanctuary. He agrees enthusiastically to accompany us and takes us to the sanctuary. On our way, he says there are several migratory birds in Koonthankulam lake and its nearby lake called Kadankulam. Soon we see a huge congregation of Bar-headed Geese, a duck that visits from countries like China and Mongolia. The truly amazing thing about these ducks is that they fly above the mighty Himalayas to reach their wintering sites like the Koonthankulam. There are about 3000 Bar-headed Goose in both the wetlands. We also see a lone Greylag Goose amidst the Bar-headed Geese.

It's five in the evening, and we wind up the survey and ride back to the guesthouse on the National Highways 7. Rajeev summarizes the day's observations "Since morning, we have studied four wetlands around Kudankulam and now have some interesting findings". The rest of us eye him keenly. He continues, "We have seen more than 90 species of birds, with an approximate total count of about 6000 individuals". "At least 20 species are migratory," adds Bala.

The jeep comes to a screeching halt as I almost scream "Pull over!" There are mixed feelings inside the motor. I am in awe and my co-riders in the car look puzzled, while the driver promptly turns his face towards me with hostility. Before he could yell at me, I explain, "I just saw a mother Spot-billed Duck with its chicks". Eureka! The puzzlement changes into excitement, and the driver's anger melts away at the cheering by the passengers. Thank God, I am saved.

A Spot-billed Duck with its trailing chicks.

"Where did you see them?" asks Bala, excitedly. "A few meters behind, in a small waterbody on our left-hand side." As I say this, Bala signals the driver to reverse the vehicle. All eyes are now on the left side of the road. The waterbody comes to our view as we race down towards it. “There it is,” Bala shouts euphorically but in a husky tone. There are seven baby Spot-billed Ducks and a mother. Every one of us watches the playful kids that move erratically here and there and their watchful mother, who patrols the area vigilant. We go speechless for a while, witnessing what is one of life’s most memorable scenes. Moments later, Bala breaks the silence, “I am excited! And although I have seen Spot-billed Ducks and its chicks many times in the past, this is different. The seven chicks are so beautiful!” He then adds, “This is the best part of the day”. Every one nods their head agreeingly.

As the sun goes behind the mountains, the mother swims towards the other end of the lake and the kids trail her one by one devotedly. Their graceful swimming leaves behind many ripples in the water and an impression in our hearts. Unlike the ripples that vanish instantly, the picture they painted will remain in our hearts forever. We watch them till they go out of sight far in the water. They are gone, but still we stand there spellbound, staring at the water on which the kids frolicked just moments ago. And finally, when it is completely dark, we leave the place with lasting memories.

Text and Photographs:
J. Devaprakash
The Author is Manager (Corporate Communication) at NPCIL, Mumbai. He is also a bird watcher and amateur wildlife photographer.

Technical Lecture Program at Shah & Anchor Kutchi Polytechnic

A lecture series at Shah & Anchor Kutchi Polytechnic, Mumbai was organized from September 16-19, 2014.

Lectures on “Need for Nuclear Power in the Country and Safety Aspects of Nuclear Power Plants" and "Omnipresence of Radiation” were organized for Diploma students of the polytechnic.

Mr. A.K. Jain, Additional Chief Engineer (Corporate Communications), NPCIL and Mr. K. Girishkumar, Executive Engineer (Health, Safety and Environment), NPCIL, delivered the lectures.

About 500 students of the institute along with Director of the Institute and faculty members attended this programme over the course of 4 days of the event. The students enjoyed this learning process with full enthusiasm and responded positively. Director of the Institute highly appreciated the initiative of NPCIL towards public outreach activities to spread awareness related to nuclear power.

A lecture session at the polytechnic

The lecture programme followed by a short quiz session was held on Nuclear Power and Radiation. Also, informative and educative exhibits were displayed and explained to the participants. NPCIL multimedia films were also screened during the programme. NPCIL informative publications were distributed to the participants.

[NPCIL HQ News Desk]

M-SAP at NAPS-1&2

Visit of Young Media Professionals of Guru Govind Singh Indraprastha University

NPCIL organized a visit of young media professionals of Department of Journalism and Mass Communication, Guru Govind Singh Indraprastha University (GGSIP), New Delhi, to Narora Atomic Power Station-1&2 (NAPS-1&2) under its long-term Media Students Adaptation Programme (M-SAP) on August 27 and 28, 2014.

The purpose of the tour was to make the participants understand about the safety, operations and functioning of nuclear power plants and also to dispel myths and apprehensions about the various aspects of nuclear energy.

Mr. Khagesh Chandra Rakesh, SO/E, NAPS-1&2, Dr. Sarvesh Dutta Tripathi, Asst. Professor, GGSIP, New Delhi, Mr. Amritesh Srivastava, Manager (Media/CC), NPCIL along with young media professionals of GGSIP and other officials of NAPS-1&2 at Turbine & Generator Hall

The visiting group was taken on a tour of the Information Centre, where several interactive panels and exhibits, models of steam generators, fuel and the structure of reactor core and working of NPPs were demonstrated to the students. Later, the students were taken to the Environment Survey Laboratory (ESL) and briefed about its role and functioning. Later, they visited the control room of the power generation unit, the turbine and the generator room of NAPS-1&2.

[NPCIL HQ News Desk]

Inauguration of NPP Model at Goa Science Center

To enhance the impact of public awareness activities, NPCIL has provided a semi-dynamic model of 220-MW nuclear power plant to Goa Science Centre & Planetarium (GSCP).

Mr. M.P. Hansora, Station Director, KGS-3&4, inaugurated the NPP Model on September 20, 2014. Mr. P.G. Raichur, TSS, KGS-3&4 as well as Mr. Hansora addressed the audience present at the occasion and explained them about radiation as well as various operational and safety aspects of nuclear power plants. Finally, questions from the audience were answered.

Mr. M.P. Hansora, Station Director, KGS-3&4, explaining the NPP model

The semi-dynamic NPP models are one of the best tools to educate and inform the general public about the nuclear power plants. This model explains the functioning of nuclear power plant in a simple and interesting manner with running commentary on various conventional as well as nuclear systems and safety features.

Goa Science Centre & Planetarium (GSCP), under National Council of Science Museums, Ministry of Culture, Govt. of India, is located at the heart of Panaji, Goa. Lakhs of people visit the center every year.

[NPCIL HQ News Desk]

Information Kiosk Inaugurated at Dharwad Science Centre

Dharwad Science Centre in Karnataka now has an information kiosk on nuclear power. The kiosk facilitates the sharing of scientific information about nuclear technology in an interactive manner. All the information can be accessed through operator-friendly software. The kiosk has been developed by the Public Awareness Committee of NPCIL's Kaiga Generating Station.

The interactive kiosk covers a wide variety of topics, such as the history of nuclear technology, how it started in India, operation of nuclear power plants, myths about radiation and nuclear power, current operating stations of NPCIL and its future projects.

The information is supported by power point presentations, relevant photographs, animations and short films. The information provided by the kiosk is aimed at students and general public seeking relevant information.

Kiosk inauguration at the science centre

The kiosk has a 42" LED screen with surround sound system and a remote keyboard with mouse, making it convenient for use by an individual or a group.

Mr. Hemant Kumar, Station director, Kaiga-3&4, inaugurated the kiosk on May 29, 2014 at Dharwad Science Centre. Dharwad Regional Science Centre, situated in the pristine Karnataka University campus, was inaugurated in the year 2012 and has been set up by National council of science museums. It is the only regional science centre in North Karnataka and covers 15 districts of Karnataka. Since its inauguration, about 1.5 lakh people have visited the science centre.

[NPCIL HQ News Desk]

Scientific Meet on Radiation and Cancer at New Delhi

NPCIL, has been organising a series of scientific meets on Radiation and Cancer for the doctors and other professionals in medical field across the country to give them scientific perspective on radiation and cancer, and nuclear safety, to dispel common misapprehensions about cancer prevalent in society.

As part of this continuing endeavour, a scientific meet on radiation and cancer was organised for the doctors and paramedics of Maulana Azad Medical College (MAMC), New Delhi on November 17, 2014. About 150 persons, including doctors, paramedics and students, took part in this scientific meet.

The meet addressed various aspects on nuclear energy such as the need for nuclear power, nuclear safety, radiation, prevailing myths on radiation and cancer, and the findings of a study on the health profile of NPCIL employees.

Dr. GK Ingle, Director, Professor and Head of Department of Community Medicine, MAMC, delivered the keynote address. Lectures and presentations were given by Dr. Tejpal Gupta, Associate Professor of Radiation Oncology Department, and In-charge of Epidemiology & Clinical Trials Unit, Tata Memorial Hospital; Dr. R. Deolalikar, Certifying Surgeon, NAPS; Shri Ashok Gupta, Station Health Physicist, NAPS; Mr. Gaurav Sharma, Training Superintendent, NAPS; and Dr. Jugal Kishore, Professor, Department of Community Medicine, MAMC.

Participants at the meet

At the end of the meet, a Q&A-based panel discussion was organised for the audience.

[NPCIL HQ News Desk]

Workshops on Preparedness and Medical Management for Radiological Emergencies at Agra

In October 2014, the Occupational Health Center of Narora Atomic Power Station Hospital in association with Public Awareness and Outreach activities committee of Narora Atomic Power Station (NAPS) arranged three batches of two-day programs on "Preparedness and Medical Management of Radiological emergencies" for i) non-DAE doctors serving with the state government ii) doctors of Sarojini Naidu Medical College (SNMC), Agra, and iii) non-DAE paramedics serving with the state Government.

This was the fourth successive year when NAPS Hospital has organized such programs at Narora. The programs were successful in achieving its goal of Spreading awareness in people about the safety of Nuclear plants and their preparedness levels for mitigating the

emergency. This program also was successful in capacity building amongst the various medical establishments around NAPS.

The program for the doctors of SNMC, Agra was organized at the SNMC campus. It was organized on October 31, 2014 and November 1, 2014 and was conducted in the Conference Hall in the Guest House, SNMC Agra.

The programs were organized with an aim of spreading the knowledge about the safety of Nuclear power plants and to appraise the doctors and paramedics of the state government serving in the three districts adjoining NAPS, and for the doctors of SNMC Agra, about the preparedness and medical management of any nuclear or radiological emergencies as a capacity building measure.

A section of delegates

The program for doctors of SNMC Agra was attended by 52 doctors, including the principal, SNMC Agra, Heads of various departments viz, Social and Preventive Medicine, Radiotherapy, Radiology and others.

[NPCIL HQ News Desk]

Seminar on Fire Load Management

A seminar on 'Fire Load Management' was conducted at Kaiga Generating Station-3&4 (KGS-3&4) for officers and supervisors on February 6, 2014 in Nuclear Training Center (NTC). Thirty participants from various sections attended the program.

The welcome speech was delivered by Mr. Michael Tomy, Safety Engineer. Mr. Hemant Kumar, Station Director inaugurated the program. In his inaugural speech, he stressed the importance of fire safety and the awareness program. This was followed by an addresss by Mr. M. Seshaiah, Training Superintendent. Among those present at the seminar were Mr. R.Y. Khasnis, Head Industrial Safety & Fire and other officials.

M.L. Kalaburgi, Sub Officer (Fire) made a presentation on "Requirement of First Aid Fire Extinguishers and Hydrants" and demonstrated various type of extinguishers and internals of extinguishers. Mr. R. Sureshkumar, FPE, explained the methodology of calculating fire load. There were other related presentations also.

A presentation by Sub Officer (Fire)

In the concluding session, the points brought out by various sections were discussed and the the improvements needed were noted by the concerned officers.

[NPCIL HQ News Desk]

Workshop on Job Hazard Analysis AT KKNPP

Two one-day workshops on 'Job Hazard Analysis (JHA)' were organized at KKNPP on July 3 and 4, 2014. The target groups for the workshop were engineers and supervisors of O&M and Construction group of KKNPP. The objective behind organizing the programme was to create awareness among the engineers and supervisors on the importance of using JHA as an effective hazard identification technique and using it as a simple tool for ensuring safety during execution of jobs.

