

## A PRIMER ON THE BATAAN NUCLEAR POWER PLANT

### 1. What is nuclear energy?

Energy is the capacity to do work. Nuclear energy is the energy confined in the nucleus of the atom. In 1905, Albert Einstein, the German-Swiss-American theoretical physicist, deduced from his theory of special relativity that any mass of matter can be transformed into energy by his famous equation  $E=MC^2$ , where  $E$  is energy,  $M$  is mass, and  $C^2$  is the square of the speed of light in empty space. In 1935, Hideki Yukawa, the Japanese physicist, theorized that nuclear energy is stored in the nucleus of the atom as its binding mass, and this is released as energy when the nucleus is split. The splitting apart of the nucleus of an atom when a neutron is absorbed by a nucleus is called nuclear fission.

### 2. When was nuclear fission discovered?

In 1938, three German scientists, Otto Hahn, Fritz Strassman and Lise Meitner, stumbled accidentally on nuclear fission while reproducing the experiments of Enrico Fermi, the Italian physicist, on transuranic elements, i. e. the production of substances beyond the size of uranium, e. g. plutonium. One type, or isotope, of uranium, the now famous uranium-235, split into two instead of becoming bigger by the bombardment of neutrons, releasing a tremendous amount of energy never before

known. Meitner was a Jew and hunted by Hitler; she had to flee Germany with nothing but her notes and her clothes on, and she went to Sweden where she met her nephew, Otto Frisch, the Austrian physicist who later became the head of nuclear physics in Cambridge University, and together they analyzed the fission experiment. (Read Brancaccio, P., The Nature of Physics, published by Macmillan Co., N. Y., 1975, p. 649). They sent the results to Einstein and Fermi who were then in America. The first nuclear reactor was produced by Fermi under the football stand of Chicago University.

### 3. What is a nuclear reactor?

A nuclear reactor is a device for controlled nuclear fission, i. e. either the splitting of uranium-235 or plutonium-239. If uranium-235 is used to produce nuclear energy, then the reactor is known as a uranium-235 fission reactor. Since only 0.7 percent of uranium in natural uranium is uranium-235, this may be augmented or enriched, i. e. more uranium-235 may be added as fuel of the reactor. Such a reactor may be used simply for research into the structure of matter and the production of radioactive isotopes for medicine, agriculture and industry, and is thereby known as research reactor. Heat is produced in such a reactor, but a coolant is utilized to remove the heat. In such a reactor also, a moderator is used to slow down the fast neutrons produced in fission in order that they can bombard other uranium-235 nuclei and cause fission by chain reaction i. e. a slowed-down (thermalized neutron is absorbed by a ura-

nium-235 nucleus and the uranium splits into two daughter nuclei with the production of one to three fast neutrons and radiation, and the fast neutrons are slowed down by the moderator to cause further fissions with, of course, some neutrons lost due to leakage or non-fission absorption by other nuclei. If the heat produced is transformed by a steam generator into steam to run a turbine that would in turn work an electric generator to produce electric power or to run a motor, the reactor is called a nuclear power reactor.

4. Is a nuclear reactor the same as a nuclear bomb?

No. A nuclear fission bomb is a device that uses the uncontrolled fission of uranium-235 or plutonium-239 such that an explosion is possible. A nuclear reactor is not a nuclear bomb and will not explode like one. It must be noted that there is also a nuclear fusion bomb, which is better known as a thermonuclear bomb, since it explodes only when great heat is introduced; basically it is due to the combining of hydrogen to form helium by merging or fusion as what happens in the sun. There is as yet no fusion reactor, for fusion has not as yet been controlled. A fusion bomb is much more destructive than a fission bomb, and it in fact requires the detonation of a fission bomb to explode it.

