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A Look At The Bright Side of Nuclear Energy

Reading *Anumukti* is generally a depressing experience. It is full of news of nuclear follies and disasters, radiation spills, cancers, deformed children and such. Don't you think you and your readers are entitled to some cheerful news ? I think so. consider the following.

The AEC has stated that India has a target of 5800 MW for nuclear electricity by 2001. Considering that we were being threatened with 20,000 MW of it in the mid 70's, this is indeed good news! The target was reduced to 10,000 MW in the 80's. Further, the bulk of this revised burden is sought to be inflicted on us through the 'advanced' 500 MW reactors Since these advanced reactors have not advanced beyond the drawing board, we can expect a further lowering of target in the coming years. I think chances are bright that we will enter the next century with no more than a dozen reactors working at 30-40% of their capacity.

An atomic power plant working below capacity should also be treated as good news. A 100% power efficient reactor produces more than twice the radioactive pollution and wastes compared to one working at 50%. Radioactive effluent treatment plants designed for a 235 MW reactor will work that much better if the reactor works only at about 150 MW. 1 am not suggesting that radioactive discharges from our nuclear reactor are actually being contained, but these discharges could have been much worse had the reactor operated continuously.

The safest reactor in the world is the one which has not been built. But among the ones actually built, the safest reactor is the orw which is not working. Since our reactors spend more.than half their life in this highly desirable state, the margin of safety, on the lives of people around also increases proportionally. A nuclear power plant in coma may be a financial loss. But it saves human lives, produces less waste to burden the future generations and is easier to decommission too! Frequent tripping off of atomic power plants also sends the right message to the state electricity boards - nuclear power is unreliable. In a globalised, liberal economy, where efficiency and cost effectiveness hold the key to survival, we can surely look forward to the well deserved demise of atomic energy as has happened in UK. All anti-nuclear activists in India should also thank BHEL whose turbines have progreased from breaking their blades, which needed a few months to repair, to going up in flames which can shut down the reactor for more than a year. No matter how righteously the nucleocrats proclaim that the turbine breakdowns have nothing to do with reactor operations, what counts ultimately is the number of units that the power plant as a whole delivers to the grid. BHEL, whose faulty turbines contribute significantly to lowering that count as well as radioactive discharges, is entitled to at least a certificate of merit for "outstanding contribution by a Public Sector Undertaking towards the environment".

Did you know that a nuclear reactor can be imported by practically anybody in India? Time was when the babus in different arms of the government decided what was to be imported and what was not. These worthies used to dictate exactly how much groveling you had to do before they favoured you with an import license. Not any more. Thing's have changed under Manmohanomics. There is only a short "Negative list". Anything not explicitly banned under this list can be freely imported. And a study of the list reveals the surprising fact that only radioactive materials are excluded. If you have the fuel and the funds, you can import any reactor of any design, including graphite moderated ones from Chernobyl.

There is a catch, though. Under section 84.01, Sub headings 8401.10 to 8401.40 of the Indian customs Tariff as amended by Union Budget of 1993-94, nuclear reactors and parts there of as well as fuel elements (cartridges), non irradiated of course, attract the highest duty slab of 80%. An year ago, the duty levied on these same items was only 60%. In other words, a nuclear reactor imported in 1993-94 would be 20% costlier than in 1992-93. One suspects some sort of connection between this and the not-yet- totally-dead issue of Russian reactors at Kudamkoolam. Perhaps a wiser reader may throw more light on this.

Plenty of light also needs to be thrown on the solar village planned by the Dept. of Non Conventional Energy Sources. (I have always wondered why something as natural as sunshine or wind should be dubbed as 'non-conventional' and a convoluted technology like N-power be accepted as 'conventional*. There certainly is a need to change our conventions.) The village of Kalyanpur in U.P has gone fully solar and is to be inaugurated by no less a dignitary than the PM, in April. True, the funds allotted for such endeavors are meager and their main role is perceived as substitutes for the petroleum products, but **these are** the first, faltering steps in the right direction. Let us hope that our non-conventional energy projects get managed much « better than the conventional energy projects get managed much better than the conventional ones.

Last but not the least, the disinformation campaign launched by our beloved editor of Anumukti is having the desired effect. We **all** know he is bluffing when he threatens to double the subscription rate overnight. Even nuclear costs do not rise that rapidly. Still, I am not taking chances. Dear Editor, your cheque for Re 260/- for a lifetime subscription is enclosed.

Sonjoy Havonur

Unlike nucleocrats, I don't bluff when it comes to money. See the subscription rates on the last page.
— Editor

From the Editor's Desk

Are Courts the Answer?

After hearing all the arguments in the petition praying for the reconsideration of the decision of the Government of India for locating the atomic power plant in the midst of a tropical rain forest at Kaiga in Karnataka, the Supreme Court on 7th May, 1993 passed the following order:

'The Centred Government will consider the report of December, 1990 submitted by NEERI (National Environmental Engineering Research Institute) and also the written submissions that may be forwarded by the petitioners to the Secretary, Department of Atomic Energy of the Government within four weeks of today, and will take its final decision in the matter of establishing the atomic power plant in consultation with the concerned departments including the Department of Environment. If the Government so desires, they may also hear the petitioners in person. However, it is made clear that it is not obligatory on the Goveminent to hear them.

Does this order represent a victory or a defeat for the antinuclear movement? Friends in Karnataka were jubilant and said that Sharavati Tail Race hydroelectric project had been shelved after a very similar order of Karnataka High Court. But nucleocrats have been equally happy claiming that the order dismisses objections to Kaiga. Have things come to such a sorry pass that we have to go through this involved, time and money guzzling procedure just to be able to present our grievances to nucleocrats, who may if they so desire give us a hearing"? Is the legal process worth the hassles?

I believe that it is only a strong people's movement which will make the operators who run the system listen and eventually adopt a policy of sanity which would respect people's rights and the environment. Deliverance will not be handed down on a platter by anyone be they learned judges and powerful politicians in New Delhi or enlightened bureaucrats in the World Bank.. First of all, these worthies need to be educated themselves. Only a people's movement can accomplish this stupendous task. Let us not waste any more effort in frivolous pursuit.

Implications of the Near Miss at Narora

How long can operator skill and heroism overcome absence of safety culture?

Indian drivers are usually quite skillful. They have to be. The condition of our roads, the diversity of our traffic and the near total absence of traffic rules makes skill a necessary condition for survival. Yet, India has one of the highest casualty rates for road accidents in the world. If one considers the fact that traffic in India is much slower than in other parts of the world, then this anomaly becomes all the more apparent. Skill alone cannot overcome the inexorable laws of probability. It cannot be a substitute for a safety culture.