Mr. J.R. Khatsuriya, Head (IS&F), RAPP-7&8 delivering his presentation

In his inaugural address, Site Director stressed the importance of identification of workplace hazards and taking immediate measures for their mitigation.

The participants on July 4 were engineers from various sections of KKNPP. Thirty-one engineers participated in the workshop.

[T.N. Praju, SO/C (IS&F), KKNPP-3&4]

National Seminar on Nuclear Power at Ghaziabad

Department of Electrical & Electronics Engineering, IMS Engineering College, Ghaziabad (UP) organised a National Seminar on "Nuclear Power – Clean & Safe" on November 1, 2014, at the Auditorium of IMS Engineering College, Ghaziabad. The aim of the seminar was to bring awareness about Nuclear power amongst students and faculty. This seminar was organized under the umbrella of public awareness and outreach programme at NAPS.

A view of the seminar in session

Chief Guest Dr. P.C. Pant, Director (HRD), Ministry of New and Renewable Energy (MNRE), New Delhi, Mr. A.R. Bansal, Scientific Officer, Narora Atomic Power Station (NAPS), Mr. Deepak Kumar, Scientific Officer, NAPS and Professor S.P. Pandey, Director, IMS Engineering College, Ghaziabad, among several officials, and students participated in the seminar.

The seminar emphasised on the safety of nuclear power plants in India, including key safety features in the design of a nuclear power plant, important systems of nuclear power plant, handling of any emergencies, the various ways in which the environment around an NPP is monitored.

[NPCIL HQ News Desk]

Lecture-cum-Quiz on 'Nuclear Science and Energy' at Haripur

Mr. Anutosh Chakraborty, ACE, Haripur Liaison office, delivering his lecture

On September 2, 2014, Nuclear Power Corporation of India Limited (NPCIL) organised a lecture–cum-quiz programme on various aspects of nuclear energy at Prabhat Kumar College, Contai, near NPCIL's proposed site for nuclear power plant at Haripur, West Bengal.

Around one hundred students and faculty members of the institute participated in this programme.

Mr. Santanu Pahari, DCE, NPCIL HQ, gave lecture on various aspects of nuclear science and nuclear power, covering topics like the basics of nuclear science, types of nuclear power plants, operation and safety of nuclear power plants. Mr. Anutosh Chakraborty, ACE, Haripur Liaison office, delivered a lecture on India's energy scenario, three-stage nuclear power programme and radiation.

A quiz programme was conducted after the lectures.

[NPCIL HQ News Desk]

Training Programme on Media Communication at RR Site

Professor Vishram Dhole delivering the lecture

A training program on 'Media Communication for Effective Outreach' was organised on June 30, 2014 at Rawatbhata Rajasthan Site (RR Site).

Thirty-five officers of RR Site attended the training program. Professor Vishram Dhole from University of Pune was the faculty for the program.

[NPCIL HQ News Desk]

Awareness Program at Kendriya Vidyalaya in Mumbai

Continuing the series of awareness programs for Kendriya Vidyalayas, NPCIL organised an awareness program for senior students of Kendriya Vidyalaya, Koliwada in Mumbai. The program, organized on August 22, 2014, was attended by a section of students numbering around 70. NPCIL representatives provided valuable insights into the origins of the misconceptions about nuclear power and replied to the queries from the students.

[NPCIL HQ News Desk]

NPCIL Participates in India Nuclear Energy (INE) Summit – 2014

Nuclear Power Corporation of India Limited (NPCIL) participated in the "India Nuclear Energy Summit – 2014" organized at Nehru Centre, Worli, Mumbai during November 6-8, 2014.

The NPCIL stall highlighted the beneficial aspects of nuclear power and shared information to allay the prevailing myths and apprehensions related to safety of the nuclear power plants, radiation, etc. With an interactive NPP model and informative displays, the pavilion also presented information on nuclear safety, India's three-stage nuclear power programme, capabilities of NPCIL in the field of nuclear power plant construction, commissioning, operation, renovation and modernisation etc.

Dr. R. Chidambaram, Principal Scientific Advisor, Government of India visiting the NPCIL stall

Mr. V.K. Sehgal, ACE (OPS), NPCIL, interacting with visitors

About 1000 persons visited the NPCIL stall. Queries of visitors on various aspects of nuclear power were answered by the resource persons. INE–2014 provided a platform to demonstrate Indian nuclear technology and capabilities, and also acted as a forum for interaction with Indian and overseas manufacturers as well as suppliers.

[NPCIL HQ News Desk]

Power Pavilion Bags Gold at IITF-2014

Nuclear Power Corporation of India Limited (NPCIL) participated in the 34th India International Trade Fair (IITF)–2014 from November 14 to 27, 2014. The fair was organized by India Trade Promotion Organization (ITPO) at Pragati Maidan, New Delhi.

Honorable President of India, Mr. Pranab Mukherjee inaugurated the trade fair on November 14, 2014. This two-week-long mega event hosted more than 6000 pavilions,

including overseas participation.

NPCIL set up an exhibition stall at the Ministry of Power pavilion to allay the prevailing myths and apprehensions related with safety of the nuclear power plants and radiation etc. Ministry of Power Pavilion was adjudged best pavilion at the event, for Excellence in Display category and was awarded Gold Medal in IITF-2014.

NPCIL stall displayed various interactive models, informative exhibits, panels and educative materials to highlight the benefits of nuclear power and the need for nuclear power in the country. The stall also showcased the capabilities of the NPCIL in nuclear power generation.

During the two-week period, over 9 lakh people visited the NPCIL stall. The queries of visitors on various aspects of nuclear power were answered by NPCIL resource persons.

Award citation and Gold medal being displayed at a photo session

Some of the prominent participants in the Ministry of Power Pavilion in the IITF-2014 were Power grid, Satluj Jal Vidyut Nigam Limited (SJVNL), Bhakra Beas Management Board (BBMB), Rural Electrification Corporation (REC), Power Finance Corporation (PFC), Bureau of Energy Efficiency (BEE), National Power Training Institute (NPTI), Central Power Research Institute (CPRI), National Hydroelectric Power Corporation (NHPC), Ministry of Power (MOP), National Thermal Power Corporation (NTPC), Tehri Hydro Development Corporation (THDC), Damodar Valley Corporation (DVC), North Eastern Electric Power Corporation (NEEPCO) and Nuclear Power Corporation of India Limited (NPCIL).

[NPCIL HQ News Desk]

Kakrapar Gujarat Site Participates in GMS-2014

NPCIL's Kakrapar Gujarat Site participated in Gujarat Manufacturing Show-2014 (GMS) at Ahmedabad from September 19-20, 2014. The exhibition was organised by Confederation of Indian Industry (CII) to promote manufacturing of electrical equipment/components, especially by micro, small and medium enterprise (MSME) sector in Gujarat. Electrical equipment/component manufacturers and maintenance & testing service providers like CPRI and ERDA were among the participants. NPCIL's participation was mainly for interaction with industry representatives and students from engineering colleges.

NPP calandria model being demonstrated to visiting students

The exhibition was inaugurated by Mr. K.K. Tiwari, Industrial Advisor, Ministry of Heavy Industries & Public Enterprises, Government of India.

The NPCIL exhibition stall was visited by government officials, industry representatives, scribes, media representatives and a large number of students along with faculty from engineering colleges and other institutes of higher learning. Approximately 2800 persons visited the exhibition.

[NPCIL HQ News Desk]

NPCIL's Stall at Rajkot Machine Tools Show–2014

Machine Tools Mfg. Association, Rajkot organized "Rajkot Machine Tools Show-2014" at Rajkot from November 5-9, 2014. NPCIL participated in the show as part of its public awareness programme.

There were about 200 stalls form various industries like manufacturers of machines and machine tools, measuring instruments, compressors, power press machines, laser and plasma cutting, laser engraving, various state government departments, etc.

Visitors being explained about the working of an NPP

During the five days, more than 50,000 people visited the exhibition, The visitors included manufacturers, suppliers, students, teachers, teaching staff, etc.

NPCIL displayed a dynamic model of an NPP with commentary. Various booklets and leaflets printed in Gujarati language were also distributed.

[NPCIL HQ News Desk]

Participation of NPCIL in 18th National Exhibition at Kolkata

Teachers and students at the NPCIL exhibition stall

Nuclear Power Corporation of India Limited (NPCIL) participated in the 18th National Exhibition during September 3 to 7, 2014 at Amarabati Maidan, Sodepur, Kolkata, West Bengal, which was organised by Central Calcutta Science & Culture Organisation for Youth (CCSCOY). The theme of the exhibition was "Service to the Nation for Progress of India".

NPCIL set up a stall in this exhibition to showcase India's capabilities and strengths in the field of nuclear power generation. The stall also depicted the safety of Indian nuclear power plants, environment friendliness of nuclear power, performance and achievements of NPCIL. A large number of students, teachers, academicians, journalists, engineers and other dignitaries visited the NPCIL pavilion. Queries raised by the visitors on various aspects of nuclear power and its safety were answered. NPCIL publications were also distributed to the visitors.

[NPCIL HQ News Desk]

Public Awareness Exhibition at Kota Fair

A Public Awareness Exhibition was organized by NPCIL's Rawatbhata Rajasthan site (RR site) from October 4-20, 2014 at the 17-day Dussehra Mela, a popular fair, at Kota, Rajasthan, with the objective to generate public awareness about the safety of nuclear power and its importance as a clean source of energy.

Demonstration of background radiation to visitors

About two lac visitors from different cross sections of the society visited the exhibition. The NPCIL RR Site exhibition stall was adjudged the second best exhibition in the Kota Dussehra Mela-2014 and was awarded a trophy and a citation by Nagar Nigam–Kota.

[NPCIL HQ News Desk]

Guidelines for Authors/Contributors

Nu-Power invites contributions related to nuclear power – its science, technology, economics, policy, public awareness, etc. Contributions should be of high standards, suitable for learned readership at home and abroad. Though, unnecessary complexity should be avoided, so that technocrats, teachers and students can also benefit.

Contributions can be made to the following sections: Articles, Indian News, International News, Reports (on workshops, seminars, conferences and lectures), Success Stories, Corporate Social Responsibility (CSR) and Environment Stewardship Programme (ESP), through Nu-Power correspondents, in case of in-house submissions, whereas outside articles from industry and other organizations can be communicated to the editor directly.

Articles should ideally be between 2000 to 3500 words, with innovative approach. Short articles can be between 1500 to 2000 words. Articles should contain a high degree of research-oriented work. The area of the articles can be on construction project management, some milestones/achievement in Indian nuclear power plants, renovation & modernisation, safety upgrades, etc.

Manuscript: The preferred order of article content is as follows:

1. Title of the work
2. Author(s) name(s) with designation
3. Abstract not more than 150 words
4. Main text organized in logical sections
5. Acknowledgements, if any, should be brief and non-descriptive
6. References in the order in which they appear in the text, beginning with the name of the author (surname first), followed by the year of publication (enclosed in parenthesis) and then the 'title' of the work (as published)

Reports (on workshops, events, seminars, conferences and lectures) and Environment Stewardship Programme (ESP) related write-ups are expected to provide the necessary background of the topics covered in a crisp format, along with relevant high-resolution photographs with appropriate captions. Irrelevant text should be avoided.

Success Stories are actually 'articles' or 'technical reports' that highlight unique achievements of NPCIL units. Please refer to Articles for submission criteria.

General Points

Page Formatting and Fonts: The body text shall be in 12-point font size using a standard font family such as Arial or Times New Roman. The pages size should be A4, with text matter set in '1.5' line spacing.

Submission Format: The acceptable formats for manuscript submission are MS Word document (.doc or .docx), CorelDraw (.cdr), or HTML. Embedded elements such as tables, illustrations, charts, graphs, etc. must be properly labeled and given suitable titles/captions. 'All capitals' must not be used for emphasis; these are to be used only for abbreviated terms.

