ANUMUKTI

A JOURNAL DEVOTED TO NON-NUCLEAR INDIA

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Nuclear power is an idea whose bright future is already behind it. The dream of a source of electricity which would be clean, safe and 'too cheap to meter' has turned into a nightmare. Windscale, Kshtym, Brown's Ferry, Three Mile Island, Chernobyl...are just the milestones of an unending series which have made words like 'melt down' and 'China syndrome' part of the common vocabulary. No wonder the nuclear enterprise is in retreat in all its strongholds. This situation poses a special danger, for, like the legendary Rajput soldier of yore, who fought on even when beheaded, it is still capable of inflicting great deal of crippling damage. All of us in the third world are specially vulnerable because of the tendency on part of the industrialised nations to export their dangerous and polluting technologies to us.

The time is thus ripe for the nuclear debate in India to raise itself from the level of trading of insults to that of a true scientific enquiry. The basic minimum precondition for this is the free availability of information. These issues which have hidden behind the cloak of being highly technical and of being accessible only to experts need to become the province of every citizen wishing to be informed about them. The basic issues in the nuclear controversy are simple in essence and are the very same issues like those of freedom, equity, social justice, vulnerability, beurocratized high technology etc. which confront us in all other facets of 'development'. Through the columns of this magazine we wish to challenge both the wisdom and the necessity of the nuclear enterprise and also its claim of being a solution to our energy problems.

This bulletin is addressed firstly to the growing number of activists who are committed to opposing the nuclear programme. We seek to provide correct and factual information so that their arguments acquire a firm foundation. We also hope to foster a feeling of solidarity with the worldwide antinuclear movement. Secondly, the bulletin is addressed to the many people who, though apprehensive about the present nuclear dangers are intimidated by the vast body and seeming complexity of the literature and also by the 'eminence' of pronuclear advocates. Thirdly it is addressed to people engaged in the nuclear enterprise as a challenge to them to justify their existence. We believe that this debate will not end till either side has convinced the other of the truth of their position.

To fulfil our aims we intend to have sections devoted to :

(1) New developments in the field of nuclear energy.

(2) News about protest movements against nuclear energy both at home and abroad.

(3) Indepth articles on special topics for activists education.

(4) Comparitive analysis with alternatives.

(5) The human cost.

In a magazine of this nature it is always difficult to decide the technical level of the contents. It will be our endeavour to bring out the essential simplicity of the issues. We shall need and encourage our readership to write to us so that the correct level is established and maintained.

It is our hope that this bulletin becomes part of a far wider ongoing debate about various ethical and social issues raised by the process of 'development' which Gandhi had aptly characterised as the 'satanic civilisation'.

S. N. G.

AN APPEAL TO OUR READERS

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Impact of the Kaiga Nuclear Power Plant on the Ecology of the Western Ghats

Nagesh Hegde

Introduction

The hill chain of Western Ghats is a rich heritage developed through several million years. These ghats harbour almost the entire forest wealth of states of Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala. The orography of these ghats interacting with the cloud-laden winds of South-West monsoon leads to the highest level of rainfall for Peninsular India. Consequently almost all the major rivers of South India originate in the Western Ghats.

Over the millenia the tropical ever-green forest clothing the ghats has evolved a tremendous genetic diversity of living organisms, a unique storehouse of many plants and animal species occurring no-where else in the world. To cap it all, this very chain of ghats has a rich treasure of minerals too.

Unfortunately this veritable treasure-house of natural resources has been sub-jected to severe exploitation over the last few decades. A number of hydel projects, irrigation projects, mining ventures, forest based industries etc. have been relentlessly operating here with little regard to ecological balance, or sustainability of the resource base—all to cater alien beneficiaries.

The Western Ghats have already paid heavily for our mistakes. This kind of erroneous developmental policy has resulted in large scale liquidation of natural resources and the gains have failed to percolate down to our masses. These hilly areas, although richly endowed with forests, minerals and water resources, are at a serious disadvantage in deriving any benefits from modern industry. The few industries that have come to this region have proven a blight rather than a boon. They have depleted natural resources, polluted the environment and brought little benefit to the local populace. The fragile ecosystem has tended to collapse under the assaults of exploitative development.[1]

It is no surprise then that the recent decision of the Department of Atomic Energy (DAE) to locate India's sixth nuclear power plant in this last vestige of the tropical evergreen forest has evoked serious concern among the ecologists. While it has become a global phenomenon to debate the hazards of nuclear energy whenever a new atomic reactor is pro-posed, the wisdom of the nuclear techno-crats is questioned in choosing Kaiga as the appropriate site. The main apprehen-sions are that—

1. It is for the first time that a nuclear plant is proposed to be erected in the middle of a tropical evergreen forest.

2. It is for the first time that a plant is being located in the vicinity of a potential urnainm deposit thus making

both ends of the fuel cycle meet at the same place.

3. It is also for the first time that such a major venture is being undertaken without carrying out a systematic environmental impact analysis.

4. It is again for the first time that a plant is located within a short distance from a cluster of major on-going projects that are highly vulnerable from the security point of view.

Geography of the plant site

Kaiga is situated on the bank of river Kali in the North Kanara district of Karnataka. It is about 40 kms. inland from the Arabian Sea where Kali debouches from deep gorges carved out of the steep west bank of the Western Ghats. It is bound by steep hills on three sides with closed canopy forests nurtured by heavy seasonal precipitation. The average annual rainfall of the area exceeds 250 cm. The climate is humid. The total duration of the rainy season is about five months, from June to October.

A total area of 1,700 hectares of forest and cultivated paddy fields will be taken over for the first two units of the proposed nuclear power plant, each of 235 MW capacity. The area at present is sparsely populated and just about 1,000 local inhabitants spread over some six villages will have to be evacuated. The nearest town on the west coast is Karwar 40 Km. away. The nuclear plant will be located adjacent to the proposed Kadra dam which itself would produce 120 MW of hydroelectricity, and entail evacuation of another 2,000 people from some 12 villages.