The near catastrophe at Narora on March 31, 1993 brings this lesson once again to the fore. Deplorably, the lesson is unlikely to be learnt. The handling of the 'incident[9] by the nuclear establishment is in striking contrast to its handling by the junior operating staff at the plant. The plant staff showed both a heroic calmness under stress and quick witted innovative thinking. This ingenuity and dedication to duty needs to be recognized and rewarded. In contrast, the top rung of nuclear establishment plumbed new depths of negligence, dissimulation ami self-congratulation.

The Facts

Even after four months, facts regarding what actually occurred are still unclear. The expert committees appointed to look into the causes have submitted their reports but even they have failed to reach a consensus regarding the cause of the fire. Let us recount the facts which are not in dispute.

- **The fire started in the graveyard shift at 3.31 AM.**
- There was a loud explosion which was heard by many people.
- At the time, the reactor was operating at 190 MW.
- The fire originated in the turbine room which is some distance away from the reactor building.
- It continued for close to two hours, whereas smoldering of cables continued till 8.30 AM.
- The fire caused extensive damage to the generator and power supply cables.
- The reactor was tripped manually by the station staff on duty when they noticed that the turbo-generator had automatically tripped after the fire.
- The fire tenders in the turbine hall proved inadequate to control the fire since the flames reportedly spread to the lubricant and sealant oil drums kept in the hall, and the entire structure housing the turbine was damaged.
- Fire extinguishing efforts were hampered by the large amount of smoke emanating from burning wires and parts of the generator.
- Smoke detectors did not work.
- During most of this time the control room of the reactor unit was filled with smoke. The emergency control room—-a special safety feature at NAPS—was rendered useless in the absence of emergency power supply. Narora Unit Two had been shut down for several months, after a generator identical to that in Unit-1 was reportedly damaged on account of overheating.
- The most serious aspect of the fire was that there was complete loss of station power for a period of 17 hours.
- None of the three emergency diesel generators was able to work, since the cables connecting them also burned down.

Defense in Depth

Since the consequences of a nuclear accident are so horrendous, nuclear reactors are equipped with redundant and independent safety systems. The idea being that even if some safety systems malfunction in an emergency, there would be others to do the job and ensure safety.

Of primary importance is the safe shutting down of the reactor. In Narora, there are two fast acting shut-down system*. The primary shut-down system consists of 14 control rods made of cadmium. These cadmium rods drop into the reactor core under gravity whenever a trip signal is received. They halt the fission reaction in less than two seconds. Besides the primary shut-down system, there is a secondary shut-down system as well. In Narora, this consists of filling up 12 vertical cores in the reactor core with lithium pentaborate solution. Boron has an extremely high neutron absorption cross section. Thus any neutron which comes in contact with a boron atom gets absorbed and thus unavailable to continue the fission reaction. According to newspaper reports, both the fast acting shut down systems are further backed by the automatic injection of controlled quantities of a boron solution into the reactor's moderator system. Even if there is complete electricity blackout in the station (as did happen at Narora) and the secondary shut down system cannot work, this arrangement ensures the addition of boron to the moderator under gravity.**

The operating staff on duty noticed the smoke coming out of the turbine room and realized from the control panel that the fire had tripped the generator. The primary shut-down system was immediately initiated and it did work. Based on the reports it is apparent that the automatic injection of boron into the moderator system under gravity also worked. In any case the fission reaction was successfully halted. A question that comes to mind is that why was it necessary in this case for the operators to initiate the shut- down system? Shouldn't it have taken place automatically? Perhaps, some technically qualified readers can throw light on this point.

In a nuclear reactor halting the fission reaction is just the first step. The fission of uranium produces a large variety of radionuclides which continue to 'decay[1] and give off additional amounts of energy. This decay heat is a substantial amount—nearly seven percent of the reactor's heat at full power—which needs to be removed to maintain the integrity of the reactor. Thus, even after the reactor is safely shut down it needs to be continuously cooled.

Senior nucleocrats have waxed eloquent on the Indian designed 'passive' cooling system which performed this cooling. Number of newspapers had headlines reading "Passive Cooling System Saved Narora Reactor." RRamachandran, the science editor *of Economic Times,* has written an article entitled 'Thermosiphoning: Pascal alone did it *(Economic Times* 10.4.1993) which describes rather well the way this cooling was accomplished in the absence of electric power to drive the primary heat transport pumps. The following four paragraphs are a quote from this article:

"Indeed, the incident has helped validate a passive cooling system built into Indian Pressurised Heavy Water Reactor (PHWR) design for safe shutdown of the reactor. The system is based of what is called thermosiphoning which enables circulation of the coolant in the core of the reactor when power supply to the reactor gets disrupted, like in the present incident, ***and power for forced circulation of water with the aid of pumps and the like then becomes unavailable.***

"Under usual reactor shutdown conditions, forced circulation of primary coolant, by keeping the primary pumps running, ensures this. Even if the primary pumps fail, there is an auxiliary diesel generator available which can be pressed into service. But in situations of complete station blackout like last week (when even the cables leading to the diesel generator line got burnt), though the reactor shuts down, the heat generated by decaying fission products needs to be removed quickly.

"Initially, soon after the reactor trips and power supply to the pumps fails, the coolant circulation is provided by the flywheels mounted on the pumps whose coasting down achieves the necessary initial circulating flow. Subsequently thermosiphoning principle takes over and maintains a natural circulation of the primary coolant. This thermosiphon flow should be adequate to transfer the decay heat to secondary coolant in the steam generators (SGs). Thermosiphon flow is an important design feature and enhances the safety of the reactor under off-normal conditions.

In fact, only in December 1992, an off normal situation was simulated in the NAPS-1 core and adequacy of thermosiphon cooling studied. Though such studies are routinely carried out in reactors abroad, this was the first such test in an Indian PWR. The tests had found that the cooling due to thermosiphoning was as predicted According to the scientists of Bhabha Atomic Research Centre (BARC), who con-

What if Shutdown Systems Fail? Catastrophe!