5. Does the Philippines have a nuclear research reactor?

In the early 1950's the US government gave the Philippines a small (1 megawatt or 1 million watts) nuclear uranium-235 fission reactor (fuel enriched by 20 percent) to be used research and the production of radioisotopes for medicine, agriculture, industry, and other peaceful uses. It has ordinary water as coolant and moderator. (See The Philippine Research Reactor, published by the Philippine Atomic Energy Commission). It was constructed in Diliman, near the University of the Philippines, amidst prior protests of the neighbours and Quezon City folk who were afraid of radiation leakage or who thought it might explode like a bomb, despite scientists telling them it wouldn't. Ever since 1962 when it was put into operation by Dr. Zoilo Bartolome, the only leak came from the cement dome when it rained for the dome was built by the lowest bidder, and the raindrops were a nuisance for they mingled with the reactor water. Now, few pay attention to the Diliman reactor, which is run by the Philippine Atomic Energy Commission, apart from the scientists who are doing work there, and even they are often forgotten. The PAEC is the Philippine nuclear regulatory commission and has the final say on the construction of nuclear reactors in the Philippines and their safety.

6. What is the story behind the proposed Bataan nuclear power plant?

In 1963, 1966, and 1972, the Philippines invited consultants from the International Atomic Energy Agency, or IAEA (Vienna), to help in studying the feasibility of constructing a nuclear power plant somewhere in Bataan to boost the electric power supply of Manila and neighbouring places. After studying possible candidates for the site, the IAEA consultants selected Bagac, Bataan and proposed that to offset any danger, if there were, due to the existence of some earthquake faults in Mariveles, China Sea, and Manila Bay, the reactor should be able to withstand a maximum earthquake magnitude of 7.2 on the Richter scale, or a horizontal earth acceleration of about 35 percent of the acceleration of gravity (equal to 35 percent of 32 feet per second each second).

The National Power Corporation, which is the government agency to install the nuclear plant, for further surety contracted the ECASCO Corporation of experts in seismology and volcanology, among other things, to examine the possible site and other possibilities. The ECASCO experts made an indepth study for two years, from 1972 to 1974, at the cost of US\$15 million resulting in more than fifteen volumes of detailed reports. They chose Napot Point instead, which is only a few kilometers from Bagac. The reason was that Bagac is near two rivers, and the occurrence of

floods will make the site unsafe and unsuitable. (See, for instance, Margulova, T., Nuclear Power Stations, published by NIR Publishers, Moscow, 1978). Moreover, Napot Point is about 18 meters above sea level and Bagac is only 3 meters above sea level, making the former a better choice against possible tidal waves (the huge ones that visited Mindanao were only 12 meters high), and the foundation was firmer than that of Bagac.

In 1976, the contract between the National Power Corporation and the Westinghouse Corporation was signed and approved by the President of the Philippines. Westinghouse was to export the reactor parts, facilitate the construction of the plant, and train the operators, subject to the issuance of the export licence by the US Nuclear Regulatory Commission. An application to the USNRC was formally submitted in the same year as the ones submitted by Taiwan and Korea. Westinghouse designed the plant to withstand an earthquake magnitude of 7.9 on the Richter scale or about 40 percent of the acceleration of gravity, just to make it safer in the estimation of the public. At 7.9 magnitude, most of the buildings in Manila would collapse but the nuclear reactor would still be standing. The reactor (core) would itself be isolated and confined within a huge containment vessel with walls made of steel 8 inches thick, which are surrounded by a 2 meter dense cement biological shielding, and all this to be encased by 2 inches of steel and highly reinforced concrete. It is so protected that not even a four-

engine jet plane crashing on the reactor vessel would dent it. And the dormant volcano some kilometers away hasn't erupted for the last fifty thousand years or so, like a woman who is fifty and hasn't given birth. The cost of the Bataan reactor is US\$1.1 billion payable from a loan from the Export-Import Bank, and the plant was scheduled to be finished by 1983.

In 1978, after the contract had been signed by Westinghouse and by NPC for the Philippine government, another group of IAEA personnel (except for the geologist who came with the earlier batch, and no one among them was a volcanology or seismic expert) visited the Philippines unexpectedly and noticed that the site chosen was not Bagac but Napot Point, a few kilometers away. This new IAEA team went over the voluminous reports made by IBASCO, glancing over them in a matter of a few days what took two years to make, and recommended that the Bataan nuclear reactor plant be designed to withstand a still high earthquake magnitude, and it submitted an adverse report in Vienna, a copy of which was apparently sent to the executive branch of the US government which noticed that the site was only about 15 miles from the US naval base at Subic. The existence of a dormant volcano near the site and some inactive faults farther away seemed to have unduly alarmed the IAEA group of 1978, despite the indepth studies of the IBASCO Corporation made up of volcanology and seismic experts.