Illustrations and other Embedded Objects: All illustrations, charts, figures, graphs, etc. embedded in the manuscript file **must 'also' be supplied separately (and individually)** in an industry-standard editable vector format (Adobe Illustrator, CorelDraw, etc.) with typed labels/captions **not** converted to curves. These separate 'individual' source files should have self-explanatory filenames or should be accompanied by a relevant description file in .txt or .doc format. Illustrations must be properly **labeled** and given **titles/captions**. Only a standard font family must be used such as Arial or Times New Roman. Sometimes, faithful conversion of an illustration to an industry-standard vector is not entirely possible (for example, AutoCAD files or similar proprietary formats). In such cases, high-resolution bitmap (TIF or JPG files) may be submitted. These must be high-resolution files (300 dpi, at least) saved at highest quality settings.

Photographs and Photo Captions and Titles: All photographs embedded in the manuscript file **must also be supplied separately (and individually)** either as 'Camera RAW' files or high-quality, high-resolution TIF/JPG files. The files should be large (thousands of pixels in width as well as height). Low-resolution files (for example, 72-dpi or 96-dpi web resolution files) will not be accepted. A suitable photo caption must accompany each photograph. Photo captions must be in sentence case, while titles for tables and illustrations need to be in title case (recursive Shift+F3 in MS Word).

Date References: All items must carry the date of occurrence/submission. Date references 'within' the story **should be 'absolute' references,** for example, **September 26, 2011**, rather than using relative terms such as **'yesterday,'** or **'Wednesday,'** etc.

Bio-data: should be as brief as possible and must be less than 75 words (can be relaxed in special cases) presented in a dignified manner, highlighting only the most important aspects. Lengthy bio-data write-ups will be sent back to author(s) for abridgement. Photographs of authors should be in high resolution.

Contact Details: Author(s) should provide their contact details, including e-mail addresses, phone numbers as well as personal mobile numbers, to the Editor.

Important

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CSR (Corporate Social Responsibility)

Welfare Activities at Kakrapar Site

As part of NPCIL's CSR activities, Kakrapar Atomic Power Station (KAPS) undertakes various welfare activities for the development of neighbouring communities. Some of the welfare activities undertaken recently at Kakrapar site were:

Establishment of Laboratory at ITI, Mandvi

In 2013, Industrial Training Institute–Mandvi (ITI, Mandvi) had started a new trade of 'Instrument Mechanic in Power Plant' (IMPP) based on their study of upcoming major power plants in the vicinity of this area. This trade was

Principal, ITI-Mandvi, explaining the IMPP laboratory set-up to Site Director, Kakrapar Gujarat site

visualized to cater to industry demand of skilled manpower and was aimed at providing enhanced employment opportunities to the local youth.

On request of Institute Management Committee (IMC) of ITI-Mandvi, the Kakrapar plant site in Gujarat has recently signed an MoU to support the establishment of an IMPP laboratory at ITI-Mandvi.

Diabetes and Hypertension Detection Camp

KAPS Hospital organized a 'Diabetes and Hypertension Detection Camp' at Vankla village on October 12, 2014 to

Patients being examined at the medical camp

create awareness among the villagers about these diseases, which are known as silent killers and are diagnosed at very late stage, when the complications set in.

In the camp, more than 170 people from nearby villages were examined by a team of doctors of KAPS Hospital. The checkup included measurements for blood pressure, blood-glucose level, and stress level to assess the condition of the heart.

Later these patients were advised to attend the rural dispensaries run by KAPS, to continue the follow-up consultation and treatment on monthly basis. Patients requiring further investigations like lipid profile, renal function test, chest X-ray, etc. were referred to KAPS Hospital for further check-up.

School children happily displaying their certificates

Distribution of Scholarship/Sponsorship and Awards to Local Students

For encouraging students, a scheme of sponsorship/scholarship and one-time awards to the local students was inducted under the site's CSR program. The program information was disseminated in July 2014 to the principals of all the schools and Sarpanches of villages located within 5-km radius of Kakrapar Gujarat Site, for inviting applications.

School children with the school kits

A total of 204 students from 34 schools from 12 nearby villages benefited through this program this year. The scholarships/awards were distributed in various phases.

Distribution of School Kits

To encourage children from neighboring villages for their debut academic session, NAPS Welfare Committee distributed school kits containing a bouquet of schoolbag, rain coat, water bottle, drawing book, crayon colour box, pencil box, eraser, sharpener and biscuit packet to about 110 children of 14 primary schools of 4 nearby villages. NAPS periodically distributes educational materials and accessories to school children of neighbouring villages, along with providing other services.

CSR Activities at TMS

As part of Nuclear Power Corporation of India Limited's CSR activities, Tarapur Maharashtra Site (TMS) undertook the following welfare activities recently.

TMS has constructed internal roads, a school playground and a crematorium at Patharali village, while it has also constructed internal roads at Dahisar village.

An English-medium school – Anuvikas English School – has been constructed at village Dandi by TMS. The CSR project was inaugurated on July 17, 2014 by Mr. Ravindranath, the then Site Director, TMS. The inauguration ceremony was attended by 300 parents, teachers, students, citizens, villagers and TMS Officials.

TMS officials and villagers after the inauguration of the internal road constructed at Patharali village

[NPCIL HQ News Desk]

KGS Organises Blood Donation Drive and Medical Camp

Blood Donation Camp

As a part of corporate social responsibility (CSR) activities of NPCIL, a 'Blood Donation Camp' was organised by Kaiga Generating Station (KGS) in association with District Civil Hospital, Karwar, Karnataka. The camp was inaugurated by Mr. H.N. Bhat, Site Director, KGS on July 19, 2014 at 'KGS Hospital' at Kaiga Township.

Participants donating blood

Dr. Renuka E., Blood Bank Medical Officer, DCH, Karwar, delivered a lecture about the importance of blood donation. The Blood donation camp collected 76 units of blood donated by the voluntary donors of Kaiga Parivar.

Medical Camp

KGS also conducted a free 'Medical Checkup Camp' at Anshi village in Uttar Kannada district on October 19, 2014. Specialist doctors, including pediatrician and dermatologist from nearby city, Hubli, provided voluntary service for the camp. The camp was inaugurated by Mr. Sanjay Kumar, Station Director of KGS-1&2 in the presence of Mr. P.G. Raichur, Chairman, CSR Committee, KGS.

Beneficiaries at the medical camp

A total of 202 patients were registered and treated at the medical camp. Around 50 children in the age group of 4 months to 10 years also benefited from the camp.

[NPCIL HQ News Desk]

Lab and More Classrooms at Kudankulam

Additional classrooms to existing ones and a laboratory were constructed at TDTA St. Andrew's Higher Secondary School at Kudankulam by Kudankulam Nuclear Power Project (KKNPP) under its Corporate Social Responsibility (CSR) programme.

A view of newly-constructed 'KKNPP Block'

The newly constructed 'KKBPP Block' containing four classrooms and a laboratory was inaugurated by Mr. R.S. Sunder, Site Director, KKNPP, on November 12, 2014 in the presence of villagers.

[NPCIL HQ News Desk]

Success Story

Historical Continuous Operation of RAPS-5 for 765 Days – A Success Story

Vinod Kumar, Station Director, RAPS-5&6 **J.R. Deshpande,** Chief Superintendent, RAPS-5&6
Yash Lala, STE (N), RAPS-5&6

Nuclear Power Corporation of India Limited (NPCIL) has achieved a historical milestone. One of its units, Rajasthan Atomic Power Station unit-5 (RAPS-5), recently clocked continuous operation for 765 days. By the virtue of this lofty achievement, RAPS-5 now stands second globally and first in Asia for longest continuous operation by a nuclear power plant.

The RAPS-5&6 plant is the last flag bearer in the series of 220-MWe PHWR type of nuclear power plants of NPCIL.

This success story of RAPS-5 is a victory of team performance and reflects the highest level of safety culture in place at the Indian nuclear power plants. Indeed, the team members utilized the operating experiences of various stations accumulated over decades, while all good practices were incorporated in the work culture at RAPS-5&6. Thus, it was a fruition of earnest and wholehearted efforts as well as meticulous planning and implementation by various teams.

RAPS-5 was declared commercial on February 4, 2010. During the initial 2 years of its commercial operation, the unit had operated continuously for 312 days. The first biennial shutdown (BSD) of the unit was taken from May 18, 2012 to July 1, 2012. The BSD was scheduled tightly, for minor jobs related to improvement in the systems, as it was the first BSD after commercialization. Operating the unit for two years from January 2010 to May 2012 had already generated plant jobs that were related to the initial periods of operation, especially in the improvement category. Everybody involved gave the optimal output, and thus all the scheduled preventive maintenance jobs, breakdown maintenance jobs, etc. were completed despite some minor hurdles. Emphasis was on proper planning of jobs during the BSD, and its implementation helped in the enhancement of equipment and system performance. Importance was given to maintenance of shutdown accessible areas equipment to ensure their trouble-free performance for longer duration. The station's endeavor to put down everything on plan, to sift through the data, to find out hidden problems, while analyzing them and implementing better, novel and safer solutions took the unit's performance to an entirely different level. Steam generator tube-leak rectification, in-service inspection (ISI) of equipment, scheduled surveillance and external water hook-up provisions were the other major jobs completed during the BSD of 2012.

Major thrust was given to improvement in ambient conditions like temperature, humidity and dust control. The parameters that affect the performance of various equipment/instrument were controlled by improvement in thermal insulation, elimination of probable leaky points and use of improved quality spares. Some of the non-conventional jobs carried out during the BSD, which contributed a lot towards the excellent performance of the unit were:

1. Dust control in vital areas like control room/control equipment rooms and associated panels
2. Removal of extra wires and elimination of ground faults
3. Ensuring terminal tightness with proper lugging – This has helped in minimizing ground faults during plant operation and thereby eliminating transients
4. Replacement of PRVs of shutdown accessible areas proactively based on the operating experience
5. Cleaning of all vital panels (programmed logic circuit – PLC) and electronic cards
6. Temperature reduction in pump room, fuelling machine (FM) vaults and in other areas
7. Overhauling and inspection of important equipment to ensure prolonged trouble-free operation
8. Replacement of primary coolant pumps (PCPs) oil circuit glass rotameters by metallic rotameters
9. Installation of plugs on downstream side of vent and drain valves to eliminate any possibility of leaks
10. Upgrading of NSR PLC software to eliminate problem of frequent halting of PLCs
11. Functional check of 600 fan modules of C&I panels and replacement of 260 panel cooling fans
12. Inspection of card guides of C&I panels and replacement of 465 guides

13. Inspection and repairing of door locks of 168 panels

14. Reconditioning of 409 JBs

Post-BSD, the unit was started on July 1, 2012, but there were two short outages due to grid- and electrical-related disturbances. finally, stabilised operation commenced on August 2, 2012. Since then, there were still enough hurdles to tilt the balance and cause an outage, but correct decisions at correct time, and appropriate corrective actions without any human error contributed in reaching the ultimate milestone.

With time, the organization has learnt new techniques on human performance improvement and error reduction techniques, pre-job briefing, JITs, etc. These have helped in reducing issues related to human performance.

The perfection of maintenance crew to maintain equipment without failure and catch a possible failure before it happens proved to be one of the important building blocks of this success. The keenness to observe what is not visible to our eyes, through many techniques like vibration analysis, thermal imaging etc. and the philosophy of post-job review/critic helped in the refinement of procedures and tools, which helped achieve reduction in repetition of jobs as well as reduction in downtime of the equipment. The maintenance and QA success is mainly due to the following:

- Performance of job by qualified and trained maintainers
- Use of mock-ups and training set-ups to qualify procedures as well as trained persons before working on vital equipment
- Timely review of procedures incorporating the feedbacks received from the field maintainers/ operators

A panoramic view of Rawatbhata Rajasthan Site

- Use of quality materials like spares and consumables to get best performance of the equipment for very long duration

The Quality Assurance group ensured that all the works were done as per the best of industrial standards. The Industrial Safety group contributed a lot by active involvement in all the critical works and regular field visits to ensure overall industrial safety.