CANDU reactors like the ones at Narora (U.P.), Kakrapar (Gujarat), Kalpakkam (Tamilnadu) and Rawatbhata (Rajasthan) share an unhappy feature of Chernobyl (RBMK) type of reactors. The technical term for this feature is "positive void coefficient of reactivity". The nuclear fission reaction tends to increase rather than decrease as the temperature of the reactor core increases and more heavy water coolant gets boiled off. This leads to an uncontrolled runaway increase in the reactor's power level as happened at Chernobyl. Safety studies conducted on the CANDU type reactors show that a failure to shut down the reactor when required, would result in a complete failure of other safety systems and a reactor 'disassembly'. Nuclear engineers consider this simultaneous failure of the three separate shutdown systems as an 'incredible' event against which no defense can work.

ducted the simulation studies, the real-life situation of a power failure proved that this auto-cooling was adequate,"

What Mr Ramachandran has forgotten and what high ranking nucleocrats have conveniently left unsaid, is the fact that primary heat transport system cannot go on cooling if it in turn is not cooled. There is only a limited amount of heavy water in the system and after removing the heat from the reactor core, this heavy water gets hot. During normal operation, the hot heavy water under pressure is cooled through a heat exchanger where it heats ordinary (light) water in a secondary (steam generator) circuit. This secondary system water becomes steam and is used to run the turbines to produce electricity. However, due to total station blackout, the secondary system's pumps also could not work. It was here that the station's operators showed ingenuity and courage. Their heroic role is mentioned in a report in *The Hindu* on April 4 and is also recounted in Ms. Rupa Chinai's article "Narora: When Emergency systems' fail in *Sunday Observer* of April 18, 1993. The following is an extract from her account:

"While the Primary Heat Transport (PHT) System remained intact with heavy water supply; the loss of power prevented circulation of light water from the boilers, which served to cool the PHT system and transport heat from futl to the boilers. Thus, the removal of reactor core heat was retarded

"ln the few minutes before toted power was lost, the operators managed to open the 'Safety Blow Off Valves' to start the cooling process in the reactor, enabling steam to be released.

"But they still had to feed the boilers, which began to run out of light water. This was manually accomplished with the use of fire fighting pumps funning on their dedicated diesel generator, transporting water to the boilers after the valve in the outer containment of the reactor was opened. This was possible because of the hemic efforts of individual reactor operators, who risked exposure to heat and possible radiation, when they reportedly entered the outer containment shell of the reactor to manually open a valve, thereby ensuring water flow to the reactor boilers which in turn controlled temperatun of the reactor core. By this they averted severe damage to the reactor core."

Despite the much trumpeted claims of nucleocrats, it was not only the •passive' cooling system "designed by Indian scientists" which prevented core damage. It was the brilliant thinking which utilised the diesel generator of the fire-engine to provide 'active' cooling, and the fact that unlike nuclear "defense in depth" safety systems, fire engine diesel generators do work, which prevented a debacle.

The operators deserve the nation 's gratitude for saving it from a disaster in one of the most fertile and thickly populated regions of the country. But what about the senior nucleocrats and ignorant politicians who have put Ganga Mai under this everlasting threat?

A word needs to be said regarding this "designed by Indian scientists" nonsense. I would be the first to cheer any genuine expression of In* dian creativity, but frankly, I find this attempt to pat one's own back on totally undeserved grounds, disgusting. The "passive[9] cooling occurs due to the way the primary heat transport system has been designed and the design in Narora is no different in its general layout from that of other CANDU tractors operating elsewhere in the world. Thus, if credit has to be given for this passive system, it should be given to the original Canadian designers of the CANDU type of reactors.

The Cause of the Fire

All accounts agree that the initial cause of the fire might have been a spark caused by a fault in the electrical system, somewhere in the cable tray underneath the turbo-generator. However, there are wide variations in versions presented by various high-ranking nucleocrats in different newspapers. The version presented by M. Satish and R. Ramachandran in *Economic Tunes* of G.4.1)3 where they quote Dr. Chidambaram, the Chairman of the Department of Atomic Energy is as follows:

"The smoke sensors in the power control room did not detect the fire in the generator area immediately, Dr. Chidambaram said, probably because the smoke itself did not build up for some time. It was also around this time that many persons reported hearing a loud blast, akin to an explosion.

"The "explosion" seems to have occurred during the long coasting down period of the shaft from its high rotor speed of 3000 rpm, the AEC chairman disclosed

"According to investigators, the reason for the explosion could be something like this: as the shaft began to reduce speed, some of the burning cables nearby may have got entangled in it, applying severe instantaneous torque in the reverse direction. The "explosion" could thus turn out to be the massive sound created as a result of a damage or breakage of the coupling shaft. What adds credence to theory is that most non-inflammable parts of both the stator and the rotor of

the generator are said to be intact, and can be salvaged."

In the same article, they expressly add,

"Most fires in hydrogen-cooled generators in the past have been caused by leaking hydrogen.. Whereas in the case of NAPS, no untoward pressure drop in the hydrogen circulation was noticed."'

The Director of Engineering at NAPS, Mr G. Ghosh, also ruled out hydrogen being the cause of the fire saying, "*the area was so wide and open that for a hydrogen explosion to take place, there would have to be a very large leak of hydrogen and this was not possible because the level of hydrogen was monitored continuously.*"

As opposed to this we have the previously referred April 4th report in *The Hindu* and Ms Rupa Chinai's article in the Sunday Observer where there is a totally contradictory version of events. To quote:

'Technical inquiries by experts have so far reportedly assessed the fire to be the result of a fault in the electrical system, and leakage of hydrogen gas within the generator. The consumption of hydrogen gas required by the generator, had shown an increase over one week, pointing to an internal leakage of the gas.

'This, however, did not give rise to a general alert from those manning the control room. Reportedly, no effort was made towards remedial measures. It is thought that hydrogen, which is used as a coolant, could have triggered the fire, which erupted from either the cables or oil."

The Official Version

The official press release put out by the Atomic Energy Regulatory Board on July 8th, that is well after the inquiry committee submitted its report, is silent regarding previous leakages of hydrogen.

"Failure of two turbine blades resuited in a severe imbalance of the large rotating mass, causing extensive damage to the bearing of the machine as well as to the various accessories and components of the turbine and the generator. In the process, the leak-tightness of the generator hydmgen seals was lost, leading to a hydrogen leakage and a fin."

Nucleonics Week, the nuclear industry journal published from U.S.A. knew the contents of the committee's report far in advance of any Indian newsmedia. In its issue of 17th June, 1993, it states:

The inquiiy committee set up to investigate tlie 31 March fire at NAPS is split on the cause of the accident, and the DAE may be presented with two reports. One section of the committee says that the fire was caused by the shearing of two turbine blades Which in turn was caused by fatigue inflicted on them by frequent grid disturbances. (Voltage control on the Indian grid is often erratic, with brown-outs and black-outs not uncommon.) The other section of the committee has traced the cause to a duct at the generator busbar coming loose. This means, in effect that the generator maintenance was at fault and not the turbines.

Public Safety Issues

Madhusudan Srinivas in his article The Narora Fire and the Communication Gap" in *Frontline* brings out the public safety aspects of the fire.

"Though emergency drills have regularly been rehearsed since 1989 (one had been scheduled for 11 cum. on April 1), when the real alarm went off at 3.35 a.m., the immediate reaction was panic. For some two hours, there was no official communication—either from the plant authorities or the district administration—to the inhabitants around NAPS. Between the relent-

Not A Day Too Soon

The Atomic Energy Regulatory Board's directive to the Nuclear Power Corporation to sequentially shut down all CANDU type reactors for a thorough inspection of the turbines, generators and associated components is not an instance of a 'smart' regulatory body on the job but rather a case of "too little, too late". Consider

Madras Atomlo Power Station Unit-1 (July 23,1983)
Site emergency declared due to fire In the boiler room.