Other projects in the vicinity

Kaiga is surrounded by a series of massive on-going projects, each one of them claiming priority over others. The entire Kali basin within a short radius of 25 kms. is undergoing severe transformation upstream due to giant hydel projects. It is being developed to yield a total of 1610 MW of electric power through a series of dams, reservoirs, tunnels, power houses, surge tanks, pressure shafts, pen stocks and pick-up dams. The most important of these projects, the Supa Dam Complex which is considered to be the 'heart of the Kalinadi Hydro-Electric project' is beset with geological problems. 'As every cubic meter is excavated, a new problem is thrown up and the engineers and geologists face the problem....[2] Total submergence including Supa town is of the order of 25,000 hectares (of which 80% is forest land) and the total population affected uprooted is about 20,000. Altogether 11 dams will be constructed within 25 kms. upstream from Kaiga.

Preparations are afoot to establish a naval base, near Karwar at an estimated cost of Rs. 2000 crores. It is supposed to occupy 23,000 hectares of land, thus evacuating some 30,000 people from their ancestral villages. No provision is made to rehabilitate these people (except giving cash compensations) and it is obvious that they seek settlement in whatever niche they could carve in the forest.

Exploratory drilling for uranium is going on in the adjacent river basin of Gangavati near Arebail about 25 km. away from Kaiga. Exploration in a stretch of 400 x 9 km. in the forested hilly area is at present confined to borehole drilling at intervals of 100 to 200 M.

Mining for manganese and iron ore is going on at a brisk rate on the upper reaches of the forest area at Bisgod and other places. Exploration for copper ore too is continuing within 20 km. of Kaiga.

Environment, Ecology and Habitat

As said earlier, the steep slope of the Ghats is a fine example of the West Coast tropical evergreen forest. Giant trees with buttressed bases and trunks that are unbranched for over 30' spread their crown high above the ground. These closed canopy forests form a verdant roof, tempering the effect of the rain and standing upto the fury of the wind from June to September. This rich, stratified forest ecosystem is also a fragile one. The opening of the canopy may result in the destruction of the storeyed structure. Ensuing heavy precipitation leads to increased runoff, pronounced erosion and heavy flash flooding.

While the wind ward side of the Ghats is covered by dense evergreen vegetation, the leeward side is clothed with deciduous forests. Both types have a rich biological diversity so typical of the tropical forests. Their hot, moist climate seems not only to encourage mutations but also to allow them to survive in the process of natural selection in different ecologicl niches.[3]

Such an interesting section of the biosphere naturally harbours a rich variety of wild life. Very close to Kaiga on the hinterland is the Anshi wild life sanctuary in about 15 km. distance. Uncommon species of birds like *long-billed vulture, pigmy woodpecker, Jordon's imperial pigeon, Malbar Pied Hornbill, white headed myna* and some 150 other species decorate these forests. Among the terrestrial animals one can locate *sloth bears, tigers, panthers, wild pigs, wild dogs, gaur, spotted deer, sambar, barking deer, otter, monitor lizards, python* and many others.

The region around Kaiga is characterized by cultivation of agro-forestry that mimic the natural forest ecosytem in their pattern of organization. The mountain terrain harbours a number of fertile valleys where plantation crops like arecanut, coconut, pepper, betelvine, cocoa and cardamom are grown. The agro-ecosystem thus has a tree layer, a shrub layer, climbers and herbs. People in the Ghat section reside in isolated small cluster of villages with little or no civic facilities like communication, health service and education etc. In fact, there has hardly been any road link to Kaiga prior to the arrival of nuclear scientists.

There are three very important characteristics of ethnic groups around Kaiga. One is a 'Siddhi group' of Negroid origin. The other group of Halakki tribe on the coastal side. The third one is of a strong contingent of nomadic milkmen called 'goulis' who keep moving with their cattle in search of new pastures.

Environmental Impact

Controversy over the nuclear power has often been focussed on the hazards of reactors at plant sites. But as mentioned earlier, the Kaiga complex includes both the front and the tail end of the fuel cycle, beginning from uranium mining and milling at Arebail; transportation of uranium concentrates through the fragile forest belt to Hyderabad and back to Kaiga; fissioning uranium in the reactor; waste reprocessing, waste storage at the plant site at Kaiga. Hence, it is logical that a discussion on the ecological consequences of this nuclear enterprise at Kaiga begin from uranium mining.

Mining

The deleterious effects of uranium mining has been well-documented in Australia, Canada, France, Greenland, the USA and other countries. The International Commission on Radiological Protection (ICRP) has recommended safe-dosage of radon gas that emanates from quarrying. However the exact nature of the impact of the uranium mining, milling, and tailing deposits vary from place to place, depending upon the sensitivity of the environment. In a region of heavy rainfall and steep slope like the one around Arebail; the many streams, springs, herbs, creepers, trees are bound to accumulate large quantity of radioactive dust. Mine tailings containing radium and thorium –230 both with long half lives reach out into the soil and waterways. Radon gas from tailings of the ore decays into non–gaseous polonium which clings to dust particles, gets easily inhaled to cause radiation of lungs of both man and animals.[4] Meanwhile the solvent used for extracting uranium from its ore in treatment for plants also becomes radioactive. These liquids have to be contained in special lagoons which will inevitably reach out to contaminate the environment. Such a situation has already arisen at Jaduguda mines in Bihar, India where even at sites 10 km. away from the uranium concentration plant, grass and milk samples show the presence of radium entering the aquatic system.[5] while the DAE assures the people that there is 'no instance of any radiation hazard is reported from exposure to radon emanation'. The situation elsewhere in the world is alarming. In 1976 measurements taken on a tailings pile at the French mine at Monts D' Ambazac indicated radiation levels between 12 to 120 times the maximum permitted concentration. The French Atomic Energy commission (CAE) admits that radiation levels in the vicinity of the Brugeaud mine are likely to be six times greater than those, around the nuclear reactors.[6]

Viewed in this background, it may be interesting to note that the DAE has not made any measurements of radon emission at Arebail, despite having been engaged in exploratory activity for the past three years. The Regional Director in charge of exploration at Arebail says, 'The amount of radiation emanating from these rocks is far less compared to... the beach sands of Kerala. In view of this, safety measures of radon monitoring at Arebail is not at all necessary'.[7]

Such a casual attitude not only precludes all possibility of preliminary data collection on the natural background radiation but also indicates the shape of things to come. Studies conducted in areas of high background radiation in coastal Kerala have shown that incidence of Down's Syndrome and mental retardation there is four times higher than that in the normal (control) population.[8] Its frequency is found to be higher than that in England, West Germany, Denmark, Australia and North East Scotland.