Regular field visit by senior officers also yielded results. Identification of minor deficiencies and their correction at the very incipient stage, regular inspection in control equipment room and ensuring that all the panels are closed properly with all mounting screws helped in prevention of dust ingress into the panels.

Regular performance monitoring of system/equipment, routine equipment change over, regular preventive maintenance on standby equipment, an error-free operations by O&M staff and the collective decision-making formed the pillars of the success structure.

Monthly sectional presentations in the meetings helped in understanding each other's work and suggestions for improvements led to overall performance improvement.

The following important activities are worth mentioning in the continual improvement of the station:

1. **Preparation, validation and adherence to procedures**

   Procedures were prepared to enable proper job planning and execution in the field. The procedures were then validated in the field and refined based on feedback. The emphasis on use of procedures, checklists helped in reduction of errors and thus jobs were done correctly not only the first time but every time.

2. **Regular work permit meetings**

   The jobs to be performed were reviewed in detail in the permit meeting on the previous day. Along with the senior persons of maintenance groups, the planning engineer and senior operation engineer also participated in the meetings. The jobs involving critical activities were planned and the plans reviewed thoroughly before permitting the works. This helped in smooth conduct of operation and maintenance, while at the same time eliminating the possibility of transients.

3. **Job observation program**

   In the job observation program, senior persons of other sections/ groups were encouraged to observe the performance of the job and give their written feedback in the standard format, which included various aspects of human performance as well as plant material condition. Coaching was given to the job performers.

4. **Operating experience sharing**

   Operating-experience sharing on regular basis was ensured for incorporation of necessary upgrades and modifications to avoid any incident or to have the resources ready to mitigate the consequences. Based on the operating experience review and its applicability, the human performance-related issues were also discussed at sectional level to bring awareness amongst all the employees of the organization.

5. **Operation crew meetings**

   Charge take-over invariably included panel walk-downs and subsequently the incoming crew members discussed the operational aspects in detail on the status of the plant. This reduced the chances of any communication gap or errors.

   Shift-duty hours were also utilized for operating experience sharing among the crew members. The supervisors and operators were encouraged to make presentations in the crew meetings.

6. **Understanding the importance of configuration control**

   Configuration control process was effectively implemented to ensure that all changes in the plant design were accurately recorded in the relevant documents such as drawings and procedures. This ensured the operation and maintenance activities to be performed without errors. Also, correct labeling of equipment was ensured.

7. **Zero tolerance for ground faults**

   Elimination of ground faults and restarting of units with zero ground faults helped in reducing transients. The MTBF (meantime between failures) of the equipment increased, which in turn helped in longer continuous operation.

8. **Stress on mandatory and need-based training**

   Keeping in mind the goal of training

that is to enhance knowledge, skill and attitudes of the personnel, need-based training program were identified on the basis of job, task analysis and the performance gaps observed. Additional inputs were taken from the low-level events, near-miss events and job observation by various teams. Section heads were encouraged to nominate persons for need-based and mandatory training programs.

9. Management field visits

The management field visits at various plant buildings observing plant material condition as well as various work practices and safety culture gave vital information on the existing status and the scope for improvement in plant material conditions and working culture.

10. Regular interaction of management with employees

Interaction with employees gave first-hand information on the difficulties faced by them and also the employees were encouraged to suggest improvement-related modifications. Without fail, there were sectional meetings with the management involving members up to the lowest level, prior to and after any major activities like BSD, internal or external reviews and while going for a major change in the work practice. The suggestions were discussed in the station management meetings, while all feasible suggestions were incorporated and informed to the person who had suggested the particular improvement. This brought in more belongingness and ownership, and this helped in the improvement of overall plant performance.

Finally, one cannot complete the penning down of memories without mentioning the contributions from those who arranged all the consumables for operating the unit. From refueling of reactor core, gas cylinders, upgrading of D2O, chemicals for maintaining chemistry, to availability of DM water and other spares for maintenance sections required many agencies, to give their output without fail.

The organizational goal on safety culture improvements in a proactive manner and reinforcing the methodology of conduct of operation and maintenance with timely support and guidance from all the Directorates of Headquarters, all the stations, AERB as well as all other DAE units helped in smooth and sustained operation of RAPS-5.

This success story has added a golden chapter to the history of NPCIL. Hopefully, it will not be the only one, and that there would certainly be many more.

Vinod Kumar, *Station Director, RAPS-5&6, is an electrical engineering graduate and from the 24th Batch of BARC Training School. Initially, he joined as Technical Engineer in RAPS and there he formulated and implemented the power cable segregation plan, which was subsequently adopted by all NPCIL units. Among other notable contributions is his role in the EMCCR of NAPS-1 and KAPS-1 as well as in the critical tasks of calandria vault and suppression pool repair.*

J. R. Deshpande, *presently working as Chief Superintendent at RAPS-5&6, is a mechanical engineer. He is from the 29th Batch of BARC Training School. He started his career at KAPS in 1986. He was involved in the replacement of cobalt elements and jigsaw panel's modification at KAPS. In 2004, he joined KGS-3&4 as SME (M) and he was involved in the identification of the end-shied repair at Kaiga-3 and its coordination with various agencies.*

Yash Lala, *an electrical engineering graduate, completed his induction training from the 32nd batch of BARC. He is presently Senior Technical Engineer (Nuclear) at RAPS-5&6. He joined RAPS-5&6 during the early phases of commissioning and was a core member of the O&M team. He has a wide experience in commissioning, operation and technical services of PHWRs.*

In this issue of Nu-Power, we are introducing a new section 'Golden Nuggets – From Nu-Power Archives'. Over the years, Nu-Power has grown from strength to strength, and there are many articles that continue to be of extended interest and reference value – and in this regard, they are timeless. Thus, henceforth, we will post such articles in this section from time to time, which I hope the esteemed readers of this journal will appreciate and enjoy – *Editor*

Tarapur Atomic Power Project-3&4: Design Innovations

S. A. Bhardwaj, former Director (Technical), NPCIL, **K. B. Dixit,** former Executive Director (Engineering), NPCIL

Introduction

Indian pressurised heavy water programme has evolved based on the development of 220-MWe units,which have been operating successfully since 1970s. While designing Narora Atomic Power Station (NAPS), where the design of all the systems had been done in the country, one of the guidelines was that the standardised design of this 220-MWe could be successfully scaled upto and above 500-MWe unit-size. Design work for the 540-MWe pressurised heavy water reactor (PHWR) unit, using the standardised 220-MWe as the model, was taken up in 1984. Apart from the predominant scaling-up, many other new features had to be developed for this design, because of the primary differences in reactor physics of a larger reactor-core, manufacturing and transportation of large-size equipment in India, site-specific issues and evolving regulatory standards. Designing of various structures, systems and components to meet these objectives was a challenging task. While some other articles in this volume discuss these design issues pertaining to the various systems, this article highlights some of the important design innovations carried out.

Design Approach

The conceptual design of the reactor incorporates all the basic features of PHWRs. The safety features in the existing 220-MWe units, such as fast-acting, diverse, independent shutdown systems (SDSs), high-in pressure emergency core cooling system, double containment, supplementary control room, etc. along with the safety objectives like redundancy, diversity, avoidance of common-cause failures, have been incorporated in these 540-MWe units. Extensive theoretical and experimental development followed by manufacturing development was necessary for implementing these features.

Important changes in design, as compared to the 220-MWe-size units, are due to changes in reactor-physics aspects, which are elaborated further in this article. Apart from this, there have been many additional design innovations in the 540-MWe PHWR. Some of these have been driven with the objective of maintaining and improving the indigenisation of nuclear power plant components. Certain pieces of equipment have been redesigned so that their manufacturing is within the capability of Indian industry. Fuelling machine of the 540-MWe is one important typical example of such an effort. The scaled-up size of the 540-MWe fuelling machine during the initial stages of design indicated that it would be difficult to manufacture certain key components like ball screws in India. It was, therefore, decided at that time to adopt an altogether new design concept using rack-and-pinion, the details of which are elaborated in the article "The Challenge of Completing the Fuelling System for TAPP-4 before Criticality" on page 129 in this volume. In TAPP-3&4 units, the use of computers in reactor control and various other systems has been incorporated in a big way. Extensive validation and independent verification programme has been implemented for these computer-based systems.

Reactor Physics of the 540-MWe

Unlike the small and compact core of 220-MWe reactors, the core of 540-MWe reactors is large and loosely-coupled neutronically. Local variations of neutron fluxes and power in various zones can independently take place. Neutron flux detection devices are required to monitor these local variations and the control systems must be capable of responding to these variations so as to avoid any

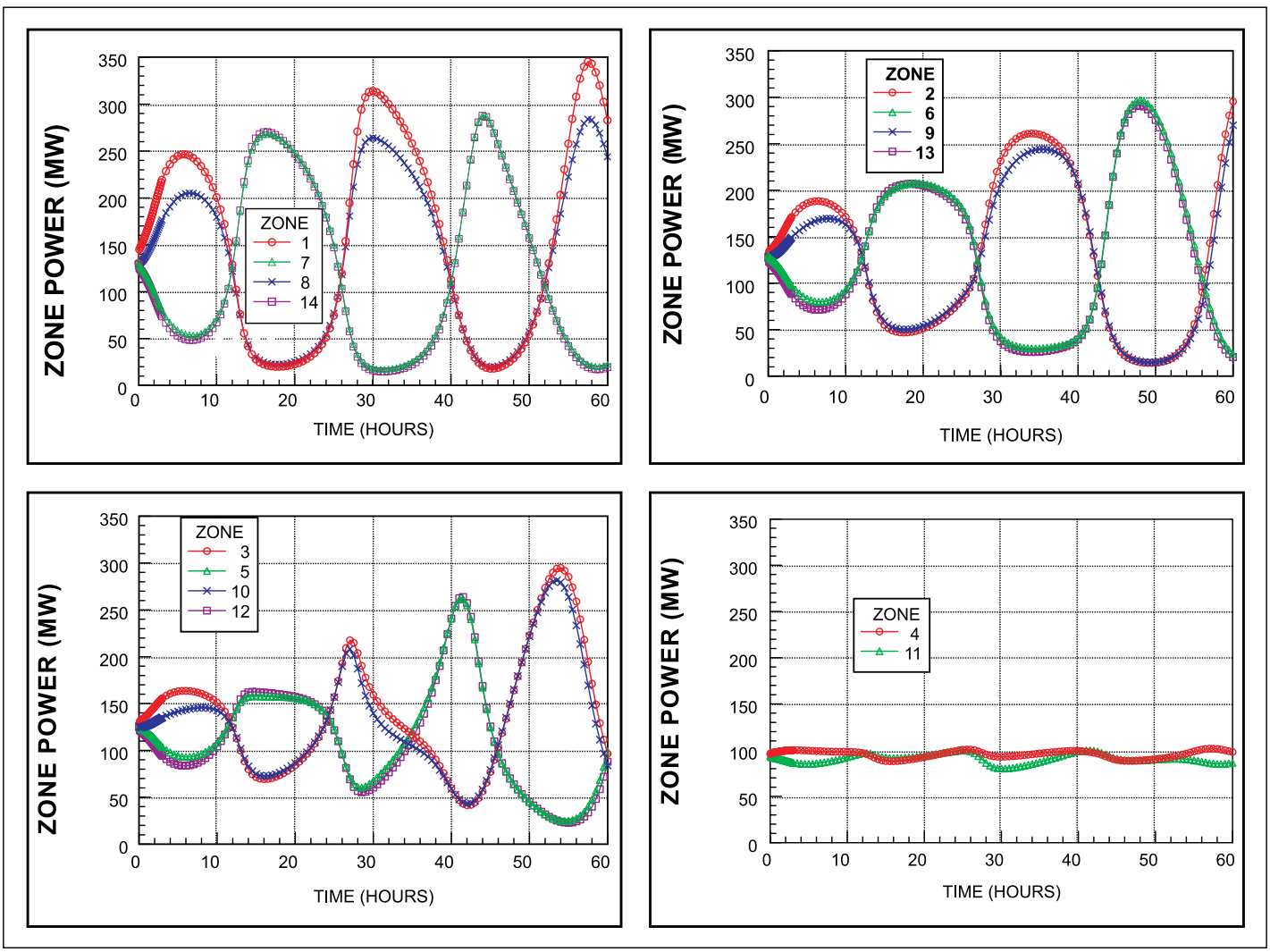

Figure-1: Zone powers without spatial power control after induced localised perturbation