Rajasthan Atomic Power Station Unit-2 (July 25.1985)
Unit operating at 190 MW. "Catastrophic" fire in the boiler room

Kakrapar Atomic Power Station Unlt-1 (September 15,1991)
Fire in the boiler room during testing before reactor opening causes extensive damage, delays opening by nearly one year.

Yet a fire in the same spot at Narora when the reactor was operating at 190 MW! isn't It time AERB realised that BHEL generators are unsafe while operating nearfull power ?

less wail of the alarm and the darkness around the plant (which is normally brightly lit) the villagers were left to draw their own conclusions. By the time the authorities sent out the information that the fire had been brought under control and that there was no radiation leak, large numbers of people had packed their bags and a few had actually fled."

According to a report in *Safe Energy and Environment,* NAPS authorities had asked the District Magistrate to keep 2,000 buses in readiness for evacuating the people if necessary, but the Magistrate had expressed his inability to do so at such short notice. This news, if true, is an eloquent comment on the state of emergency preparedness near nuclear facilities. Do the authorities think that emergencies will come with adequate prior notice? Probably civil authorities are competent to arrange buses only for political tamashas where they have enough advance warning.

Incompetence at the Top

"The chairman told newspersons on Monday that the fire was 'unusual' because of its magnitude and location, which was below the turbogenerator—"a very unlikely spot."

'New panel fo probe Naroca mishap"
Observe Economic Bureau
Observer of Business & Politics 6.4 \ 993

"July 23, 1983: Stand by emergency was declared to fight the fire in unit-1 (MAPS) boiler room and below the TG"

•Review of Rodtatton Emergency OrWs and Actual Emergencies Declared at Madras Atorrtc Power Station'
S. Paramesvaran, R. S: Vocodhan. T. S. V Ramanan
Thrid National Sympotfum on Operating Experiences of Nuclear Reactors & Power Plants

How many fires need to start under the turbogenerator, before Dr Chidambaram considers that as a likely spot and takes appropriate precautions?

"Wepropose to make improvements in electrical cables like fitting survived cables and fire barriers."

Chairman of the Nucleou Power
Corporation, Mr S K Chotterfee,

What was Mr Chatterjee doing after the RAPS fire of July 25, 1985? Should these Improve* ments not have been made at least then as one of the lessons learnt (see following article).

Lessons that the Public Needs to Learn

Fires in nuclear power plants are nothing new. Fire at the Brown's Ferry nuclear power plant in the U.S. as early as 1975, had demonstrated common mode failures. (Failures of multiple standby safety systems as happened at Narora). It had highlighted the need to isolate cables controlling independent safety systems. Although the Brown's Ferry fire took place before any substantive construction had even begun at Narora, this elementary precaution seems to have escaped the designers.

Even within India, the Narora fire is not the first instance of a major fire in a nuclear power station (see following article). But the nucleocrats have been behaving as if it is.

The main lesson the public needs to learn from the near miss at Narora is that nucleocrats and politicians will never learn and public safety can only be ensured when the public itself forces a closure of these deadly, demented machines.

There is another small lesson which too can be of immense benefit to the public. Like the dog in Sherlock Holmes' story, the smoke detectors in nuclear plants never seem to bark. The Nuclear Power Corporation would do a lot of good if they would only publicise the type and make of their smoke detectors so that the public would know which detectors to avoid. In all probability, these smoke detectors are the ionising type which *use* radioactivity of Americium-241. Nuclear authorities should immediately themselves switch over to nonradioactive smoke detectors which use photoelectric cells and advise the Atomic Energy Regulatory Board to ban ionising smoke detectors which don't work and are a serious source of radioactive pollution.

Surendra Gadekar

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A Wasted Warning

Lessons Not Learnt from a Fire in RAPS in 1985

The Narora fire of March 31, 1993, despite newspaper claims of nucleocrats to the contrary, is not the first time an operating nuclear power plant in India has come close to the brink. Rajasthan Atomic Power Station (RAPS) for instance, suffered a serious fire in 1985 within the reactor building itself The official account of this fire has been published four years after the event in an obscure Bhabha Atomic Research Centre publication and makes chilling reading, Although written in a nuclear engineer's jargon, we reproduce it in full and provide a glossary which we hope would be sufficient to decode the officialese.

Handling Experience of Reactor Controls During Large Cable Fire Incident

R. Venkata Raman

Third National *Symposium on* ***Operating*** *Experience* ***of Nuclear Reactors & Power Plants***

March **15-17,*1989***

25th of July 1985 was a critical day in the operation of Rajasthan Atomic Power Station (RAPS) Unit-2. On this day, when the unit was operating at 190 MWe a catastrophic fire ignited in boiler room. The resulting inferno disabled many vital instruments and indications, jeopardising reactor safety.

In spite of the non-availability of important indications and display of many false system status indications, the station operating staff managed to bring the reactor to a safe shutdown condition, thus averting a potentially dangerous situation.

Brief Chronological Description of the Incident

10.12 Heat Transport Pump No.2 tripped.

10.13 Reactor tripped on high differential temperature followed by turbine trip.

10.18 Reactor was reset and fast start initiated.

10.22 Heat Transport Pump No.9 stopped for 3-3 pump mode operation, but the pump tripped immediately. All the heat transport pumps had tripped due to ground fault and instantaneous overcurrent as observed from their respective breakers subsequently.

10.26 Suspecting major problem, station startup was abandoned, reactor was scrammed and crash cool-down was initiated.

During the above period, the following safety systems got actuated:

1. Emergency Injection Operation indication appeared.
2. Dousing system Red Lamps for valves closed position disappeared, indicating possible unlocking of the valves, preparatory to operation.
3. Reactor Building got Box-up.
4. A number of critical 48 Volt supply fuses blew making connected loads non-operational.

Also the following critical systems became unavailable:

1. Heat Transport System Pressure Control on wide range.
2. Floor beetles in boiler room got actuated spuriously, wrongly indicating large water leak in boiler room.
3. Valving in of shutdown cooling system became inoperative due to spurious initiation of Emergency Injection.
4. The fire and smoke detection system alarmed only at 10.35 hours (23 minutes after the incident), delaying protective measures till then.

There were six indications that ruled cut the possibility of a large leak either from the Heat Transport System, Secondary System or the Process Water System.

1. **Heat Transport System Storage Tank level was steady.**
2. **Boiler pressure and feed water pressure were steady.**
3. **Boiler levels were steady.**
4. **Low pressure and high pressure process water system pressures were steady.**
5. **Area Radiation Monitors registered normal values at this time.**
6. **Boiler room pressure was normal**

Actions Taken

Acting on the above basis, the following actions were taken by control room personnel, despite the above handicaps:

1. **Spurious actuation of the Emergency Injection system and possible actuation of the dousing system were blocked.**
2. **As heat transport pressure recorder was reading off-scale, controller malfunction was suspected and**

3-3 Pump Mode Operation

The steam generator is operated with an equal number (three) on both sides to maintain balance of pressure in the reactor.