Biological effects

Although no systematic studies have been conducted on the radiation effects on the tropical biosphere, artificially induced gamma ray exposure on oak–pine forest in Canada has shown profound effect on the health of the plants[9]. Whether due to mining or nuclear plant operation, if radiation stress is of long duration, it is found that the ecological succession is permanently delayed. Forests nearer the source of ionizing radiation are destroyed. One well known and undisputed evidence that radiation can cause mutations in flowering plants has come from spiderworts plant. **(Tradescantia ohiensis)**. The petals, stamen filaments and stamen hairs of the spiderwort flower so quickly change their colour from yellow to pink due to mutations induced by radioactivity that the Japanese farmers use these flowers as biological dosimeters to gauge the presence of radiation.[10] Some radioactive materials like iodine–131 get concentrated into plant tissues with high concentration factor of 3.5 to 10 million. Because when the radioactive nuclei get attached to plants or animals, absorbed radiation dose especially of beta rays becomes very much higher. Once these primary producers accumulate radioactivity it is bound to enter into the bodies of higher organisms through food chain.

Impact During Construction of Nuclear Power Plant

The pristine forest area around Kaiga is already being trampled due to road construction, helipad preparation, exploratory drilling and general survey activities. Building of roads, power transmission lines, pipelines, workers colonies and townships will soon begin. More than 1500 hectares of dense forest will soon be buzzing with human activity. Some 5000 workers will make it their abode for at least 10 long years. These labourers and their dependents are bound to exploit the forest for their housing, fuel, hunting and fodder needs. Hunting for wild boars and other big games in the nearby Anshi wild-life sanctuary located just 15 km. away will be a routine event. Large scale degradation of the forest becomes inevitable not only because of the influx of workers but also due to the resettle ment of the outgoing refugees.

Impact of Nuclear Power Plant Operation

Gaseous Release : It is a well–known fact that the routine operation of the nuclear plants and their ancillaries lead to a slow, inexorable rise in the background radiation levels. Radioactive wastes are emitted to both the atmosphere and the aquatic ecosystem. Certain radionuclides such as Krypton–85 and tritium are released in their entirety from the nuclear plants. A typical heavy–water reactor of the type proposed to be erected at Kaiga will emit 50,000 curies of tritium per year. This radioactive hydrogen easily finds its way into the human tissue through water. The maximum allowable dose in human tissue is at present one thousandth of a curie.

History is replete with radioactive gas releases, both open and secret, that have caused havoc to the animal population close to the nuclear plant and also several kilometers downwind. Although these gases do not concentrate in the human body, they transform themselves into biologically damaging cesium, strontium and yittrium inside the body, causing far more serious damages to the respiratory organs than external radiation. Incidence of cancer and infant mortality are closely linked with the release of radioactivity from heavily emitting reactors at Dresden, Indian Point, Brookhaven and Shippingport etc., in the United States.[11] Near the Lingen reactor in West Germany, death rate from leukemia is reported to have risen seven times in the ten years after the plant became operational. Infant mortality is strongly associated with the levels of strontium-90 and cesium-137 in milk. Both these reactor-byproducts are found at especially higher levels in meat. Animals vary in their uptake of radioactivity – pigs being six times as vulnerable as cows.[12] Strontium-90 is a key element in radioactive fallout and low level radiation. It readily becomes concentrated in the cows' milk, as has been amply proved by the Chernobyl disaster.

Hazards of all these radioactive products will be many fold more in Kaiga because of the peculiar geo-climatic nature of the region. Emissions from the reactor will invariably rise upwards through the Kaiga valley and sweep along the mountain ridges of the Western Ghats to be deposited on the grasslands, meadows, plantations and forests during heavy precipitation. It will have pronounced effect on the nomadic milkmen and other tribal people.

Liquid Release

The coolant water taken from the Kadra reservoir will be let out into the downstream of Kali river and into the estuary, with enhanced thermal regime. As such the river water is rich in iron and copper pyrites and sulphates due to mining activity upstream and leaching of copper deposits in the vicinity of Kaiga. Coolant water creates thermal stratification in the estuary and would result in anaerobic conditions in the bottom, where mud-grubbing life forms like prawn fishes dwell. Bottom becomes acidic and reduces sulphates to hydrogen sulphide, H_2S. It becomes soluble in water and is toxic to aquatic organisms.[12A]

Release of reactor effluents impregnated with tritium will further aggravate the threat to the life supporting environment in the estuary. Warm water with the inevitable radioactive elements will, in all probability make the Kali river a veritable biological desert. When the marine fauna eat large quantity of radioactive plankton, it is bound to end up at the top most link of the food chain, the man.

Noise, Waste, Heat and Other Effluents

Noise is generated at the steam turbines, electrical generators and at the draft-cooling towers located near the nuclear power plants. Sound pressure levels for large (150 meters and above) hyperbolic towers alone have been variously estimated, a reasonable approximate being 500 dB at 800 meters from installations.[13]

Nuclear power plants produce water heat load 60-70 percent higher than fossil fuel plants. A typical 200 MW reactor produces waste heat at the condenser at the rate of 13×10^9 Btu/Hr.

The other common pollutants are : grease, degreasing detergents, H_2SO_4 (to control pH), silt depressing agents, corrosion inhibitors, demineralizers like Na_3SO_4 and H_2SO_4, sewage and sanitary wastes, gaseous wastes from auxillary boilers, diesel engines and incinerators.

Effect of all these viz. noise, heat and noxious gases on the flora and fauna of the natural ecosystem around the Kaiga nuclear power plant is bound to be quite serious. Besides, movement of radioactive raw materials, fuel components and waste products through the forest will have deleterious impact on the fragile mountain ecosystem.