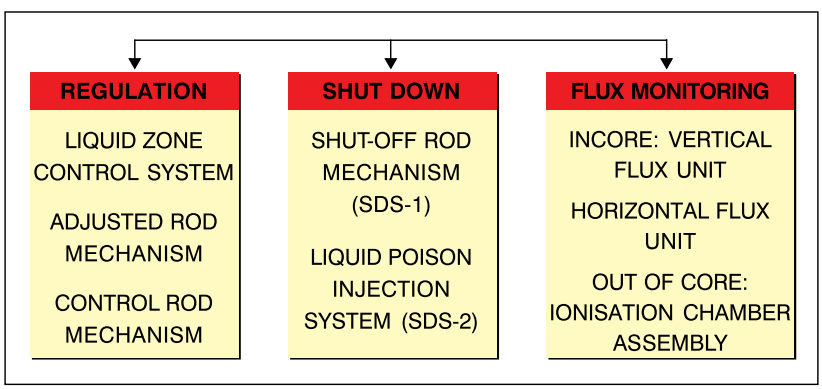

Figure-2: Reactivity devices

undesirable transients. Reactor physics has to account for any possible xenon oscillations in axial,radial and azimuthal modes. Typical variations are shown in Figure-1. These xenon oscillations could be induced because of reactivity changes as they happen because of on-load fuelling or movement of reactivity devices. Thus, on the theoretical plane a considerable amount of work with regard to 3D reactor kinetics was a new prerequisite activity in the design of these reactors.

The reactor physics input thus worked out led to the incorporation of a significantly different set of devices for reactor-regulating function. The liquid zone control (LZC) system,adjuster rods and control rods have been incorporated as a result. A 3D matrix of cobalt- and vanadium-based self-powered neutron detectors is incorporated in the reactor core to monitor the neutron flux and provides the necessary input to the reactor regulating system for the control of the reactors. Types of reactivity devices used and their functions are indicated in Figure-2. As these different types of devices are required to be present in different zones, the total number of such devices provided increases considerably and this causes the crowding of the systems on the top of the calandria vessel. Accommodating various components of these systems on the top hatch and providing working space for their installation,maintenance and replacement was a challenging task. The available space at the top of the calandria is fully occupied by LZC system, vertical flux monitoring units (VFUs), adjuster rods, control rods and shut-off rods,and therefore a second shutdown system (SDS-2) is provided from the side of the calandria. In-core horizontal flux units (HFUs) are also provided from the same side of the calandria. Ion chamber units located in the sidewalls of calandria vault provide out-of-core detection of flux.

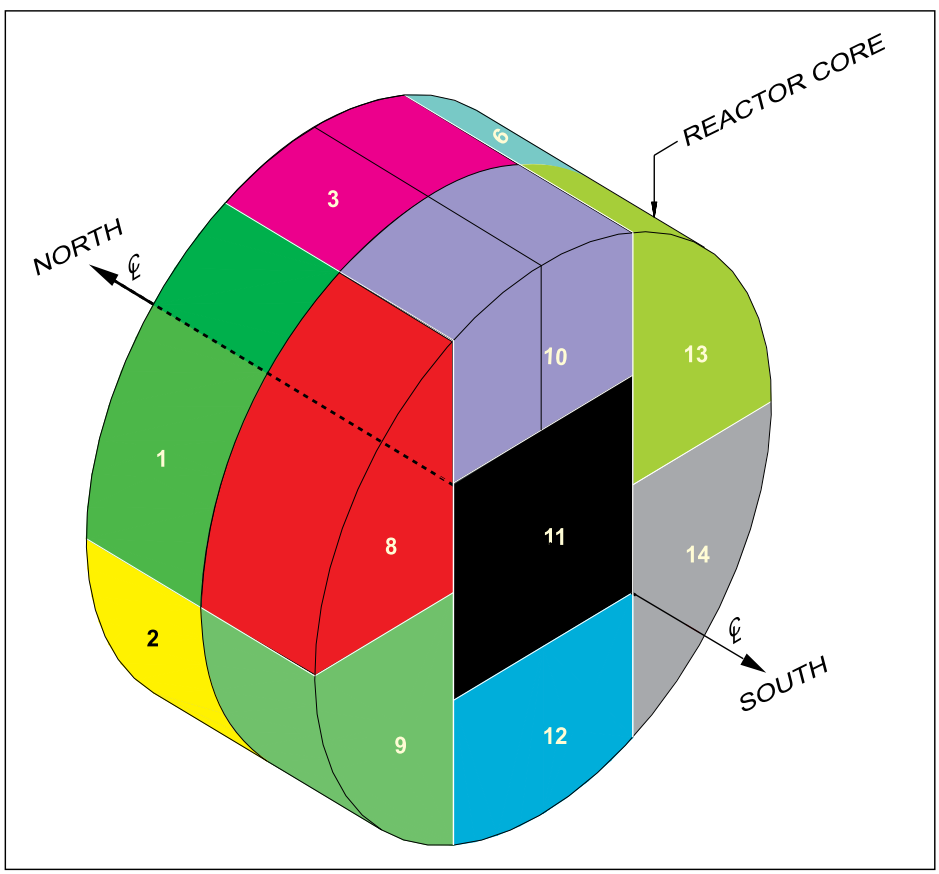

Figure-3: The fourteen zones for zone control

Shut-off rods, adjuster rods and control rods are operated by winch mechanisms. LZC, SDS-2, VFUs and HFUs are new systems introduced for the first time in Tarapur Atomic Power Project unit-4 (TAPP-4). While conceptual design and working principles of these systems is based on similar systems being used in similar applications, a detailed design of these systems was worked out. Extensive experimental work was carried out in the laboratories at Bhabha Atomic Research Centre (BARC), feedback of which was used in fine-tuning and validating the design. Design details were worked based on constraints related to availability of materials, manufacturing facilities, etc. Details of these new systems are further described below.

Liquid Zone Control System

The large size of reactor core of the 540-MWe PHWRs requires zonal control capability to take care of xenon-induced flux tilts. The LZC system designed for this purpose consists of six in-core LZC

A panoramic view of reactor building pump room (TAPP-4) with all its intricacies

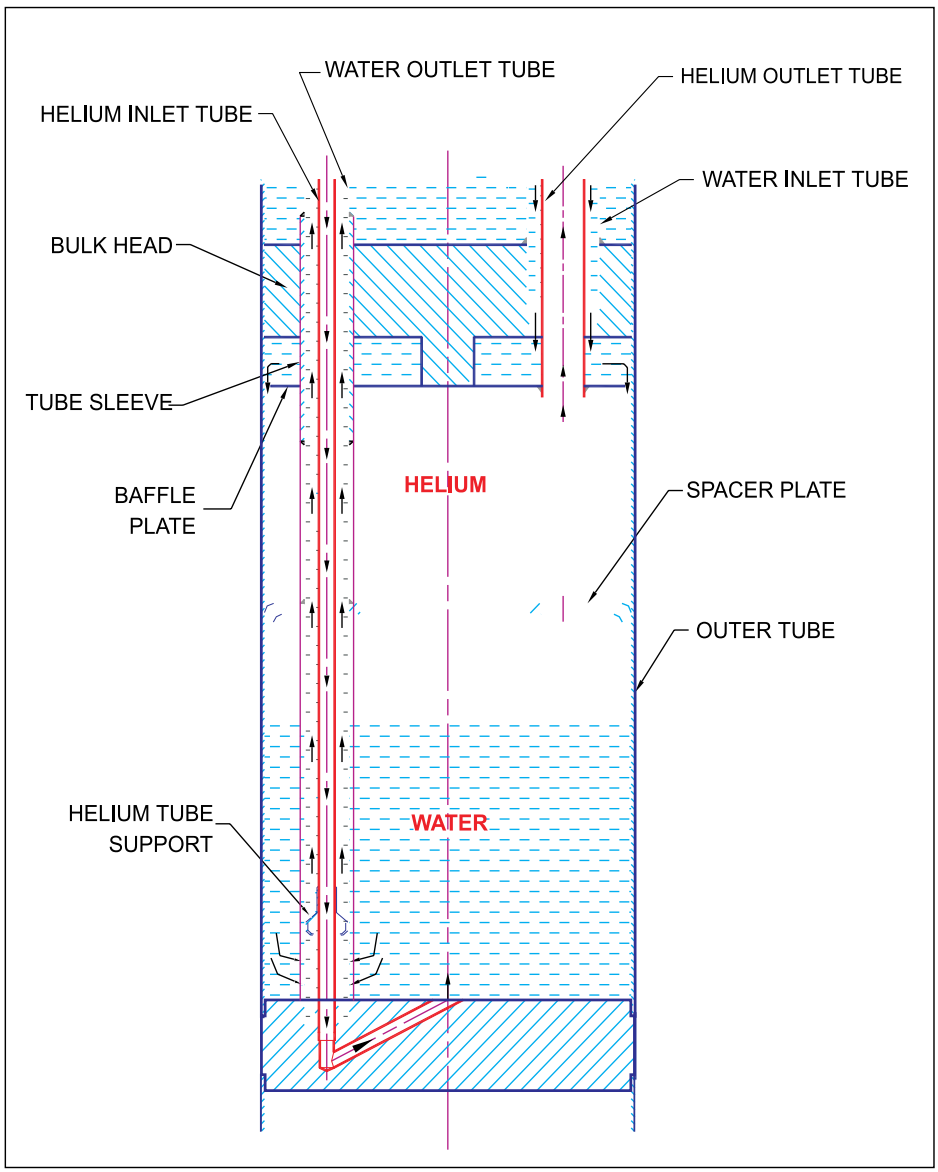

Figure-4: Zone control compartment

assemblies and the associated process system. The reactor is controlled in 14 zones (Figure-3). One zone control compartment (ZCC), containing alight water column with helium cover gas, is provided for each zone. A typical ZCC is shown in Figure-4. Two central LZC assemblies accommodate three ZCCs and four corner LZC assemblies accommodate two ZCCs. Using light water as neutron absorber, the system allows a fine control of reactivity in each of the zones, either individually for flux-tilt control or in unison for bulk power control. The system design demands a delicate balance of the water column and change in water level to suit the permissible reactivity change. The LZC assemblies, viz., 2- and 3-compartment assemblies, made of zircaloy, are installed in the calandria using a bayonet-type joint at the bottom. The assemblies are provided with axial tension to suit the bayonet-type joint as well as for increased stiffness. The assemblies are thus replaceable. A typical assembly is shown in Figure-5. The process system is similar to the moderator system, though the operating pressure is higher. The neutron absorber water and helium cover gas are under circulation. The helium is maintained at the required pressure of about 9 $kg/cm^2_{(g)}$ using a water-seal ring compressor. The selection of such a compressor is governed by the considerations of oil-free compression and helium leak-tightness. The system has been commissioned successfully for TAPP-4.