Ground Fault

Pumps are operated by motors connected to the electrical power supply. If a point on the winding becomes connected to the ground on account of damage to insulation, a large current (an overcurrent) may flow. This is sensed by the protection equipment which opens the circuit breaker thus disconnecting the motor from the power supply.

Dousing

This is an emergency water spraying system to reduce the steam pressure inside the containment building in the event of a steam leakage and pressure build up to prevent the possibility of a steam explosion.

Box-Up

The reactor building gets isolated from the outside by closure of dampers in the ventilator to prevent escape of any radiation which may have built up.

Emergency Injection

The Emergency Core Cooling System (ECCS) will iryect cooling water into the Primary Heat Transport System (PHTS) when **the primary cooling fails by leakage through a pipe.**

48 V Supply

A number of critical reactor con= trol, measurement and breaker operations use the 48 Volt direct current power supply (battery).

Heat Transport System Pressure Control on wide range

The enormous heat produced in the reactor needs to be expeditiously removed at all times. This is done by circulating heavy water at high pressure. High pressure is needed to prevent boiling. Heavy water at atmospheric pressure would boil off. But this enormous pressure has to be adjusted within specified limits. The range of pressure is regulated within H wide and a narrow range by separate mechanisms.

High Differential Temperature Trip

The temperature difference between the inlet and outlet arms of the primary heat transport system has to remain within a specified range. If this temperature difference becomes larger than required due to the tripping of one of the pumps, this would upset the balance between the hot and the cold legs of the system and initiate a turbine trip.

Valvlng In

To open the valves (in this case the valves of the shutdown cooling system).

Shutdown Coding System

Two Shutdown Cooling Systems connect to the reactor inlet and outlet headers, essentially in parallel with the primary pumps and steam generators. As the reactor cools down, these systems, each with a pump and heat exchanger gradually take over decay cooling. Initially pumping force through the heat exchangers is provided by the primary pumps, but, as the coolant temperature decreases, shutdown cooling pumps assume this function and the primary pumps and steam generators are isolated.

Note: The thermosiphoning effect leading to passive cooling mentioned in the article "Near Miss at Narora" in this issue also performs the same function

Jumpering

In this case the Emergency Inejection Control System was bypassed by putting a short circuiting wire between the input and output points and the control supply was directly connected to the system which controlled the valves of the shutdown cooling system.

Incipient Degradation

In a cable joint, duo to the esrtosive effect of moisture or due to other causes, the joint slowly becomes open in small areas finally leading to a heavy arc of a huge current.

pressurising pumps were put off.
3. Shutdown cooling system was valved in by jumpering the emergency injection logic and the system maintained solid by starting the auxiliary pressurising pump (Fueling machine supply pump) and maintaining the system pressure by the indication provided on the shutdown cooling loop.

Meanwhile all entries to the boiler room were thwarted by the presence of thick black smoke and soot. Boiler room ventilation was shutdown to prevent possible spread of fire.

Reactor building dampers were opened to purge out the building atmosphere and also depreasurising damper was opened. At 1900 hours ventilation duct manhole cover was opened and boiler room smoke was fully purged out. At 2100 hours first proper entry into boiler room could e made and by this time fire was completely extinguished

Control **Room Staff** Handling of **the** Incident

Que to the huge fire in the boiler room, many control cables were damaged, thus making vital indications, systems and controllers unavailable. Also many safety systems got spuriously actuated and false indications/informations were flashed into the control room annunciation system.

To sift out the false indications, discard the false information and come to the right conclusion became a difficult task.

But, the availability of some vital indications despite the fire, good system knowledge and experience among the control room staff resulted in good operator response leading to the safe shutdown of the station. The availability of expert knowledge and other forms of help from the general shift, Technical Unit staff, Fuel Handling System staff and the maintenance staff present at the time of the incident was a big help.

Also the maintenance of a calm environment without panic in the control room led to the fast and correct actions being taken to mitigate the consequences of the fire.

Cause of Fire and Rehabilitation

The incipient degradation of the integrity of the 3.3 kV cable joint of heat transport pump No.2 resulted in a heavy drawal of arc which in turn ignited the fire and this spread to surrounding power and control cables, thus causing the accident. The oil deposition on the power cables in boiler room could have aggravated the situation.

All 3.3 kV and 415 V power cables totaling 250 in number damaged by the fire, were replaced and nearly 70 joints made using the Raychem technique. All control ca-bles were terminated in 9 newly installed junction boxes. Rerouting of power and control cables were also done. This was a massive job involving site and outside agencies.

Modifications

1. Smoke detectors were installed in discharge ducts of boiler room cooling fans, to trip the fans in case of fire.
2. Spraying of fire retardant paint was done on cables in boiler room.
3. Fire barriers were constructed.
4. Tray covers were provided on top of control cable trays.
5. 3.3 kV cable joint temperature monitoring was made available.
6. Regular cleaning of cables to remove oil deposition was initiated.

Lessons Learnt

1. Fire re tardant cables to be used in future.
2. Cable joints to be avoided.
3. Installations of automat* ie fire extinguishing systems to be provided.
4. Adequate separation between power and control cables to be provided for.
5. Provision for closed circuit television surveillance of potential fire hazard areas.

Concluding Remarks

The fire incident handled was without precedent. Calm and judicious observation by experienced control room staff led to correct and rapid actions being taken to reduce the consequences of the accident and a safe station shutdown.

On the basis of this incident, *appropriate design modification are to be carried out in operating and future reactors,* **not to mention the extreme importance of the availability of trained adequate and experienced manpower for safe handling of such accidents.**

Evidently, the "lessons learnt" in 1985 at RAPS remained confined to published reports and did not result in any modifications to layout design and operating procedures at Narora. Even essential fire fighting equipment was absent. Will Narora lessons help in avoiding a future catastrophe? With the nucleocratic mindset being so impervious to self-examination, the prognosis is not good.