A Look Back at the Future

The greatest impact of all will be on the long-term future of the Western Ghats and the West Coast. There is no known technique to dismantle a dead reactor. Even if it becomes available in the future it will be so expensive that the future people will prefer to safeguard the reactor chain rather than dismantle each reactor. This means that for thousands of years these defunct reactors will have to be carefully guarded against the elements, landslides, earthquakes, breaching of upstream dams etc. Wind, rain, air and ground water all will have to be watched closely for contamination. Thus, future generations will have to commit themselves to this technology even if safe, cheap and clean energy sources become available.

Kaiga hence poses a moral and ethical question too. Do we have a right to impose such a Hobson's choice upon the future generation ?

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NEWS

In February, West German anti nuclear activists broke into train wagons filled with radioactive powdered milk and threw sacks of it into the snow cutting open some and throwing oil over the others. They wanted to make sure that the milk, which West German environment minister Wallman said still had 'commercial value', would not be used.

The milk powder originally came from Bavaria. This region of West Germany was severly affected by radioactive fallout from Chernobyl. The farmers had been ordered to turn their milk into powder and had been compensated for their losses. There are fears that the 3000 tons of milk powder meant for export to third world countries is just the tip of the iceberg.

(Source : WISE News Communique # 268. 2270 (13.2.'87)

Editor's Note: Thanks to the 'White Revolution' India is the largest importer of EEC milk powder and butter oil. There has been no instance at least in my knowledge of India rejecting a large consignment of milk products from Europe after Chernobyl.

What Can Happen Here!

Ever since Chernobyl, all the big shots in the Department of Atomic Energy have treated us to an unending litany:

'It Can't Happen Here'.

The reasons given to facilitate public acceptance of this optimistic hope are many. 'Their (Russian) nuclear technology is old.' 'The reactor at Chernobyl was of a different type than those in India.' 'Graphite as moderator and water as coolant is a very poor choice.' 'Chernobyl was due to operator's error—our operators are graduate engineers and they are better trained.' And so on and on. The implication being that technological novices like the Russians and Americans, who let mere high school technicians operate their plants, can have their disasters, but we, 'second to none' with the 'third largest scientific manpower in the world,' who have done great deeds like imploding the peaceful nuclear device at Pokharan and sending Rakesh Sharma into space, shall insure that nothing shall ever go wrong here.

In this article we shall examine the safety implications of the CANDU reactor design, which has been adopted by India as the mainstay of the nuclear power generation programme. The probability of a nuclear disaster, its consequences and our ability to deal with them will not be our focus in this issue but we hope to deal with each of them at length in the future. The article is arranged as follows : in section 1 we shall discuss some general aspects of reactor hazards; section 2 is a brief description of reactor design criteria; section 3 is a look at the CANDU reactor design and its safety implications from the text of the section 4. Section 5 is a brief statement about the attitudes of the people involved in the nuclear industry. Most of the material in this article is drawn from an 'International study on the effects of nuclear reactors' commissioned by Greenpeace of Germany and which appeared in September, 1986.

Sec. 1 : General Aspects of Reactor Hazards

The most important lesson to be learnt from Chernobyl is that reactor accidents are not just hypothetical events of concern only to experts. *They do occur* and can affect your life and mine.

Nuclear power reactors have all grown out of the early military models used for bomb production or submarine propulsion and they are still bound by the basic constraints of their decades old design principles. Within these constraints however, they have developed a great deal and have more or less reached the limits of their potential for improvement. In other words they are as good as they can get. In India we are faced with a special situation. The Tarapur reactors are the only boiling water reactors (BWR) of their vintage operating anywhere in the world. Similarly the Rajasthan and the Madras reactors are based on a very old (early 1960's) CANDU design (Douglas

Point) and do not incorporate all the modern safety concepts in their design. Thus Indian reactors have additional safety implications over and above those pertaining to reactors in operation elsewhere.

The history of reactor accidents has focussed attention on human error as the single most important factor responsible. This by no means implies that the operating personnel are to get the blame for the reactor's lack of safety. Rather it shows the operators have to work under conditions which demand near perfection, whereas it is human to make errors and to be allowed to make errors. Technical systems must be benign in reacting to human error; nuclear reactor systems certainly are not. However well trained our operators may be they are not isolated islands totally uncontaminated by the 'Chalta Hai' attitude prevalent in the rest of the society towards safety. A contradiction to the myth that these 'Technological Brahmins' are a special breed above ordinary human failings was recently provided by the petty squabbling engaged at the very top of our atomic establishment.

The safety problems of reactors are exacerbated by the fact that, world over, all those involved in the nuclear enterprise have a very optimistic attitude to safety. Enormous investments in resources and prestige have been made by them in the present system and they desperately want to be proved right. Thus they cannot bring themselves to question the priorities and the standards that have brought us to the present pass, for the fear of having to get off their high horses and writing off these investments. Thus, there are strong pressures to overlook 'small', 'stray' malfunctions and the continuation of hazardous operation. There is also a grey zone between errors and deliberately malicious acts. Nuclear reactors with their extreme complexity and the large number of vulnerable components are particularly sensitive to sabotage.

Sec. 2 : **Basic Criteria for Reactor Design**

Nuclear reactors are like kettles; they boil water. The process of atomic fission is used to heat water and produce superheated steam which then generates electricity by moving turbines like in any ordinary power plant. Fission is the splitting of a heavy nucleus such as uranium into two smaller fragments and also lighter pieces such as neutrons. Fission may be spontaneous but in a reactor neutrons from a previous fission interact with a 'fissionable' (fissile) neucleus to cause another fission and so on to a chain reaction fission events. The only naturally occuring fissile material is an isotope of uranium (U235) which constitutes only 0.7% of naturally occuring uranium; the rest 99.3% is uranium 238 which does not fission.