Shutdown System-2

The shutdown system-2 (SDS-2) employs direct injection of gadolinium nitrate poison into the moderator. The system consists of six poison tanks, each connected to a perforated injection tube installed horizontally within the calandria. The energy for injection is obtained from the high-pressure helium stored in a helium tank. The system schematic is shown in Figure-6. The design incorporates several new features such as a floating polyethylene ball,which, when seated, prevents the entry of residual helium gas from the poison tanks to the calandria (Figure-7). A built-in freeze jacket in each of the six injection units allows the maintenance of components associated with the injection unit located outside

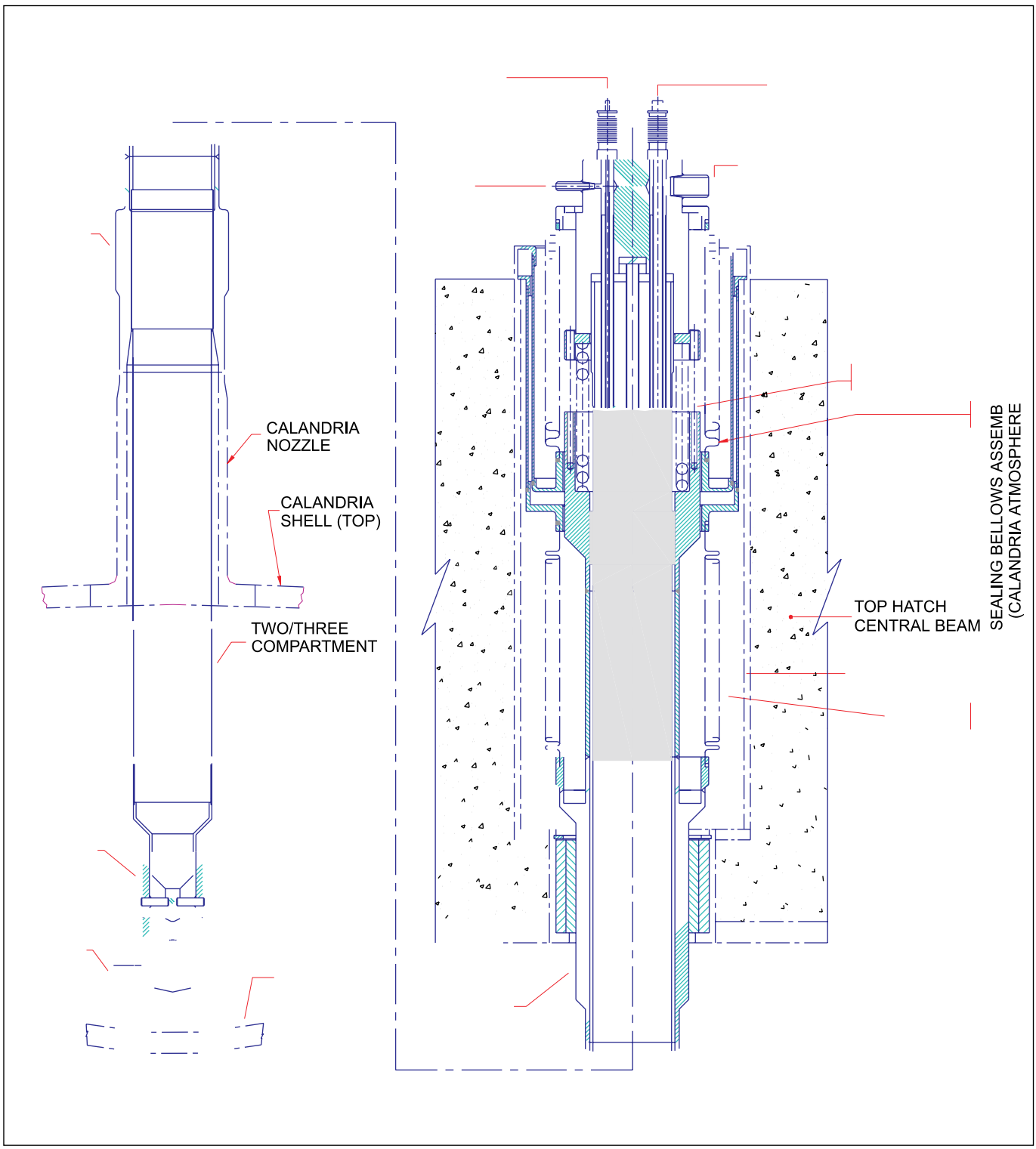

Figure-5: A Typical LZC assembly

the calandria vault. The requirements of fast addition of negative reactivity and total worth, for prolonged shutdown of the reactor, are realised in the design. The measurement of poison injection time, which is of the order of 2.5 seconds, posed a challenge due to the fast transient. Conventional level measurement by differential pressure method does not suit. An innovative approach using a pressure transmitter mounted in the injection line was used to indicate the time at which the plastic ball gets seated at the tank bottom. The experimental results with regard to poison growth profile and rate were used for evaluating the system worth. Since there is no isolation in the poison injection line, there is migration of poison toward calandria. The shift of poison-moderator interface is detected by conductivity transmitters mounted in these lines. This is used to bring the migrated poison back to the poison tank by back-flushing. The fast-acting valves, floating plastic ball, conductivity elements, etc. are manufactured indigenously.

Vertical And Horizontal flux Units

Self-powered neutron detectors (SPNDs, Figure-8) are used for in-core flux monitoring for regulation,protection and flux mapping. The detector materials used are cobalt and vanadium. SPNDs were tested in APSARA experimental reactor at BARC and thereafter at Kaiga Generating Station (KGS) and Rajasthan Atomic Power Station (RAPS) for an extended period to confirm their characteristics and reliable operation. These detectors are located in specified positions inside the vertical and horizontal flux units, which are tubular assemblies of zircaloy. General arrangement of a VFU is shown in Figure-9. These assemblies have been designed to allow individual replacement

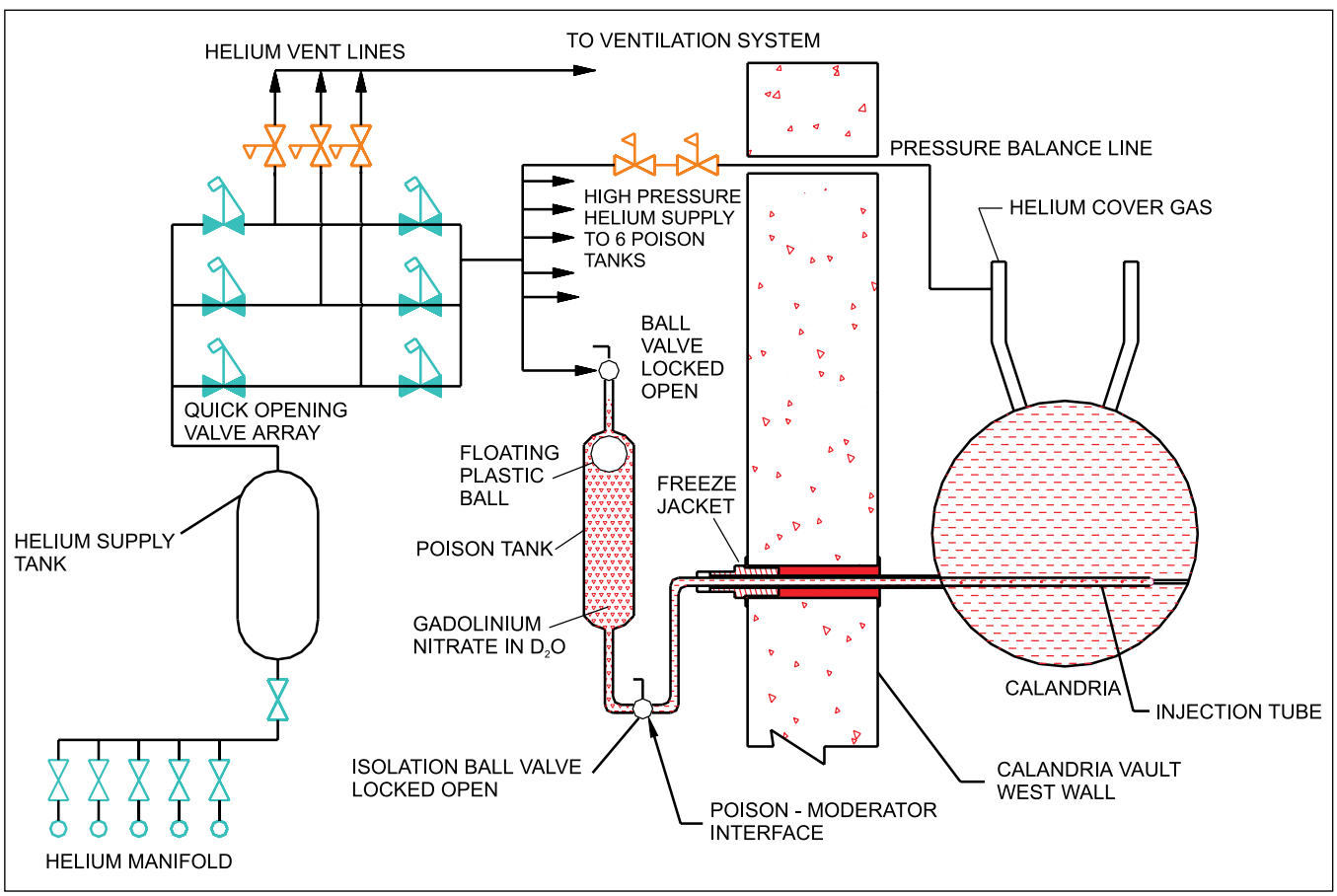

Figure-6: Shutdown System-2 (SDS-2) schematic

of SPNDs. Positive circulation of helium is provided for cooling of SPNDs. The design also allows replacement of full assembly, if warranted.

Primary Heat Transport System

The primary heat transport (PHT) system of these reactors is split vertically into two separate, independent and identical loops. Each loop consists of two reactor outlet headers, two steam generators, two primary coolant pumps and two reactor inlet headers along with feeder pipes connecting coolant channel assembly at both ends. This feature has been introduced in Tarapur Atomic Power Project unit-3&4 (TAPP-3&4) reactors and it helps in limiting the amount of coolant lost during the postulated loss of coolant accident and, thereby, reduces the consequences of such event.

Pressuriser, Pressure Control And Relief System

The heat transport medium is kept in a pressurised liquid state by a pressuriser backed up by feed and bleed control valves. This design innovation required a detailed thermal hydraulic analysis of PHT system for various postulated transients. The requirement of size and operating parameters of pressuriser were finalised after a detailed review of the results of analysis. The pressure in the pressuriser, which is kept riding over the reactor outlet headers of both loops, is maintained by electrical

Figure-7: Poison Tank - Ball seat with ball of Shutdown System-2

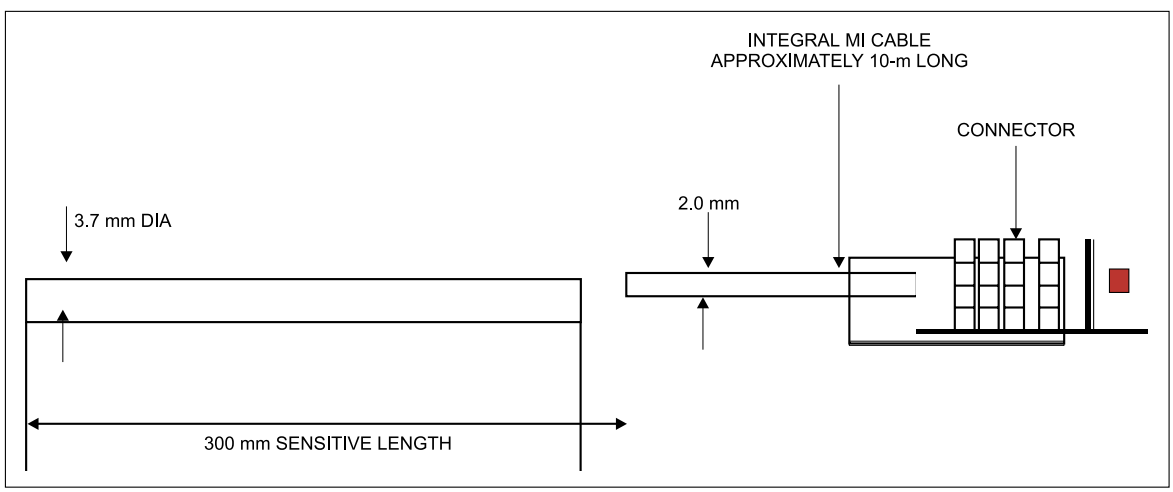

Figure-8: Self-Powered Neutron Detector, its mineral insulated cable and connector schematic