OOPS! We Goofed

Self Serving Antics of the International Atomic Energy **Agency**

In 1986, just after the nuclear disaster at Chernobyl, nuclear industry worldwide was in doldrums. If an accident of this magnitude could happen in Russia, it could happen anywhere. Despite all attempts at playing down the scale of the accident at Chernobyl, the industry and IAEA knew very well that the public would not tolerate an industry with a potential for causing such cxitastrophes. It was imperative to find an excuse-an extenuating circumstance demonstrating that what happened at Chernobyl was an aberration, a state of affcurs so abnormal and unrelated to nuclear operations, that it could not in any likelihood be repeated anywhere else ever again. The Soviet nuclear establishment was understandably eager to find scapegoats amongst the operating staff and shift the blame away from itself

The interest of both these powerful lobbies were thus coincidental and hence at the Vienna Conference on Nuclear Safety in August of 1986, there was a great deal of mutual bonhomie. The Western nucleoctxits went gaga over "Soviet openness", while the Soviets were full of talk of "International cooperation and solidarity" in the nuclear field. Soon afterwards International Atomic Energy Agency sent a team of 14 'experts' from 14 nations—International Nuclear Safety Advisory Group (INSAG) to study the accident in detail. INSAG presented a report (INSAG-1) which came to a number of conclusions—atnong them$_f$ that tlie accident represented "almost a worst case in terms of the risks of nuclear energy/' It went on: "As discussed in detail atnongst the experts, the accident was caused by a remarkable range of human errors and violations of operating rules in combination with specific reactor features which compounded and amplified the effects of the errors 'and led to the reactivity excursions."

One would expect that since these were ' Inter nationally Renowned Experts' giving their considered opinion after many months of deliberations and after any number of computer simulations and other such high-tech wizardry. their opinion would be of lasting value to future generations. Specially since their 'expert opinion' was instrumented in sending some operators to jail for a period of five years on charges of gtx>ss and criminal negligence. The public prosecutor cited the INSAG-1 report as proof that international experts agreed with Soviet authorities that the RBMK design was not to blame.

As the following piece so charmingly puts it, much has changed in the last seven years both politically and technically. Western nuclear industiy has survived the Chernobyl blotv, but is today desperately looking for orders for new construction of power plants and its eyes are set firmly towards tlie erstwhile Eastern Block. Its interest no longer coincides with that of the nuclear establishment in the old Soviet Union. Thus, we now have a revision of INSAG-I by another group of 'experts' of the International Atomic Energy Agency which finds the conclusions arrived after so much deliberations by INSAG-l to be erroneous and in need of 'updating'. One wonders if this is the final version of what actually transpired at Cliernobyl or whether another change in the political and economic climate would produce another updated INSAG report.

INSAG Revises Chernobyl Report

It is, it seems, in the nature of human beings to seek scapegoats. In the aftermath of a major catastrophe there is an instinctive search for an individual or individuals, to blame. In the case of Chernobyl, it was the operators. In their report—INSAG-1—tasued in September 1986, and baaed largely on Soviet evidence, the International Atomic Energy Agency's International Nuclear Safety Advisory Group (INSAG) ascribed much of the blame for the Chernobyl accident to those in control of the plant at the time.

Much has happened, politically and technically, since then. Most analyses now associate the severity of the accident with defects in the design of the control and safety rods, in conjunction with certain characteristics of the physics design which permitted the inadvertent setting up of large positive void coefficients. It has also become apparent that these deficiencies were known about in the Soviet Union before the accident, but had not been corrected.

In its recently released second report on Chernobyl, (INSAG-7 The Chernobyl Accident: Updating of INSAG-1, IAEA, Safety Series 75 1992) the Group revises INSAG-l and places a greater emphasis on design issues.

*

Beyond Vienna

The account given by the Soviets to the 1986 Vienna Conference stated that the accident arose through a low probability coincidence of a number of violations of rules and procedures by the operation staff and by those responsible for authorizing the test.

The analytical work which followed in late 1986 had the benefit of Soviet data on the control rod configuration, the power level and the spatial distribution of power just before the accident, as well as information on the thermal-hydraulic conditions that prevailed.

Some analysts found that it was difficult to match in their models the time history of the power excursion as it had been published by the Soviet scientists at the Vienna meeting. A search therefore began for an additional mechanism that might have come into play.

The existence of the positive scram effect was first acknowledged by Soviet experts at the Conference on Nuclear Power Performance and Safety in Vienna in 198T. However, the 1991 report on Chernobyl by a Commission of the USSR State Committee for the Supervision of Safety in Industry and Nuclear Power (SCSSINP) states that this phenomena had been known of at the time of the accident and that it had first been identified at the Ignalina RBMK (Chernobyl-type) nuclear power station in the Lithuanian Republic in 1983. But no oorrection was made following this discovery at Ignalina, no compensatory measures were taken and any dissemination of information to operating organisations was not followed Up.

Two earlier accidents at RBMK reactors, a fuel channel failure at Leningrad-1 in 1975 and a fuel failure at Chernobyl-1 in 1982, had already indicated major weak* nesses in the characteristics and operation of RBMK units, according to SCSSINP. The accident at Leningrad-1 is even considered by some to have been a precursor to the Chernobyl accident. However, the lessons learned from these accidents again prompted at most only very limited design modifications or improvements in operating practices. Because of lack of communication and lack of exchange of information between the different operating organisations, the opera* ting staff at Chernobyl were not aware of the nature and causes of the accident at Leningrad—1.

The most likely final event at Chernobyl seems to have been thee insertion of safety rods at a vital moment in the test, which worsened to a destructive level the conditions already prevailing. On the other hand, the RBMK design had set a number of other pitfalls for the operating staff, any of which could just as well have caused the initiating event for this or an almost identical accident, INSAG notes.

For its part, INSAG finds it difficult to say with confidence which particular weakness ultimately caused the accident, preferring to point out that a precise identification hardly matters when any of them could have done it.

Violations, or just mistakes?

Specific violations of procedures were identified in 1986 as major causes of the accident. INSAG—7 corrects the apparently false impression given about a number of them. In particular:

- The statement that there was a proscription on continuous operation of the reactor at power levels below 700 MWt was wrong- There should have been such a proscription, but there was none at the time.

- In INSAG-1 it was stated that operation with too low an Operating Reactivity Margin (GRM) was a violation of requirements. In recent deliberations, INSAG has in fact questioned the ORM concept.

It was stated in INSAG-1 that, at the time of the test, three components of reactor protection had been disabled at Chernobyl. INSAG-7 points out that disabling of the Emergency Core Cooling System (ECCS), which happened 11 hours before the accident, was not prohibited under normal procedures at Chernobyl. In fact, INSAG understands that it was a requirement of the test schedule. Disabling of the trip on the steam drum water level would have been allowable; however, it did not occur. Disabling of the "two turbines' trip was allowed, and indeed was required by normal procedures at low power levels. In any event, the occurrence of this trip might well only have caused the destruction of the reactor sooner rather than later.

In general, INSAG concludes that the accident can be said to have flowed from deficient safety culture, not only at the Chernobyl plant, but throughout the Soviet design, operating and regulatory organisations.

Andrew Cruickshank
ATOM March/April 1993

The recurrence of fires in Indian nuclear plants clearly show that the Indian design, operating and regulatory organisations are as deficient in safety culture as their counterparts in the Soviet Union at the time of Chernobyl.

When Experts Utter Unpalatable Truths Change the Experts

"Speak the truth, but speak that truth which is pleasing to the ears! is an old Sanskrut saying. Nuclear experts at Pace University in U.SA. must be feeling that it would have been better if their 'classical' education had included a course in old Sanskrut.