On an average each fission produces 2 to 3 neutrons and releases an enormous amount of energy. Most of this energy appears as the kinetic energy of the fission fragments. These fragments are stopped rapidly by the materials in the core of the reactor which heat up in the process. The heat is taken up by a coolant which flows through the core of the reactor. To extract power at a sustained level it is necessary that on the average one and only one neutron produced in a fission induces another atom to split. The number of neutrons in each succeeding generation will then remain constant. Since each fission produces two to three neutrons, surplus neutrons are available. Neutrons can interact with the core materials in any of the following way : (i) Interact with a fuel atom causing fission. (ii) Be absorbed by a fuel atom without causing fission. (iii) Be absorbed by the non fuel atoms (coolant, moderator, structural materials fission products e.g. xenon), (iv) Get lost from the core by leakage through the boundary.

The probability that a neutron will cause fission depends a great deal on its speed among other factors. Slow (thermal) neutrons are more likely to cause fission than fast neutrons. Therefore, the fuel is surrounded by a 'moderator' which slows down neutrons rapidly (thermalizes them) to improve their chances of causing fission and thus continuing the chain reaction. Moderators need to made up of light elements for maximum energy transfer during neutron collisions. The usual moderating material are water, heavy water, and graphite.

The fuel material is in a solid form, normally contained in metal cans. Most of the heat is produced in the fuel which is substancially hotter than the surrounding coolant and one of the prime design consideration is to have adequate hea transfer between the coolant and the fue so that the fuel or the container does not overheat and melt. The cooling fluid is therofore pumped through the nuclear core. In the pressurised coolant design the coolant is kept under high pressure so that it does not boil but in its turn heats a secondary coolant (water) to make steam which runs the turbine.

As a result of reactor operation there is a buildup of fission fragments in the reactor core. Some of these (e.g. xenon) have a very large probability for neutron absorption and are termed neutron poisons. Thus it is not possible to maintain the number of neutrons precisely the same in succeeding generations, without some control mechanism to regulate the number of available neutrons. This can be done by inserting control rods of Boron or Cadmmiuin (also very good neutron absorbers) into the reactor core and slowly moving them out or in as the need arises, during reactor operation. Replacing burnt out fuel with fresh fuel during reactor operation (online refuelling) also helps in maintaining neutron balance.

All thermal nuclear reactors are in their most reactive configurations. This implies that any rearrangement of the fuel will lead to a decrease in the reactivity and hence the power level. As nuclear spokesmen never forget to remind us reactors can't explode like bombs. This does not apply to the fast breeder reactors which can, infact, explode (more about that in a future article). Reactivity coefficients measure the change in reactivity of a reactor as the physical state (e.g. power level, temperature, amount of coolant etc.) of the reactor changes. All thermal nuclear reactors have negative power and temperature reactivity coefficients. Reactivity coefficient of the void measures the change in reactivity consequent to a void (loss) in the coolant. A positive void coefficient means that any loss of coolant will cause a sudden increase in the power of the reactor. Ominously both RBMK (Chernobyl) type reactors and CANDU reactors have positive void reactivity coefficients. (see section 4).

By normal operation one means that enough cooling is supplied so that the structural integrity of the reactor core is maintained and that the radioactivity produced in the core is not released to the environment. A number of safety features are incorporated in the design to ensure normal operation. The safety features are of two kinds, i.e. inherent and engineered. No reactor today is totally inherently safe. An example of inherent safety feature is the negative reactivity coefficient in a light (ordinary) water reactor. (LWR). Any rise in the reaction rate causes overheating which makes the moderator boil over thus reducing the reaction rate due to insufficient slowing down of neutrons An example of engineered safety is the scram system which causes a rapid insertion of control rods into the reactor core to shut it down. Defense in depth is the name given to the concept governing engineered safety. The idea is to have independent and redundant active safety systems available so that a catastrophe is prevented even if some of the systems fail to perform as desired.

Sec. 3. CANDU Design Features

Till now the mainstay of India's nuclear energy programme is the CANDU reactor. One unit is presently operating in Rawatbhata near Kota in Rajasthan and two units at Kalpakkam near Madras. Two units each are under construction at Narora (U.P.) and Kakrapar (Gujarat.)

The CANDU is a natural uranium fuelled (0.7%uranium 235) heavy water moderated and cooled reactor originally of Canadian design. Heavy water absorbs 600 times fewer neutrons than water and this allows reactor operation without need for enriched fuel. The fuel is in the form of thin cylindrical pellets size of pencil erasures encased in very thin tubes made of an alloy of zirconium. Zirconium is chosen because it has a very small neutron absorbtion probability, is a metal and hence can be worked into thin tubes and has a fairly high melting point. The zircalloy tubes are arranged into cylindrical bundles with spaces in between to allow for the flow of coolant. These bundles are in turn encased in a zircalloy-niobium pressure tube through which the primary coolant flows under high pressure. High pressure is required in the primary heat transport system (PHTS) so that the coolan (Heavy Water) does not boil off. This is necessary because after many cycles of circulating through the reactor-deuterium in the heavy water is liable to absorb neutrnos and become Tritium. Tritium is radioactive and is a serious health hazard. Thus for reasons of both economy and workers safety, it is imperitive to minimize losses of tritiated heavy water from the primary heat transport system (PHTS). It is this which puts a limit to the pressure and temperature that can be maintained in the PHTS. Each pressure tube runs axially through a horizontal cylindrical stainless steel vessel called a calandria. The calandria is filled with cool (1000°C) heavy water moderator.

A notable feature of the CANDU design is on-live refuelling. Spent fuel rods can be removed and fresh ones inserted into a pressuae tube with the help of a refuelling machine, with reactor at full power. The on power refuelling also controls the long term number of neutrons.

3(a) Safety Systems

Scram Systems: CANDU reactors contain two independent techniques for emergency termination of the fission chain reaction. These are a moderator dump and medianide shut off rods. The trend has been to make both systems independent of each other and each individually capable of rapidly shutting down the reactor. The two systems are physically separate and operate on different physical principles.

Emergency Core Cooling System (ECCS): Even with the reactor totally shut (scrammed) it continues to produce around 7% of the heat prior to shut down due to the decay of the radioactive fission products. Thus the core needs to be continuously cooled even with the reactor shut to prevent overheating and melting of the fuel. In case of a loss of coolant accident (LOCA) one needs an ECCS with its own separate water and power supplies.