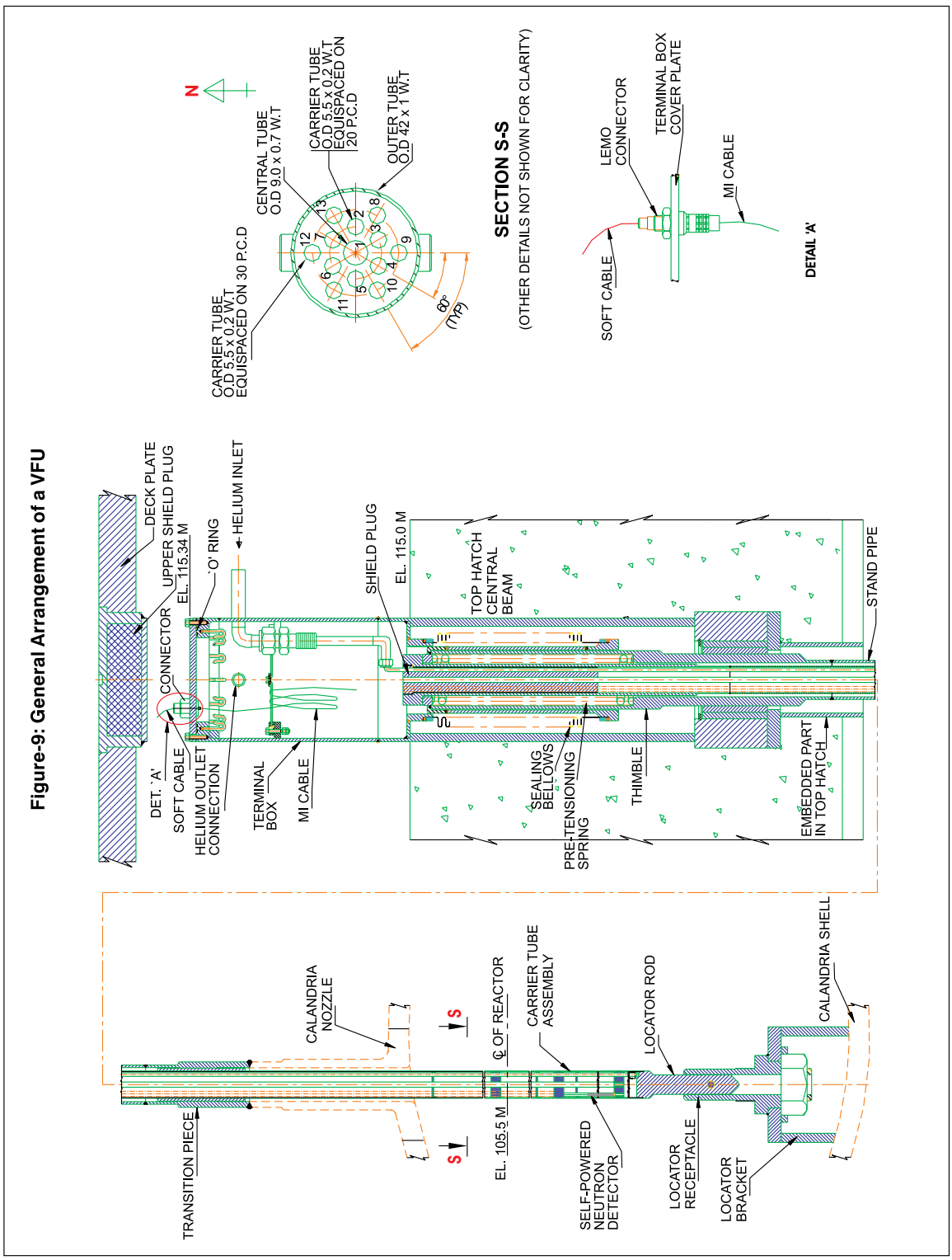

Figure-9: General arrangement of a VFU

Figure-10: Installation of major components

Figure-11: A view of Reactor Building Structural Steel Frame

heaters and steam bleed valves on pressuriser. The pressuriser remains connected to the main system at high temperature from zero-power hot standby to 100% full power and acts as a cushion for pressure variation resulting from various operational transients, and thus,reducing reactor outages on system pressure transients. Whereas the above said functions in 220-MWe units is achieved by feed and bleed system only. The internal volume of pressuriser is 30 m^3 and approximate diameter and height is 2.2 m and 12 m respectively. The mechanical and hardware design was a great challenge. The intricacies involved in the sealing of heater element penetrations called for state-of-the-art technology.

Design of Large Components

The conceptual design of large-size components of large components of 540-MWe reactors is similar to those of 220-MWe reactors. However difficulties arise due to factors such as increase in weight,larger dimensions, raw material sizes, etc. Constraints on manufacturing facilities, handling arrangements and transportation also govern various options available for the design of large components. Due to the effect of such factors certain design modifications are inevitable.

Table-1: Two-Group Concept

Required Safety Function	Group-1	Group-2
Shutdown capability	SDS-1	SDS-2
Decay heat removal	Steam generator cooling / shutdown cooling system / ECCS	Cooling by fire-fighting water through SG/moderator cooling
Minimising radio activity release	Timely operation of SDS-1 and ECCS	Containment system
Monitoring of status with regard to the above	Main control room	Supplementary control room and local panels / controls

Baffle plates in the end-shields have been eliminated to reduce the weight of end-shields. This in turn required modification in lattice tube-to-tube sheet weld joint. Extensive development efforts were necessary for establishing the design of this configuration. Development work was also involved in evolving suitable inspection methods for this joint.

Disposition of non-conformances occurring during the manufacturing of large components often call for thorough review and analysis. Corrective actions have to be evolved considering the cost and schedule implications. Alternative inspection and testing methods have to be worked out for verification and confirmation. Acceptance criteria are required to be evolved so as to satisfy the design intent. Innovative design alternatives are necessary for local corrections. All these activities require extensive development trials on mock-ups.

The requirements of handling and transportation are also considered in the design of such large components. Schemes for handling and transportation are reviewed and details of lifting lugs,attachments for anchoring and lashing, etc. are provided. Shipping frames are also carefully designed so as to prevent any damage to components during transportation. These heavy components are installed in reactor building using crawler crane, from open top before construction of dome. Suitable arrangements are provided for handling these components in this manner. Figure-10 shows views of installation of end-shield, calandria and steam generator and turbo generator.

In the case of main airlock bellows, transportation in one piece was found to be difficult and costly. It was decided to transport the segments of bellows, which were further reassembled at site. Design of stiffeners on end rings of this component had made due provisions for proper matching of the segments,while reassembling at site.

Reactor Building Structural Steel

In reactor buildings of TAPP-3&4, structural steel frames consisting of 28 columns and about 440 beams have been used to transmit various loads acting on the concrete floors. With this arrangement parallel and non-sequential construction of walls can be taken up. This has considerably reduced the construction time of reactor building. The structural steel frame also facilitates provision of left-in shuttering made of steel plates,which allows releasing certain critical areas before completion of construction of the top slab. The structural steel left-in shutterings are also used as embedded parts for supporting various ducts / cable trays / light-weight equipment.

Due to compressed schedule of the project, it became necessary to deliver the structural steel members weighing about 3000 MT in the shortest available time. Careful preparation of drawings and technical specification taking into consideration the past experience,in-house design of all end connections, proper selection of the free issue material, specifying stage assembly and matching of the members, adoption of mechanised cutting, welding and other processes, etc. resulted in speedy manufacture. During installation at site, all heavy members of structural steel matched perfectly as per the assembly requirement. Figure-11 shows a view of reactor building showing the structural steel frame. This has helped in reducing the construction time of reactor buildings and further erection activities could be speeded up.

Two-Group Concept

To protect the plant against common-mode incidents, such as fires or internally generated missiles, a two-group concept has been followed. The groups are so arranged that shutdown of the reactor and heat removal from the reactor fuel while preventing any subsequent escalation of failure is ensured. Important systems covered under these groups are shown in Table-1.

Site-specific Changes

Some other new features are incorporated from the site-specific considerations at Tarapur. This being a coastal site, it was decided to have a compact SF_6-based covered switchyard for this plant. Selection of material for various systems exposed to marine atmosphere or seawater being a very critical issue, corrosion protection measures were very important from consideration of long-term operation.

Development

The new features like LZC system, the two shutdown systems (SDSs), cobalt and vanadium neutron detectors,fuelling machine and including certain features of fuel transfer system, etc. have undergone rigorous development and testing. Full-scale mock-up of LZC system, SDS-1 and SDS-2 were commissioned in BARC and extensively tested to validate the design and confirm reliable operation. Indian industry has also come forward in a big way to develop the fabrication of larger-size components. Development of large sized canned motor pump for use in moderator system is also a remarkable contribution of Indian industry.

Commissioning

After successful commissioning, the as built systems of TAPP-4 have undergone extensive testing at operating condition in the last few months. Verification and validation of the design of all new systems could be carried out during commissioning. The efforts put in for evolving the design and development has resulted into trouble free commissioning and operation of all the systems. This includes the major systems like new fuelling machines. It may be noted that two fuelling machines were tested in a specially created calibration and maintenance facility (CMF) at the site. All the sequences of fuelling could be commissioned and tested in a period of three months without any major snag.

Conclusion

TAPP-3&4 has given a valuable experience in carrying out design and development of new systems. Based on this confidence, the design of Indian PHWR units of 700-MWe size is being carried out. Improvements based on the feedback from the current experience are being incorporated. Many improvements are also contemplated with a view to further cutting down the gestation period. Conceptual design is being finalised and work on detailed engineering will now commence in full swing.

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S.A. Bhardwaj, *former Director (Technical), Nuclear Power Corporation of India Limited, joined the Department of Atomic Energy in the year 1971 after successfully completing his one-year induction training from the 14th batch of BARC Training School. He holds an M.Tech degree in Design of Mech. Equipment from IIT–Delhi.*

[Shri Bhardwaj superannuated in January 2013]

K.B. Dixit *is a graduate in mechanical engineering from IIT–Mumbai. He joined PPED (now NPCIL) in 1973 after completing his one-year induction training from the 16th batch of BARC Training School. He has made significant contributions in the evolution of design of India's PHWRs. He is former Executive Director (Engineering), NPCIL.*

[Shri Dixit superannuated in May 2012]

CMD's Page

Newer Peaks in Performance

Dear Friends,

Following the highest-ever power generation in the previous fiscal, the NPCIL units continue to perform at higher levels of capacity factors and availability factors, producing power for the nation safely, and we continue to approach our current goals and future plans.

Established in 1954, Department of Atomic Energy (DAE) is in its diamond jubilee year. Indeed, nuclear technology has come a long way in the country.

RAPS-5's Historical Continuous Run

Unit-5 of Rajasthan Atomic Power Station (RAPS-5) reached a historic performance milestone on September 6, 2014 by clocking 765 days of nonstop operation at a single stretch, thereby becoming the 'second' nuclear power reactor in the world and 'first' in Asia to achieve this stellar feat.

As you are aware, prior to this remarkable achievement by RAPS-5, the earlier longest continuous run by an Indian nuclear power reactor was established by Tarapur Atomic Power Station unit-2 (TAPS-2) in 2011 (590 days). In all, Indian nuclear power reactor units have recorded more than a year of continuous operation on sixteen occasions so far.

This exemplary achievement of RAPS-5 is a testament to the highest level of professionalism in place at the station. I congratulate the teams that contributed their expertise and dedicated efforts to make this stupendous achievement look easier than it actually was. Meticulous planning, down to the minutest detail, which was needed for this achievement, goes to show the vital importance of teamwork.