In the wake of Chernobyl, Pace University had been commissioned by the U.S. Department of Energy (DOE) to do a study to determine the health and environmental costs to a community of nuclear power production. However, now that these experts have found that the costs are much higher than the 'officially approved numbers', the DOE and Federal Energy Regulatory Commission (FERC) have both cried foul and have oriticized the study in rather harsh Ianguage.

What both the report's authors and critics agree on is that almost all of the external costs associated with nuclear power are associated with reactor accidents rather than normal plant operation. (They ought to read the last issue *o{Anumukti* on Rawatbhata—-Editor.) Where there is strong disagreement, however, is in estimates of the scale of costs associated with the Chernobyl accident - the benchmark upon which the report is based - and the likelihood of a similar accident occurring in the U.S.

The Pace report estimates that the likely frequency of a Chernobyl-ocale accident is 1 in 3300 reactor years. (Since there are already over a hundred reactors operating in the US for well over twenty years, they have accumulated over 2000 reactor-years of experience.) The DOE on the other hand, feels that the chance of a Chernobyl scale accident in US is less than 1 in a million reactor years—a figure 300 times lees than that arrived by Pace experts.

Long experience with sometimes recalcitrant experts have taught DOE never to have just one set of experts to do a study. Thus, it is no surprise that two other studies have simultaneously emerged from Organisation for Economic Cooperation and Development's (OECD) Nuclear Energy Agency. This OECD report puts this figure in the middle at 1 in 100,000 reactor-years. In a note included in the report, the chairman of the OECD report said that the principle reasons for the differences between the Pace and their studies was that the University analysis looks at the existing US situation rather than modern plant options (for both nuclear and fossil fuel plant).

In addition, DOE argues that by failing to take into account updated data on the radioactivity releases from Chernobyl, Pace estimates on fatalities are more than what would actually occur. Richard Ottinger, one of the Pace report's principal authors, has accused the DOE "of playing politics with science".

These studies are being conducted since the US nuclear power industry is desperately trying to revive itself by doing an integrated resource plan. The attempt is to show that everything considered nuclear power is a less environmentally harmful source of future electricity than alternative options. Following the controversy, Federal Energy Regulatory Commission has urged state regulators to postpone efforts to take on board external costs in their integrated resource planning until after a DOE/European Community study has been completed later this year.

Based on a report in
Atom March/April 1993

Another Blot on the Russian Landscape

This April, when the Western media first carried coverage of an 'accident' in a reprocessing plant at a mysterious place in Russia called Tomsk-7, we could be excused for thinking the event was no more than a minor hiccup in a decrepit weapons complex and of little or no importance for the nuclear industry worldwide.

Newspapers said that there had been an explosion in a tank 'containing an industrial uranium solution' and the event was a '3' on the International Nuclear Event Scale (INES) (Same as Narora fire) implying virtually no offsite contamination. For comparison wo ware reminded that Chernobyl waa a 6 or 7.

What we were not toia for some time was that the Tomsk-7 plant is a vast, sprawling complex, the size of Paris'. Technically, 'no off-site consequences' on a site this big are entirely consistent with hundreds of square kilometres of on-site contamination! Nor were we told that the blast took place during the reprocessing of spent nuclear fuel from military production reactors.

Up to 100,000 'people work at the complex, a* military 'closed city' 15 km from the oity of Tomsk' in Siberia, 2,700 km east of Moscow. Its inhabitants enjoy a relatively privileged existence, immune to the problems of price rises and unemployment that trouble other Russians. According to one report in the New Scientist, "Unlocked Mercedes stand outside houses, wages are high and the shops are full all year round with bananas and other goods unimaginable to the ordinary Russian."

By 1990, Tomsk is thought to have produced about 60 tons of plutonium using reactor fuel from Chelyabinsk. When the military production reactors at Chelyabinsk shut down in the late 1980s, the volume of spent.fuel being reprocessed at Tomsk fell considerably, but in 1991 commercial reprocessing contracts were concluded with France and South Korea.

Russia is awash with the world's largest stockpile of plutonium, estimated at 180 tons, of which 150 tons are,—or were — for military use, and is nominally committed to nuclear non-proliferation, yet it continues to reprocess and separate plutonium at Tomsk, Chelyabinsk, and Krasnoyarsk.

In January 1993, the deputy Minister for Atomic Energy, Viktor Siderenko, announced that Tomsk was to be the disposal site for plutonium from warheads destroyed under the START treaty. The idea was to make the weapons-grade plutonium into grapefruit-sized balls, then wrap each ball in boron-impregnated plastic, place them four at a time into argon-filled steel containers, then stack the containers 14 metres deep in concrete lined basins covered by massive concrete roofs, Strong enough to withstand a direct hit by a nuclear weapon*. However, the programme was officially vetoed by the Tomsk regional parliament months before the accident.

The explosion apparently occurred during an otherwise routine process late in the reprocessing cycle in which uranium and plutonium is extracted from spent fuel. This involves the addition of nitric acid and organic solvents to a solution of dissolved spent fuel. As it involves several stages, and because heat-producing chemical reactions happen when nitric acid is added to anything containing organic solvents, it has to be carefully monitored.

When government experts examined instrument records, they found that senior shift operators at Tomsk "had not monitored the concentration of nitric acid and had added too much, which had led to the explosion. As well emergency relief valves that should have opened were closed.

The explosion happened when two out of three of the extraction cycles had been completed and' large quantities of very highly radioactive fission-products already removed. It blew the top of the underground stainless steel and concrete tank in which the blast occurred, and led to a fire that burned for one and a half hours before it was extinguished.

Sources at the Tomsk plant later acknowledged that quality control there was a problem, and that at least three similar explosions had happened during the 1960s. But officials claim that safety standards were better in the past before cuts in wages and funding.

Reports about the extent of contamination from the explosion have been contradictory. A north easterly wind was blowing'at the time and Greenpeace claims Russian air force pilots picked up a plume of radiation traveling at an altitude of 3000 metres in that direction. An area of about 120 square kilometres of forest and mountain is said by another source to have been contaminated. Reports from Tomsk indicate that iodine was administered in some villages, and there was confusion and panic with people trying to flee the *city*,

Friends of the Earth UK claims the International Atomic Energy Agency has never carried out any safety inspection of Tomsk, and that it was officially notified of the explosion only 12 hours after it had heard media reports. The IAEA has no powers to inspect installations such as Tomsk-7 or Hanford, Sellafield, La Hague, Marcoule or BARC in Bombay and it has "no knowledge" of safety systems at Tomskr-7.

In the immediate aftermath of the accident, all reprocessing activities at Tomsk were halted but plant officials said the plant would go on line again 'in a few weeks'.