The Philippine Atomic Energy Commission has approved the site, and as a sovereign state the Philippine choice of the location should be respected, unless it can be claimed that Filipinos do not know what they are doing.

7. But aren't there protests even among Filipinos regarding the construction of the Bataan nuclear power plant?

Yes, there are some protests. They really started after the Three Mile Island accident on 28 March 1979, at Pennsylvania USA. The TMI nuclear power reactor utilized uranium as fuel, and light water (as distinguished from heavy water) as moderator and was of the two-loop type, similar in some ways to the Bataan reactor although not manufactured by Westinghouse. It was a pressurized water reactor, PWR, utilizing a pressurizer to keep the heated water (about 600 degrees Fahrenheit) from boiling. In the first loop (primary) of circulating water, water is heated by the heat from the nuclear fuel (uranium fissioning) but kept from boiling by the pressurizer as it travels in the tube towards the steam generator. In the steam generator, the heat from the first loop tube is absorbed by surrounding water and transformed into steam which is then sent through a tube forming part of the second loop and into the turbine to run an electric generator, and the steam is then condensed as it later passes through a condenser, and changed back into water and returned to the steam generator for another round, etc.



A mechanical failure started the accident, i. e. a valve (regulating the flow of feedwater) in the second loop which feeds the water from the turbine and condenser back to the steam generator, which in turn removes the heat from the reactor core and first loop, malfunctioned and would not open for some time, and the backup water pumps had been shut off earlier because of repairs. Loss of steam supposed to run through the turbine shut it off automatically, and this in turn automatically triggered the shutoff of the reactor, but with an eight second delay which was still enough for the reactor to produce more heat without the heat being removed or utilized. The pressure and temperature rose rapidly, and emergency water was supposed to cool off the system, but the valve leading to the quench tank failed to close and the pressurizer itself became filled with water, another malfunction. The injection of more water would cause overpressure, so the operator manually shut off the pumps.

By this time, contaminated water overflowed onto the reactor floor and into the adjacent auxiliary building, and the evaporation of same irradiated water resulted, although the radioactivity was below dangerous proportions. The overheated fuel (bars) emitted hydrogen from zirconium oxide formation (since the uranium fuel cladding or covering was made of zirconium) and a hydrogen bubble was supposed to have formed inside the confinement building and vessel, but since not much oxygen was available there was really no danger of even a chemical explosion. After five days, a hydrogen recombiner was available to remove the supposed

hydrogen bubble. Nobody was hurt, but some panic among the civilians living in the neighborhood was created when it was announced that children and pregnant women should evacuate as a precautionary measure, to test the atmosphere. (Read the Staff Report on the Generic Assessment of Feedwater Transients in Pressurized Water Reactors Designed by the Babcock & Wilcox Company, prepared by the Office of Nuclear Reactor Regulation, US Nuclear Regulatory Commission, Washington D. C.

Because of the Three Mile Island accident there was some need to investigate the safety of the proposed Bataan nuclear power plant, even if only to assure the Filipinos that the reactor will be safe within reasonable risk when it is constructed, assuming that it is needed to supply at least one-fourth of the power needs for electricity in Metro-Manila, and surrounding towns, including those of Bataan, since hydroelectric power is no longer available for this purpose of producing bulk power, and no other substitute is in sight. President Ferdinand Marcos appointed Justice Ricardo Puno to be the chairman of a committee of three to conduct hearings on the safety of the Bataan nuclear power plant. Among those who submitted and defended position papers and recommendations are the following: The National Power Corporation, the Philippine Atomic Energy Commission, Westinghouse Corporation, EBASCO Corporation, the Samahang Pisika ng Pilipinas (physics Society of the Philippines), opposing groups led by former Senator Lorenzo Tañada and representatives from Bataan, and others. Views, for and against the

establishment of the nuclear power plant, were ventilated openly but in orderly fashion, for the purpose was to arrive at the truth.