Containment: The last barrier against a catastrophic release of radioactivity is the containment. This is a concrete dome enveloping the entire steam generating unit designed to withstand large pressures. Under normal operating conditions the pressure inside the dome is kept slightly below atmospheric and ventilation dampers are open to the outside environment. There are building coolers that can condense steam from small leaks. If sensors detect over pressure or if x-ray detectors detect high radioactivity inside the building, the dampers close and the containment is isolated. A dousing system is turned on to condense steam. The building is equipped with filters to retain radionuclides.

Sec.4. Implications of the CANDU Design

The point to note is that no reactor designed till now is totally inherently safe. All require the active intervention of engineered safety systems and human operators to ensure safety. Both have been known to fail. The CANDU design has both good and bad features as regards safety.

Good Features:

(i) Reactors produce a great deal of heat. Thus any interruption in the flow of coolant (LOCA) can be catastrophic. Since LOCAs are the most obvious path to a serious accident, most of the safety studies have concentrated on them. In the event of a LOCA and the failure of emergency cooling, the large mass of cool unpressurized heavy water in the calandria can take up the heat being produced and thus provide additional time for repairing the problem in the primary cooling system (PHTS).

(ii) The control and safety devices are not exposed to violent thermal and hydrolic forces during accidents because they are located in the cool unpressurized moderator.

(iii) Unlike the light (ordinary) water reactors (LWR) which have a huge pressure vessel, the CANDU design is based on pressure tubes. This allows the division of the cooling pipe system (PHTS) into two or more loops. Thus any accident in the cooling system does not affect all the fuel but only a small part of it thus reducing the initial impact of a LOCA.

(iv) Leaks in the pressure tubes (that sometimes precede breaks) can be detected by monitoring the gas in the annular space between the pressure and calandria tubes.

Features with Both Positive and Negative Aspects :

(i) CANDU reactors are capable of refuelling with the reactor on at full power. This allows monitoring of the integrity of each fuel channel and also the immediate replacement of faulty fuel. However, the fuelling machine becomes part of the PHTS while connected, and this introduces a whole new category of accidents involving the fuelling machine and the fuel handling system.

(ii) The pressure tube design procludes the possibility of a major pressure vessel break as in a LWR, but the much greater surface area of the ANDU PHTS and the much greater surface area of the CANDU PHTS and the uch greater muse of small and medium sized piping increases the overall LOCA probability in a CANDU.

Dangerous Features :

(i) The most dangerous feature of the CANDU is the positive void coefficient of reactivity. As explained earlier, (see also the next section) this basically just means that the reactor is unstable with respect to any boiling off of the coolant, with the possibility of the power level jumping to many times its operating value within a few seconds. This a feature common to CANDU and RBMK (Chernobyl) type reactors.

(ii) The pressure bearing components (i.e. the pressure tubes) are exposed to the full neutron flux, with the consequent high risk of embrittlement and other weakening effects due to neutron 'creep'. Creep refers to the lengthening of the tubes as a consequence of constant neutron bombardment. The sudden break of an embrittled pressure tube had resulted in a LOCA at Pickering reactor in Canada in 1983.

(iii) The use of heavy water as coolant and moderator results in large inventories of Tritium, which is a serious health hazard.

(iv) At temperatures of around 1000° C zirconium reacts strongly with steam to produce a lot of heat and Hydrogen. Hydrogen forms an explosive mixture with air. No containment yet built anywhere is designed to withstand the impact of a large hydrogen explosion. CANDU reactors have very large inventories (typically around 16 to 20 tons in a 230 MW reactor) of zirconium in the core.

(v) The siting of two or more units nearby and also the storage of spent fuel on site cause serious complications in case of a major accident.

Worst case event Scenario

There is a great dearth of experimental data on the behaviour of CANDU's during the violent conditions characteristic of worst case scenarios. Since there are only a few reactors of the CANDU type operating anywhere in the world, the cumulative reactor years of experience is rather small. Also there has been very little safety related research conducted on the CANDU e.g. the behaviour of materials after prolonged exposure to intense neutron flux is a new science. In the CANDU programme, the elongation of pressure tubes due to 'neutron creep' and the cracking of pressure tubes due zirconium deuterium reactions were not appreciated until they caused major problems.

The most serious event for a CANDU is a loss of coolant accident (LOCA) followed by a failure of the SCRAM system. This is due to the positive void reactivity coefficient. In most LWRs' any loss of coolant in the core immediately lowers reaction rate. In a HWR on the other hand, the moderator is separated from the coolant and any loss of coolant does not affect, the slowing down of neutrons. without the SCRAM system to terminate the chain reaction the power level increases by about fifty times its normal value within five seconds. Scram failure after a LOCA leads inevitably to core disassembly and fuel melting which stops the chain reaction. when the molten fuel hits the cool moderator, the resultant vapour explosions will probably blow the calandria. Missiles from the calandria vessel can cause a breach in the containment. Steam generation from the PHT system break will also add to containment pressurization. The zircaloy–steam reaction becomes a major source of heat in the calandria and the hydrogen produced from this reaction adds to containment pressure. There can also be a hydrogen combustion. It is unlikely that the containment will be able to contain the radioactivity in such an event.

Sec. 6: Attitudes

The Kemeny commission (which investigated the Three Mile Island disaster and other enquiry commissions have again & again pointed towards the critical importance of attitudes as a factor in safety. Certainly the public face the nuclear industry has displayed, borders on bravado. This cavalier attitude seems both widespread and deep seated and many in the nuclear industry believed at least until Chernobyl that major releases of radioactivity from power plants were so unlikely as to be incredible.

Like other developmental 'czars', but only more so, people at the top in nuclear industry believe that they and only they can have a full understanding of what they are doing and they are under no obligation to explain their actions to those whose lives these actions jeopardize. 'Somebody has to pay the price of progress' is their refrain and invariably their choice for this falls on adivasis and other weaker sections of the society. Some even think that elaborate safety systems are needed more for public relations than for public safety. This, inspite of large and mounting evidence that nuclear experts are prone to the same human frailities that bedevil other experts' and that have managed to make common names from Bhopal to Chernobyl. with a more forgiving technology such arrogance would be of little concern. In this article our aim has been merely to show that the CANDU like all other reactor types in operation today is not immune to large and uncontained fuel melting accidents.