"Unit-5 of Rajasthan Atomic Power Station (RAPS-5) reached a historic performance milestone on September 6, 2014 by clocking 765 days of nonstop operation at a single stretch, thereby becoming the 'second' nuclear power reactor in the world and 'first' in Asia to achieve this stellar feat."

The Rawatbhata Rajasthan site, the first PHWR site in India as well as the largest nuclear power plant site in the country in terms of number of nuclear power reactor units at a site, is an example of India's nuclear power success story.

The Safety Imperative

While we rejoice our proud achievements and reaffirm our commitment to scale newer peaks in the coming time, safety continues to our top-most priority at NPCIL. When it comes to achieving and maintaining highest levels of safety, human factors are as important as technological aspects. A chain is only as strong as its weakest link. Therefore, we should be keen and ever-vigilant about all aspects of safety.

Progress at KAPP-3&4 and RAPP-7&8

The indigenous 700-PHWR projects at Kakrapar and Rawatbhata are moving ahead steadily.

At Rajasthan Atomic Power Project-7&8 (RAPP-7&8, 2x700MW PHWRs), construction activities are progressing on multiple fronts. Both End-Shields have been received at the site and ball-filling activities have been completed. Erection of these equipment is expected to be taken up soon, after receipt of Major Equipment Erection Clearance, which is under review by the regulator, AERB.

In May 2014, Kakrapar Atomic Power Project-3&4 (KAPP-3&4, 2x700-MW PHWRs) received the mandatory clearance from AERB for major equipment erection at the site. Immediately following this, a series of works for the installation of major equipment commenced. Erection and welding of Calandria and End-Shields has been completed at KAPP-3. Several other related works are also being implemented in parallel.

KKNPP-1

The wait for the country's largest single-unit power-generation reactor (nuclear

CMD's Page

or any other kind) is coming to an end. Kudankulam Nuclear Power Project unit-1 (KKNPP-1), the first of the twin reactor units under commissioning at Kudankulam, Tamil Nadu, is now in the final round of testing and validation for commencing commercial operation. The unit has been operating at full power and has generated 2835 million units of infirm power till November-end 2014.

Its identically specified twin-unit reactor, KKNPP-2, is also in the commissioning stage and will enter the final stage of commissioning with the commencement of Hot Run soon.

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New Projects

A General Framework Agreement (GFA) for KKNPP-3&4 with M/s. Atomstroyexport was signed in April 2014. Further activities for project implementation, including AERB clearances for excavation, are being pursued.

At "Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP)", Haryana, pre-project activities comprising land acquisition, Environmental Impact Assessment (EIA) studies followed by Environment Clearance by the Ministry of Environment & Forests (MoEF) have been completed. This year (2014), Government of India accorded the administrative approval and financial sanction to the project. Currently, siting consent is under review by AERB. While geotechnical investigations at site are nearing completion, various activities related to establishment of site infrastructure are in progress.

Initiatives have been taken to pursue the pre-project activities for the new projects of 700 MW series pressurised heavy water reactors at Chutka (Madhya Pradesh), Mahi Banswara (Rajasthan) and Kaiga-5&6 (Karnataka) as well as light water reactor sites, at Jaitapur (Maharashtra), Chhaya Mithivirdi (Gujarat) and Kovvada (Andhra Pradesh). Public hearings for MoEF clearance have been completed for Jaitapur, Chhaya Mithivirdi and Chutka projects.

Corporate Social Responsibility (CSR)

Social inclusion has always been one of the cornerstones of NPCIL's growth impetus. In this spirit, earnest efforts are made to tangibly improve the day-to-day life of the people residing in the vicinity of our power-generating stations. A series of CSR activities were organised at NPCIL's various stations, which included infrastructure projects as well as educational and healthcare programs.

Project Turtle – Narora

Conservation of nature in and around NPCIL sites is an intrinsic part. Through our voluntary Environmental Stewardship Programme in association with premier conservation institutions, many nature conservation activities are being pursued. Recently, a conservation programme "Project Turtle – Narora" has been initiated by NAPS to save the freshwater turtles of Ganga river. A turtle breeding facility has been established in the Narora township to incubate and rear turtles. We already have the first batch of eggs and neonates. When sufficiently grown up, these neonates will be released back into their natural environment.

Public Awareness for Better Understanding of Nuclear

We continue to extend our public outreach through a bouquet of multi-pronged public awareness programs,

> **"Social inclusion has always been one of the cornerstones of NPCIL's growth impetus."**

for general public as well specific target groups, ranging from doctors, media professionals, students and teachers, to name a few. Sharing of scientific information about nuclear power helps in allaying the fears and apprehensions about nuclear power in the public. Quite a bit has been achieved through these efforts, and yet a lot still remains to be done in this area.

Awards and Accolades

Safety of our nuclear power plants in operation and projects under construction has won several state and national-level awards such as National Safety Council, India (NSCI) Safety Awards, 'Sarva Shreshtha Suraksha Puraskar', ENERTIA Award, India Power Award and Atomic Energy Regulatory Board (AERB) Environment Protection Award.

At NPCIL, our human resource is our core strength. I deeply appreciate your dedication and hard work and seek your continued support to our journey to realize NPCIL's potential to the fullest in the coming time.

I wish one and all a Happy New Year 2015.

(K.C. Purohit)

PLANTS UNDER OPERATION

UNIT-LOCATION	REACTOR TYPE	PRESENT CAPACITY (MW)	DATOMMENCING COMMERCIAL OPERATION
TAPS-1, Tarapur, Maharashtra	BWR	160	October 28, 1969
TAPS-2, Tarapur, Maharashtra	BWR	160	October 28, 1969
TAPS-3, Tarapur, Maharashtra	PHWR	540	August 18, 2006
TAPS-4, Tarapur, Maharashtra	PHWR	540	September 12, 2005
RAPS-1,* Rawatbhata, Rajasthan	PHWR	100	December 16, 1973
RAPS-2, Rawatbhata, Rajasthan	PHWR	200	April 1, 1981
RAPS-3, Rawatbhata, Rajasthan	PHWR	220	June 1, 2000
RAPS-4, Rawatbhata, Rajasthan	PHWR	220	December 23, 2000
RAPS-5, Rawatbhata, Rajasthan	PHWR	220	February 4, 2010
RAPS-6, Rawatbhata, Rajasthan	PHWR	220	March 31, 2010
MAPS-1, Kalpakkam, Tamil Nadu	PHWR	220	January 27, 1984
MAPS-2, Kalpakkam, Tamil Nadu	PHWR	220	March 21, 1986
NAPS-1, Narora, Uttar Pradesh	PHWR	220	January 1, 1991
NAPS-2, Narora, Uttar Pradesh	PHWR	220	July 1, 1992
KAPS-1, Kakrapar, Gujarat	PHWR	220	May 6, 1993
KAPS-2, Kakrapar, Gujarat	PHWR	220	September 1, 1995
Kaiga-1, Kaiga, Karnataka	PHWR	220	November 16, 2000
Kaiga-2, Kaiga, Karnataka	PHWR	220	March 16, 2000
Kaiga-3, Kaiga, Karnataka	PHWR	220	May 06, 2007
Kaiga-4, Kaiga, Karnataka	PHWR	220	January 20, 2011
Total		**4780**	

**Owned by DAE*

PLANT UNDER COMMISSIONING

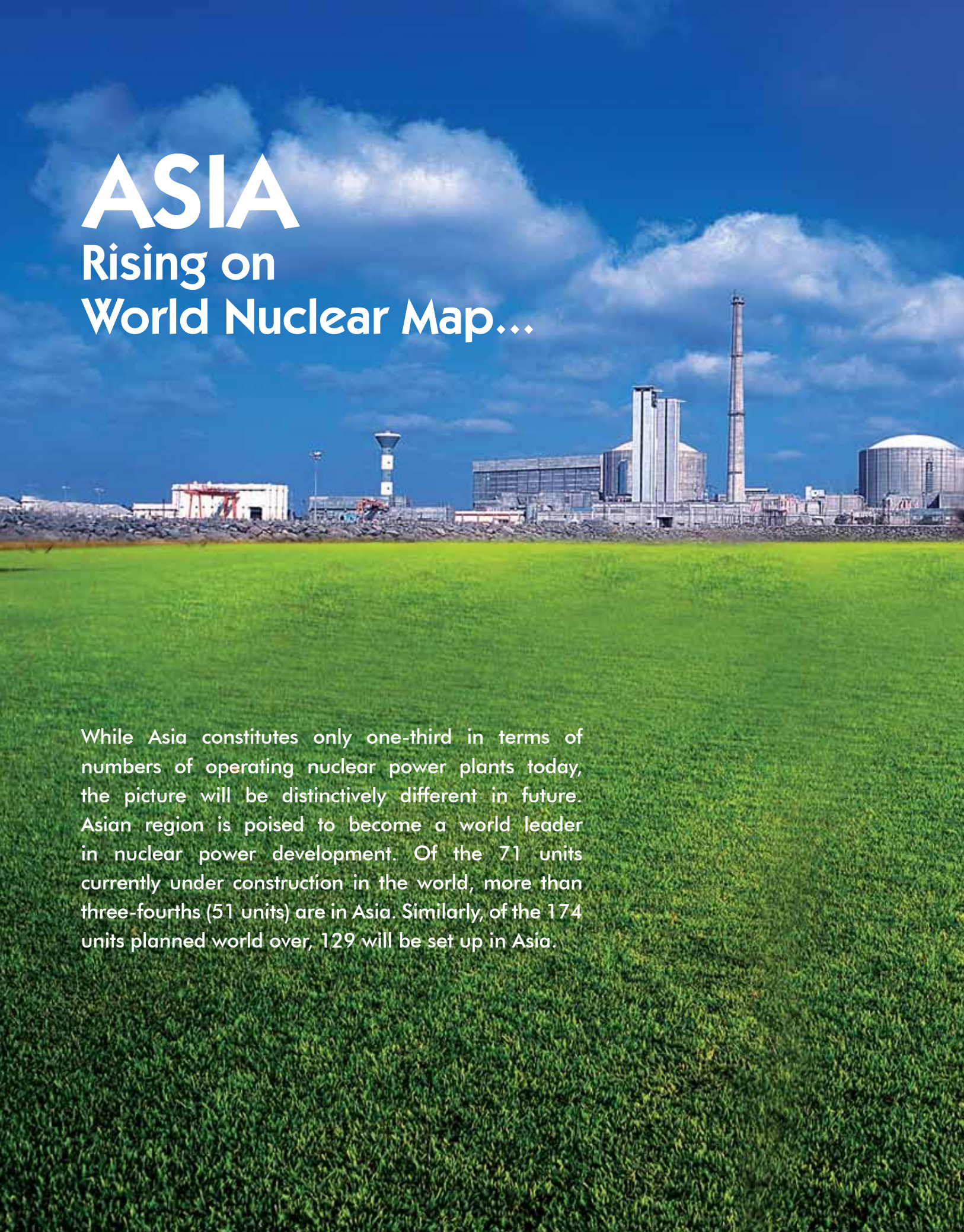
PLANT	CAPACITY (MW)
KKNPP-1,* Kudankulam, Tamil Nadu	1x1000 LWRs
KKNPP-2, Kudankulam, Tamil Nadu	1x1000 LWRs
Total	**2000**

**KKNPP-1 achieved full-power operation on June 7, 2014 and will begin commercial operation soon.*

PROJECTS UNDER CONSTRUCTION

PROJECT	CAPACITY (MW)
KAPP-3&4, Kakrapar, Gujarat	2x700 PHWRs
RAPP-7&8, Rawatbhata, Rajasthan	2x700 PHWRs
Total	**2800**
PFBR** Kalpakkam	1x500 FBR

***Being implemented by BHAVINI*



ASIA
Rising on World Nuclear Map...

While Asia constitutes only one-third in terms of numbers of operating nuclear power plants today, the picture will be distinctively different in future. Asian region is poised to become a world leader in nuclear power development. Of the 71 units currently under construction in the world, more than three-fourths (51 units) are in Asia. Similarly, of the 174 units planned world over, 129 will be set up in Asia.