8. Is the Bataan nuclear plant safe within reasonable risk?

So far it can be deduced from the testimonies given that nothing is defective with the design of the proposed Bataan nuclear power plant. The Westinghouse scientists gave expert testimony to justify the safety of the proposed nuclear reactor within the reasonable limits of safety as specified in the contract, and it is hard to refute their claim since Westinghouse has constructed several nuclear reactors not only in the United States but also in Korea and in Taiwan and other parts of the world. By expert is meant one experienced and knowledgeable in a given field of knowledge or art, and in the field of nuclear reactors the Westinghouse panel are experts. Of course we should not take the Westinghouse word alone, but scientists who interrogated them couldn't show cause to say that the Bataan reactor is defective even in design. Moreover, if one will consider the Three Mile Island accident as one out of one hundred PWR existing, then the probability of such an accident occurring is 1 out of 100 or one percent; in other words, it is ninety-nine percent safe. In fact many people die in airplane accidents, and yet people still ride in airplanes. Indeed, in this world one can never be assured of absolute safety, not even at home, for the roof may suddenly collapse and kill one in one's house.

The TMI accident was not even the worst accident in nuclear history, there was the actual meltdown of a reactor in Windscale, England, sometime in 1960. Nobody was hurt, and the British government paid the surrounding dairy farms their losses. (See Ridenour, L. and Nierenberg, W., Modern Physics for the Engineer, published by McGraw-Hill, London, 1961, page 319, and Nuclear Energy in Britain prepared by the Central Office of Information, London, 1975.) There may have been worst accidents in Russia, but the only news about them come from unofficial dissidents' reports. Korea has eight nuclear reactors, Taiwan has four, and Japan has more than two dozen. The industrialized countries, including North and South America, the European countries, Russia and the communist bloc, are all determined to have more nuclear reactors in view of the oil shortage. If the Philippines doesn't look out, it might be left behind because some people may not want to take a reasonable risk, they want absolute safety, as if this were possible in this world!

9. Suppose we have the nuclear power plant, where will we put the radioactive waste?

The proposed Bataan nuclear power reactor plant will hopefully be made up of two 620 megawatt power nuclear reactors, so that if one breaks down the other would still function to keep the electric supply up. Apart from the power source, which is nuclear fission, the other parts are conventional, well known to electrical engineers who don't have to be

nuclear physicists or nuclear engineers. In fact, work in a nuclear power plant to supply electricity will after a time be routine and, provided the operators are well-trained, and there is assurance they would be, the plant operation is not a spectacular affair. We must, of course, guard against complacency and negligence, such as those that took place in Three Mile Island, if that accident can at all be useful to teach our operators to be careful. We must as much as possible try to avoid human errors and dependence on human indecisions by improving warning devices and automatic safety devices that work automatically. Granting that all these are well taken care of, there is still the question of waste disposal, where do we put all the radioactive waste when even America doesn't know that to do with its waste? (Read Facts About the Philippine Nuclear Power Project, published by the Philippine Atomic Energy Commission).

From the point of view of storage, we can classify radioactive waste into low level and high level. Low level radioactive waste consists of contaminated clothes, gloves, pieces of instrument no longer useful, and the like, which may be sufficiently harmful if left out in the open; such low level waste would amount to about 330 tons per year, according to Westinghouse (Times Journal, 11 July 1979). High level waste consists of intensely radioactive elements of the spent fuel, about 16 tons of it per year, which however can be safely stored provided they are not removed from the containing fuel rods. There is enough storage space in the nuclear

plant to accommodate such waste for about ten years, which would give the NPC time to look for a burial site in which to safely deposit the excess waste. Another possibility is to have the high level waste in the spent fuel rods sent to the US for reprocessing, i. e. the process in which the spent fuel is dissolved and the fission products are separated from any remaining fuel, in which case the high level waste could be reduced to only about a cubic meter per year.