S. N. G.

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NEWS

Multinationals are diverting milk products which they cannot sell in Europe to markets in the third world. For every contaminated shipment that is detected by Asian governments there must be many others that reach market shelves.

Singapore, which probably has the most efficient system of testing and control, rejected no less than 240 consignments of food contaminated by radioactivity. This was 4% of the total 6000 consignments checked.

Malaysia, where the government sent back 3 consignments including 45000 kg of butter oil form Holland, requires food items from all Europian countries to have health certificates from the country of origin stating radiation levels.

In Sri Lanka, sale of many varieties of jam imported from Poland ahd Bulgaria was banned. A shipment of milk from Holland was also withdrawn after testing.

(Source: WISE News Communique ; 264. 2208 5.12.'86)

The Victims of Radiation

by Jean Emery

To tell about the lives of radiation victims is never easy. Sadly there are so many cases and in not having the time to give full details of every case you feel you are denying those people something of their existence, their history, their own unique and individual life. Sometimes those who are suffering are too close to us for us to be able to talk about the issue. Sometimes we are the victims. For those who have been contaminated it is very difficult to convey the silent fears to a world which demands evidence of physical harm before it will react. For those who have the cancers and the illnesses for these people who satisfy the 'statistical demand' or refute the hypothetical cases, it is too late–they are too far gone for our help.

In my home town of Barrow we have a long history of shipbuilding, building ocean going cruiser liners before the war, but since 1940 we have concentrated on building of warships and submarines. In the early sixties Barrow built the Polaris nuclear armed (and powered) submarines, we then moved on to the conventionally armed, but nuclear powered hunter–killer submarines and now, we are also to build the Trident submarines. But to start my tale I would like to go back to the early fifties. At that time Windscale was in its infancy and the skilled workers required to build the Calder reactors simply were not available from the local rural community. Many men came from the industrial towns of Barrow and Millom to work on the plant. They were so ignorant of the dangers that one wonders how they survived some of the incidents at the plant. The supposed experts of the day were only a step ahead of the workers. Windscale had several accidents in the first few years of operation, but 1952 was the year of the first recorded 'incident' of any significance. In that year the Windscale management, United Kingdom Atomic Energy Authority decided to release a large quantity of Iodine–131 via the cooling towers to see the effeccts of such a release. The only reason we know of this is because two of those who were sent out to track the release, found large quantities in their own children. All this was kept secret, until recently, under the thirty year rule which governs military installations. We shall probably never know who those two innocents were and we shall probably never discover why their parents lacked the courage to speak out.

The next major incident was in 1955. Windscale's Plutonium reactors had already been fixed 300 times by robotic operations, but in 1955 a piece of the monitor which scans the face of the reactor had been pushed through the fuel rod enclosures. To fix it needed men to crawl through to the foot of the reactor; 250 men volunteered their help. They were led in this operetion by the plant manager, H. G. Davey, that rare creature who was prepared to take the same risks as his men. Many BNFL (British Nuclear Fuels Limited) workers do not know of this accident; in fact it was CORE (Cumbria Opposed to a Radioactive Environment) who discovered it. No attempt was ever made to carry out a follow up health survey of the men involved, although the accident must be relevent to many compensation cases. The men were only allowed 25 minutes working time near the reactor. They each received a dose equal to three weeks permissible dose. Doses in 1955 were three times the level permitted today. H.G. Davey died of multiple myloma in 1960. Most people, felt his death could not be due to his work as they only knew of his involvement in the 1957

(Courtsey : The Ecologist, Vol.16, No.4/5, 1986)

accident and three years seemed too short a time for disease to take its toll of his life. No consideration was given to previous accidents.

When the 1957 accident happened what can only be described as a panic broke out. Firemen were sent in without the proper breathing gear. It took three days to bring the fire under control, it took three days for the authorities to warn the public. Nonessential personnel were allowed to go home. Those skilled workers who were needed, were forced to stay on site. The management drew peoples' names out of a hat to see who would go into the stricken reactor. Many of those involved have had cataracts, cancers, early heart attacks and rare diseases of the nervous system. One man who suffered such a disease is Arthur Wilson. He was the man who found the fire and ran to alert the management. Their reply was to tell him 'Don't be so bloody stupid and stop fooling about'. Arthur was one of the men who helped fix the thermo couples to the reactor. He now has a disease of the central nervous system, his doctors cannot diagnose, but most blame it on his part in the Windscale fire.

Les Jenkins, who had come from BNFL's Capenhurst plant to help fight the fire, has multiple myeloma. He tells of how he came out of the reactor with his monitor badge blackened. The health physics department was in chaos, and badges and reeords lay scattered around the room. When Les applied for compensation for his illness BNFL told him he had never worked at Windscale! It took six months of legal wrangling to get BNFL to admit he had worked there. It took national publicity of his case to get BNFL to pay him compensation. He received. 23,000, the price BNFL put on a loyal and brave person's life. They still deny any liability.

In 1957 the public were far more ignorant than the workers. The personal accounts we have of that time are a legion, the cancers and the illnesses suffered are quite horrifying. One vital witness is Tyson Dawson, who farmed the land bordering Windscale. He tells of how he stood at his farm and watched the people running around the plant 'like ants under attack'. He tells of how they could taste the cold iron (iodine) and how they all felt tired. The fire started on a Thursday afternoon; at 2.00 a.m. the following Sunday morning Tyson was woken by men knocking on his door. They told him to destroy all his milk. He lost many animals over the years he spent farming next to Windscale. Some died of cancers, others were born deformed. Some died due to the 1957 fire, others from drinking water and eating food contaminated by Windscale's daily releases,

1957 was a worrying time for Cumbrians. Of course we did not know the full facts, we just had a gur reaction to anything nuclear. We now know that Windscale released 100–1000 times more iodine–131 than the Three Mile Island accident. Indeed, as the cloud passed over London, three days after the fire started, it trebled the 'natural background rate' of the city in one hour. An international row broke out behind the scenes as the Dutch government realised what had happened. Actually it would be wrong for me to give you the impression that I remember the fire, I was 'around' then but not alive'. My mother was carrying me when the fire happened and because she had three young children and was pregnant she was allowed two tins of milk a day. My father, who had worked on the building of Calder Hall (Britain's first nuclear reactor) was sick with worry that my elder sister and brother would eat fresh fruit on the way home from school.

