Gagging the runaway nuclear machine

Boron, which is being pumped into the Fukushima reactor in Japan, could help stop a nuclear reaction, says s ananthanarayan

THE great catastrophe that nuclear reactors need to guard against is runaway reaction, which gives rise to the generation of heat and the escape of materials and radioactive elements into the atmosphere. Such accidents have happened in the recent past, first in the Three Mile Island case in the USA in 1979 and again in the Chernobyl mishap in Ukraine in 1986. As of last Sunday, it was feared that three reactors in Japan, which had been damaged by the tsunami, may also suffer dangerous collapse. Those fears have, as of now, been allayed even though explosions hit one reactor of the Tokyo Electric Power Company's Fukushima nuclear plant the following morning after which the International Atomic Energy Agency – the UN atomic watchdog – said the radiation levels were "normal".

The great danger in the case of nuclear reactors is that their energy-producing *core* contains a large quantity of radioactive material. A nuclear power plant is similar to a coal-fired power station in that it heats water to create steam, which turns turbines, which generate electricity. The difference is that in the place of coal that heats the boiler which produces steam, the heat source in the nuclear reactor are rods of radioactive material which take part in a *nuclear chain reaction*. Any mishap that allows this material or the products of the reaction to escape can be disastrous decay.

In a small piece of uranium, most of the freshly emitted neutrons do not find targets and escape the material. But if an adequate quantity of such fuel is brought together, it then becomes more and more likely that each nuclear fission (or break-up) will set off, on the average, more than one new nuclear fission. When this happens, the number of fissions rapidly multiplies and the whole fuel assembly heats up.

The heat is quickly taken away by circulating a coolant, under pressure, which exchanges its heat with water in an exchanger to produce steam to drive turbines. One idea of keeping the coolant, which is usually also water, under pressure is to avoid producing steam, because steam tends to react with some of the metals used in the reactor casing and become hydrogen. Apart from leading the heat away by the coolant, the reaction itself can be controlled by blocking the path of the neutrons between fuel rods. This is done by inserting other rods of materials that absorb neutrons and get them out of the chain reaction cycle.

The whole arrangement, which is entirely remotely controlled, is encased in a specially designed concrete structure, both for concrete to provide some shielding of radioactivity which escapes from the reactor as well as to contain the intense heat and huge pressures than can develop in case the reaction goes out of control.

In the Three Mile Island case, the trouble started when the secondary loop (see figure, below left) of steam that carries heat away and to the turbines suffered mechanical failure. This caused overheating of the reactor and a safety valve, which allows the pressure to drop, was activated, as also the automatic shutting off of the plant by lowering the control rods which block the neutron traffic. But the valve did not close when the pressure dropped and because of the heat that fuel rods generate for some time, even after the reaction has been controlled, some coolant water escaped into the atmosphere and spread radioactive contamination.

In the Chernobyl case, accidental overheating of the core led to increase in pressures and collapse of the concrete casing, which had not been designed to withstand the pressures of an accident. This led to the escape of coolant and also exposure of the graphite rods, which were being used to control the reaction, to the air and they caught fire. Huge quantities of radioactive material were transported by the resulting smoke. The Chernobyl disaster brought home the need for strict enforcement of safety norms for reactor structures to be able to withstand the pressures and temperatures that can arise during mishaps.

In the present emergency in Japan, it is the cooling system at the Fukushima Daiichi plant that has stopped working because of power failure as a result of damage caused by the tsunami. The reactor is a "boiling water reactor" or one that uses water coolant directly to run the turbines.

The type of water used is *light water*, or water from which occasional hydrogen atoms that have nuclei with a neutron and a proton, in place of only a proton, which is called *heavy water*, has been removed. This kind of reactor has a number of advantages and economies, but these get largely set off by high maintenance costs because of radioactive contamination arising from water circulation.

With failure of the cooling system in the Fukushima reactors, there was pressure build-up which was controlled by the release of steam, and high radiation levels were measured both outside and within the reactor assembly. At the high temperatures, above 3,400° Fahrenheit, *zircalloy*, a special material used in the fuel rod containers, induces steam to break up into hydrogen and oxygen, and hydrogen escaped. This resulted in explosions and the fear of a "meltdown", where the exposed fuel rods could continue to react. The engineers at the facility have engulfed the reactors with seawater to cool them down and have pumped compounds of the element *boron* with the seawater to slow down the chain reaction.

Boron is one of the substances that is used to capture neutrons and control nuclear chain reactions. It is one of the simplest of elements, next only after hydrogen, helium, lithium and beryllium, and has five protons in the nucleus with five electrons in orbits around the nucleus. Along with the five protons, the nucleus has either five or six neutrons, giving boron an atomic mass of either 10 or 11. The case of boron 10, which has only five neutrons, is useful for neutron capture because the fifth neutron is "unpaired" and ready to "accept" a neutron. But boron 11 has six neutrons which form a compete set and so is quite useless for neutron capture. The engineers at Fukushima have been pushing in boron 10, along with the seawater, hoping to block the rate of chain reaction and the generation of heat within the reactor core.