However, there are more far reaching consequences for the siting of the proposed plutonium storage facility. On the day of the accident, the regional parliament had rejected a motion by environmentalists to hold a public referendum on the future of the Tomsk-7 complex by a margin of five votes. The explosion has changed the political environment. The referendum is expected to be re-launched.

Chernobyl, Chelyabinsk and Tomsk are not the only household names in the nuclear lexicon of the former Soviet Union. In Voronezh, where the first Soviet nuclear power plant was built, there are reports of people stealing and drinking radioactive alcohol used for flushing out the cooling system. As a result of numerous radioactive spills, the soil in the area is almost as' contaminated as that around Chernobyl and yet Voronezh potatoes can still bebought at any market in Moscow.

Bated on *an article* by: John **Holam**
The Third Opinion Autumn 1993

Nagarjunasagar or Srikakulam
Atomic Threat Remains Potent in Andhra

Recently we received a letter forwarded by Mr Batu Sahgal, editor of The Sanctuary Asia magazine. It Was a letter from Mr Kamal Nath, Minister for Environment & Forests. At the same time we also received a letter from Ms Indira Vijaysimha-a reader from Bangalore—forwarding a letter to her from an NGO in Orissa and requesting help with regard to information regarding nuclear power plants. We publish both these letters together since they show that even after organised protest, (as happened at Nagarjunasagar) nuclear threat does not vanish. It just threatens next door.

Kama! Nath
Minister
Environment & Forests
INDIA

D.O.No. 11018113 /85-Env.5-IV

7 May 1993

Reference is invited to your letter of 16 March, 1993 conveying your concern for the proposal to set up a Nuclear Power Plant at Nagarjunasagar which happens to be a Tiger Reserve.

I may inform you that the Ministry of Environment & Forests has not approved the site.

Kamal Nath

Samman
Bhimsagiri, Dist: Ganjam 761066
Orissa

You must be aware that the Government of India is planning to set up a nuclear power plant, reportedly for power generation at Ranasthalam in the Srikakulam district of Andhra Pradesh. Radiation from the plant, we have been told will affect the human population and the environment in a radius of 170 km.

Unfortunately, we are woefully short of information regarding nuclear power plants. Could people involved in the antinuclear struggles elsewhere send *US* material that would be relevant to our situation? We would also like to network with other antinuclear groups within the country.

Ungia Panda

The Coming Battle

Orissa, the theater for some powerful people's movements in recent times, is gearing itself up to wage another significant one on the southern-most fringes of the state.

The proposal to put up two nuclear reactors of 500 MW capacity each at Ranasthalam in Srikakulam district, will pose grave danger to life and environment of a vast area in Orissa and Andhra. The major towns lying within a radius of 100 miles of the proposed site, include Viaakhapatnam, Vizianagaram, Berhampur, Jeypore, Rayagada, Koraput, Anakapalli, Tuni, Parlakhemundi and Gunpur. Apart from these towns, significantly, the eco-eenaitive Mahendragiri biosphere falling in both the states would be directly affected by radioactive pollution.

Many people and organisations have decided to oppose the project. Samman, a Berhampur based voluntary organisation in Orissa engaged in safeguarding the eco-system of Mahendragiri-Kerandimal mountain range and COPDANET (Coastal Poor Development Action Network) in Andhra Pradesh have taken the lead in spearheading the opposition.

Plans have been already drawn up for a mass awareness campaign and a padayatra through the region likely to be affected by the proposed plant. What is agitating the people of the area most is the prospect of a total devastation of the fragile Mahendragiri forests already ravaged over the years by rapacious timber merchants and shifting cultivation. The climate of this region is governed by the Mahendragiri forest reserve-home to some of the rarest species of orchids and having a bio-diversity of bewildering variety.

While the specter of a Chernobyl kind of nuclear disaster is fresh in the minds of the people what causes more alarm is the radiation hazards which are routine in normal operation of a nuclear reactor. Another cause for real concern is the large amount of radioactive wastes generated by the plant According to T. Shivaji Rao. emeritus in environmental engineering of Andhra University, Waltair, the notion of safety dose propagated by Department of Atomic Energy is a "myth". The activists in Andhra as well as Orissa have been using Shivaji Rao's study on the hazards of nuclear plant as the manifesto for their movement. Supporting Rao's contention they have been demanding the right to information and decision- making for the people under Article 48(A) and 61(A) of the Constitution.

The opponents of the Ranasthalam nuclear power plant have another significant objection. Such projects of 'development', only help the rich and the strong. The only real beneficiaries of such plants are contractors, suppliers, the politicians and the officials."

Srimoy kar
Indian E*xpress* February 6 1993

Sources of Contamination of RAPS Workers

I refer to Rawatbnata (Special Issue, Anumukti, Vol 6. No.5, April/May 1993). The value of your excellent study would have been greatly enhanced if you had included very important data on the functioning of the Rajasthan Atomic Power Plant since its inception. There have been various design, operational and maintenance shortcomings which could have resulted in greatly enhanced radiation exposure to workers and public alike. These are documented in a publication entitled *Third National Symposium on Operating Experience of Nuclear Reactor* and Pouter Planls (198)* brought out by Bhabha Atomic Research Centre and the Department of Atomic Energy. I list a few of these instances bordering on criminal negligence and irresponsibility.

Enormous fuel failure rates went unchecked for many years.

Because'of a lack of confidence in their own instruments for an unspecified number of years, RAPS authorities disregarded indications of fuel failures. This, by their own admission resulted in greatly enhanced exposure to workers and the public.

Workers had to frequently enter restricted areas while reactor was on-power, because of frequent breakdown of the adjuster rod control mechanism.

Exposure to heavy radiation of workers due to faulty pressure relief devices.

There are blow-out panels at various locations in a pressurised heavy water reactor used for relieving pressure. (Much like a safety valve in a pressure cooker- Editor.) This blow-out panel is sealed with an adhesive tape at **RAPS. The sealing effect is lost after sometime as the tape unglues. This results in a release to the atmosphere of tritiated heavy water. Workers in the area are exposed to radiation due to this tritium. Since the adhesive tape requires frequent replacement, this activity too exposes workers to additional radiation.**

- Seventeen categories of major incidents involving on-line fueling machine have been described in an article by Mr Dileep Bhatia in the reference cited above. These involved manual handling of irradiated fuel bundles. These fueling machine failures also involved several station shutdowns.
- The notorious south end shield which protected workers from heavy radiation cracked in 1981 and tenaciously refused to be effectively plugged. Attempts to repair this shield resulted in additional cracks. Despite the vehement assurances of Mr S. L. Kati that you have quoted in your paper, the years spent in trying to rectify this problem did. result in heavy radiation doses.

No wonder your data about the proximate villages reveals the horrifying extent of the multidimensional tragedy.

R. Ashok Kumar. Negentropist
Bombay Sarvodaya Mandol
Bombay

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