Anne Todd was a house–mother at a local school in 1957. She lived in the small town of Broughton–in–Furness. She lost her son through leukaemia following the fire, so did two other women with whom she worked. All blame Windscale. Kevin Murphy was on holiday near the plant when the fire happened. He died of leukaemia in Manchestor when he was eleven, some nine years after the fire. Bob Benson's son was diagnosed too late for treatment to be any good. He died aged eleven, he had been on holiday from Barrow at Seathwaite reservoir when the fire broke out. He drank the water from the fresh water lake. It had rained very heavily on he days of the fire, all surface water in the tarea becoming contaminated. Yet no one was told to avoid drinking the water.

potentiality to pollute the country's most populous and fertile region, the Gangetic plain has attracted the attention of some intellectuals from the universities of Delhi. A few hundred people mainly students from Delhi participated in a procession at Narora in March '87. Further demonstrations are planned for the summer.

Kerala Shastra Sahitya Parishat has been investigating the high incidence of early mortality, cancers and sterility amongst the workers of Indian Rare Earths Ltd. which processes the Monazite sands to produce Thorium and Zirconium. A detailed report has been published in the February 28th issue of Economic and Political Weekly. A video film has also been made.

There have alredy been some stirrings amongst citizens to voice concern about the proposal to site a nuclear reactor at Nagarjuna Sagar in Andhra Pradesh. A seminar was held in Secundrabad.

The visit last year of Drs. Caldicott did succeed in stirring up debate in the cities they visited. A follow up meeting was held in Bombay in March, and it was decided to start a regular newsletter.

This magazine itself is part of the continuing protest. It has grown as part of the follow up of the 'Atom in India' seminar held in Bombay in August last year.

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NEWS

Resurgence of Hydropower

Small is beautiful once again in Soviet energy planning. Several small hydroelectric stations mothballed in the mid 1960s are now being recommissioned. In the post Chernobyl energy crunch, caused not only by the loss of capacity of 2 of the 4 Chernobyl reactors (units # 1 and 2 are now operational again) but also by the temporary withdrawal from service of all RBMK reactors to upgrade their safety systems, every kilowatt of capacity counts. Furthermore, now that the Russian ecologists have won their campaign to halt plans to divert the northern flowing rivers to the arid lands of central Asia, energy planners are taking a closer look at unused generating capacity.

Small hydroelectric plants were a feature of the Soviet energy scene for many years. They played an effective role in providing electricity for isolated towns of up to 70000 inhabitants. In some cases however, the use of low land rivers with a relatively small gradient led to the flooding of valuable farmland and caused considerable disturbance to the water table. By mid 1960's, the energy planners were firmly committed to the idea of a small number of giant power stations and a nationwide grid. Some 300 small stations with capacities up to 30 MW were phased out. Now these stations are to be brought back into service and the first of them at Kalinin in Kirgizia was recommisioned in August '86.

Soviet economists are enthusiastic about small stations. In remote areas, hydroelectric power can be upto 50 times cheaper than oil fired plants. Small hydroelectric plants can be automated so that there is no need to provide a service infrastructure of housing, schools and shops.

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Antinuclear Protest Movement in India the Story So Far

Narayan Desai

Antinuclear protest movement in India is comparitivly young. Till the implosion at Pokharan most of the peace lovers believed the government's claims of totally peaceful nuclear intentions. On the other hand the environmental depredations of the nuclear fuel cycle were by then not so manifest as to disturb the environmentally conscious. As a result many shared in the Nehruvian dream 'of utilizing new sources of power which science has placed at our disposal to find a way out ot the viscious circle of Poverty.'

Awareness about the need for a balanced ecology that spread throughout the world had its echoes in India too. The 'Chipko' movement in the north and the 'Silent valley' movement in the south were manifestations of this. Kerala, with the highest literacy rate in the country and a strong peoples' science movement represented by the Kerala Shastra Sahitya Parishad took the lead in opposing the siting of a nuclear reactor in its territory. The Organisation for the Protection from Nuclear Radiation successfully opposed the governments plan of siting the reactor at Kothamangalam.

Sadly Indian politicians irrespective of their party affiliation have been greatly enamoured of nuclear power. This is firstly a lingering legacy of the Nehruvian dream and secondly due to a desire to be associated with high technology in the hope that some of the enormous prestige accorded to it would rub off of them. A lot of states vied with each other in trying to get DAE to locate a nuclear plant within their borders. The politicians of U.P. (Narora) and Gujrat (Kakrapar) managed to 'win'.

The disaster at Bhopal shocked some people out of their slumber. In 1985 a group of Gandhian activists and intellectuals gathered together to question the wisdom of establishing the Kakrapar reactor. Two demonstrations took place at Kakrapar and Surat in May and August respectivly. The agitation attracted wide public support a year later in August '86. Sampoorna Kranti Vidyalaya and Anu Urja Jagruti were able to organise a massive rally near the Plant site inspite of the government's efforts to prevent it. The repressivs measures included promulgation of sec. 144 in 3 talukas, stopping of all vehicular traffic, recourse to lathi charge, tear gas and letting loose mounted gallopping horses on people. Unfortunately, the rally, which included thousands of local adivasis did not remain entirely peacful and a section of it indulged in stone throwing and causing damege to public property. The Gandhian leader ship of the movement later fasted for two days as an expression of their opposition to government provocation and of regret for their inability to control the crowd. The government persisted in its efforts of trying to terrorise the people even to the extent of resorting to firing in which one boy was killed and another injured. These events received wide publicity in the local press and also some questions were raised in the state assembly.

The proposal to site a reactor at Kaiga in Karnataka has mobilized a number of environ ment–lovers to organise an agitation against it. (See Nagesh Hegde's article in this issue.) There is also a proposal to challenge this decision of the government through a writ in the supreme court.

The constuction of a reactor at Narora in an earthquake prone region which has the

P.T.O.