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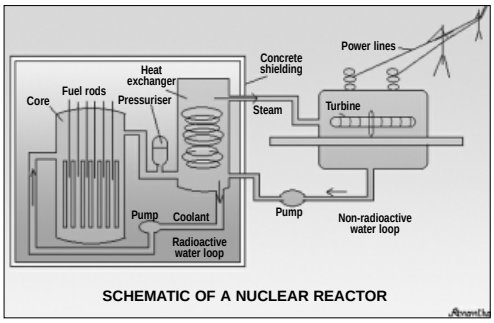
The Fukushima Daiichi nuclear plant, after a second explosion on Monday morning, which was followed later by a third. The International Atomic Energy Agency, however, said the radiation levels were "normal".

Chain reaction

The fuel in nuclear plants is usually an isotope of uranium, an element whose nucleus can decay or break up when it is struck by a neutron, causing it to break up into two parts and also involve two extra neutrons which do not find a place in the "daughter" nuclei. The break-up gives off sizeable energy which heats the fuel rods and their container, the heat from which can be tapped and made use of. But the important thing is that a uranium nucleus, which needs one neutron to get it to decay, produces two more neutrons when it does, which can then push other uranium nuclei into



SCHEMATIC OF A NUCLEAR REACTOR

Left unheeded…

The dengue virus persists for a period of five years at 70° Celsius in a dried state and remains viable for two months in a patient's serum at room temperature, writes tapan kumar maitra

THE viral nature of dengue fever was ascertained in 1907 by P Ashburn and C Craig. The virus measures from 30 to 40 nm. After adaptation to the body of mice by successive intracerebral passages, it grows readily in a chicken embryo. Two types of viruses have been disclosed. The virus contains thermostable and thermolabile antigens. The latter causes a group complement-fixation reaction with the viruses of yellow fever and Japanese and West Nile encephalitides.

The virus persists for a period of five years at 70° Celsius and in a dried state and remains viable for two months in a patient's serum at room temperature. It dies very quickly on exposure to light and is non-resistant to heating. Weak bile dilutions (1: 10, 1: 15) inactivate it in five minutes and ultraviolet rays and a 0.05 per cent formalin solution destroy it.

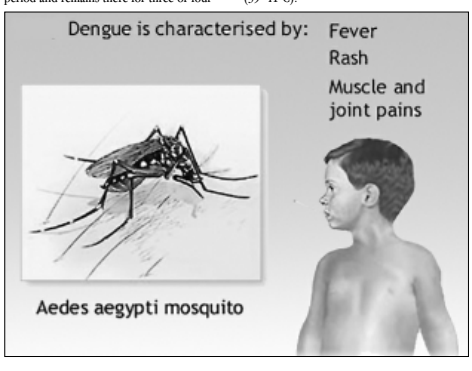
The virus is poorly pathogenic for laboratory animals. Adapted strains cause paralysis and death in albino mice and virusaemia in guinea pigs. Infection of Macaca rhesus monkeys results in a mild form of the disease.

The virus possesses toxic activity. It affects the neurons in the cerebrum and spinal cord and causes degenerative changes in the cells of the liver, kidneys and heart. It produces haemorrhagic lesions in the endocardium, pericardium, gastric and intestinal mucosa, peritoneum, central nervous system, muscles and skin. Deep disorders are revealed in the small blood vessels — swelling of the endothelium, perivascular oedema and infiltration by mononuclear cells.

The sources of infection are sick people. The virus appears in the patient's blood during the latter 24 hours of the incubation period and remains there for three or four days of the febrile period.

Infection occurs through the bite of *Aedes aegypti*, *Aedes allopictus and Aedes scutellaris* mosquitoes. At a temperature of 22° Celsius the mosquito becomes capable of transmitting the virus in eight to 12 days after a meal on the patient's blood. At 16° Celsius the causative agent does not develop within the mosquito's body. The mosquito remains infective for a period of 174 days.

The incubation period in dengue fever varies in duration from 2.5 to 15 days, lasting five to eight days on the average. Quite frequently, the disease has a sudden onset with chills, headache, severe pains in the joints, muscles and eyeballs and a high fever (39- 41°C).



The face becomes crimson and the sclerae injected. Erythema may be encountered in some patients. A remission occurs in one to four days. The temperature drops and the body becomes covered with profuse perspiration. This is followed by a second attack which is characterised by an elevation of temperature and the presence of the same symptoms as in the first attack. A maculo-popular — or scarlatina-like eruption — appears on the body, lasting not longer than three or four days. The duration of the disease is usually four or five days.

During epidemics, mild and severe forms of the disease are encountered along with the typical form. They are marked by coma, delirium, convulsions and mucopurulent diarrhoea. Mortality rate is low… the patient usually recovers.

The disease leaves an immunity which lasts two to six months.

Diagnosis rests on clinical, epidemiological and laboratory findings. The virus is isolated from the blood in the first days of the disease by intracerebral inoculation of mouse sucklings — not more than three days of age — and the complement-fixation reaction and neutralisation test are performed.

There is no specific therapy. Symptomatic remedies are used: large amounts of liquid are given to drink, a 10 per cent glucose solution is injected intravenously and amidopyrine, acetylsalicylic acid, preparations of iron, and vitamins C, B_1, and B_2 are given.

Dengue fever occurs as an endemic disease in regions with a tropical and subtropical climate.

Prophylaxis comprises isolation of patients, prevention of access of the vectors to them, extermination of mosquitoes and protection from their bites. Quarantine measures are enforced to prevent the spread of the infection to countries free from the disease. Measures of specific prophylaxis are still being elaborated.

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Beware the ghost of emails past

Why do so many of us use our office address for gossip, shopping and other darker deeds? We hit the send button at our peril, argues rhodri marsden

EMAILS are quick to rattle off and ridiculously easy to send. If this wasn't already manifestly obvious, try going on holiday for a fortnight, come back, check your emails and witness the avalanche of slurry that slides inexorably into your inbox. Actually, perhaps emails are far too easy to send; maybe they should require us to complete some onerous physical task before the server is prepared to deliver them.

The medium often stands accused of being inefficient, unhelpful, of presenting us with too much of the wrong kind of information and also erecting a kind of depersonalised barrier behind which we all feverishly type without thinking. It gives us *carte blanche* to present ourselves as, say, forceful, demanding individuals, when in reality we're simpering yes-men who are terrified of causing offence. Brutally aware of this, various companies will proudly announce a "No-Email Day", hoping to inspire employees to enjoy a more human way of communicating.

But we can't leave emails alone, not now. As soon as No-Email Day is over, we dive straight back in. It's too convenient to abandon, its most obvious advantage in the workplace being its talent for proving you said something (or didn't say something) whenever a dispute arises. It's there, all in black and white. You cover your back, and they can't deny it. And thanks to a raft of data-protection legislation, your company email account is a permanent, ever-expanding data-trove, providing an incredibly useful record of who said what and to whom. Millions of virtual conversations can be stored in an easily searchable database on a disk the size of the palm of your hand.

Would you like to save this email? Office workers don't get a choice when it comes to permanently deleting their emails. Every misdirected missive and inappropriate memo is kept on record by their employers.

But... there are so many buts. We sometimes have off days at work; in fact, your emails may reveal more off days than on days. If we were presented, This Is Your Lifestyle, with the contents of our "Sent Mail" box over the past few years, we'd inevitably wince at the way we dealt with certain issues. We'd regret dashing off a vaguely abusive two-liner to a client that irritated us.

If you have an office-based job and you're at work now, just as an experiment, have a look at your email folders. You might find confirmations of online shopping sprees you've done with various retailers. There'll undoubtedly be a sprinkling of personal communications covering non-work topics, both with your colleagues and with your friends in other buildings.

There might be Facebook notifications, extended bitching about the boss or links to semi-amusing YouTube videos. But if you find yourself experiencing twin rushes of guilt and shame and you're now stabbing furiously at the "delete" button, there's no real point. They're probably already stored, somewhere, because your employer is obliged to have them so. And while you might get away with a stern warning if all the above were discovered and you were hauled out of your chair for a disciplinary, it's a curious thing about our propensity to misuse work emails that we simply carry on doing it.

You have to understand – and you probably do, but just ponder it again for a moment – that if you send an email with even mildly eyebrow-raising content from your work machine, you have absolutely no control over its eventual distribution. If you're fortunate, it might sit on a server for eternity and never be seen again, but if luck's not swinging your way, it could be forwarded around the world in minutes, appended with a whole series of comments from disbelieving strangers.

Then again, there's this lengthy tract of prose typically sits underneath any email that's sent or received from a corporation, and says something along the lines of "The information within this email is confidential and intended solely for the addressee. If you are not the intended recipient, you must not read, use or disseminate the information contained in this email".

There's a glaring problem with this straight away: once I've read the text telling me that I might not be allowed to read the email, I will have already read the email. If I'm not the intended recipient, why was the email addressed to me? And what power, exactly, do you have to stop me forwarding this email if I don't even work for your company? The disclaimer typically goes on to say that "Any views expressed in this message are those of the individual sender"; that's all very well, but an eye-popping work email that ends up going viral will forever be associated with the company, regardless. Attempts at enforcing confidentiality start to lose some of their efficacy when an email is spinning its way around the planet suffixed with LOLs. And, in any case, these disclaimers have no legal authority; they've simply never been tested in court. Their only real purpose is to add about three pointless sheets of paper to a printout of any email.

Another, perhaps more ominous, addendum to our work emails is the casual mention that we might be being watched "for staff training purposes" or similar. Your IT department may well have access to your email account for maintenance reasons. Larger-scale monitoring of email content – which undoubtedly goes on – is much harder for companies to do in a way that's proportionate to the risks posed by unauthorised use and that doesn't breach data-protection legislation.

Then there's use of the web – always a thorny issue with employers, initially because of the mass of not-safe-for-work content, but latterly because of the rise of social networking, with Facebook or Twitter providing a permanent online social playground in a browser window. So these sites get blocked, but the choice of some of the websites that companies make inaccessible seems disproportionately draconian.

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