The problem of storage of radioactive waste, or even getting a burial site for it, would not be great for the waste product of one 1240 megawatt nuclear reactor plant (comprising really of two 620 reactors America has more than 70 and is building more, that is why the Americans find some difficulty in waste disposal of radioactive waste from their reactors. As the saying goes, if you have only one or two people using the toilet there is not much problem of waste disposal, but if you have more than 70, there would indeed be, particularly if people are allergic to radioactive waste or afraid of it. It is rather strange why the same people who would be happy should uranium mines be discovered in their country would be afraid to have radioactive waste buried deep under somewhere in an isolated place, when uranium mines are also radioactive with uranium emitting alpha-particles, while radioactive waste products are mostly beta emitters, less dangerous. But of course, one would get money from uranium mines and not from burying radioactive waste.

10. Will the people of Bataan not be exposed to contaminated air and water?

A person residing near the nuclear plant will probably receive a dose of 5 millirems over a period of one year added to the 120 millirems per year that he usually gets from the natural radiation of the earth's crust and surroundings and from cosmic radiation. (Read Pryde, L. Environmental Chemistry, published by Cunnings Publishing Co. Calif., 1973; p. 62, pp. 47-48). One millirem is one-thousandth of a rem (roentgen equivalent mammal) which is the standard unit of the RBE (relative biological effectiveness) of radiation. For x-rays, gamma rays, and beta radiation, the RBE is 1, whereas for alpha particles the RBE ranges from 10 to 20 units. But this relative biological effectiveness of radiation is due to the radiation absorbed by the body whose unit is the rad (radiation absorbed dose) defined as "a unit of absorbed energy equal to 100 ergs per gram." (See Berry, J., Osgood, J., and St. John, P., Chemical Villains, A Biology of Pollution, published by The C. I. Mosby Co., Saint Louis, 1974; p. 180). A simple equation to bear in mind is the following:  $\text{rems} = \text{RBE} \times \text{rads}$ .

In the early days of nuclear energy and radiation dosimetry, the standard unit was known as the roentgen or R specifically for x-rays and gamma

rays (since Roentgen discovered x-rays in 1895). The curie (in honour of Mme Curie and her husband Professor Pierre Curie who discovered the radioactive substance radium in 1898, which decays by emitting alpha particles and has a half-life of 1612 years, i. e., half of its activity will be gone every 1612 years until it all turns into isotopes of lead) is the standard measurement or unit of disintegrations per second, i. e. the number of emitted particles per second due to the decay of the nucleus of the radioactive atom. One curie is equal to (ave.)  $3.7 \times 10^{10}$  disintegrations per second of radium) or 37,000,000,000 disintegration per second, it is the number of nuclear disintegrations per second and not of x-rays or gamma-rays. The roentgen corresponds to an energy exposure of about 100 ergs per gramme, and is about the same value as the rad.

All these disintegration and radiation produce breakdown of cells and tissues by ionization or by bombardment of the molecules (combinations of atoms) in the body, and in this sense they damage the organism. But 0.034 millimeter of lead or 0.13 millimeter of water is sufficient to stop the alpha particles emitted by radioactive substances, and beta particles or rays (which are essentially electrons) emitted can be stopped by a few millimeters of lead. Gamma-rays of about 2 mev (million electron volt) energy will not penetrate beyond 1.3 centimeter of lead. (See Lapp, R., Andrews, H., Nuclear



Radiation Physics, published by Prentice-Hall, NY, 1955; p. 493). Escaping neutrons cause radiation damage too, but protection from them can be provided by dense shielding material such as lead, or iron and cement, the neutron decays in about 12 minutes. Enough precautionary measures and regulations to ensure safety are contained in such manuals as Basic Safety Standards for Radiation Protection (1967 Edition) published by the International Atomic Energy Agency, Vienna, as well as the TMI-2 Lessons Learned Task Force Status Report and Short Term Recommendations published by the Office of Nuclear Regulation of the U. S. Nuclear Regulatory Commission, Washington, D. C., July 1979.

There are two hypotheses regarding the effects of radiation on human beings. The linear hypothesis states that even low level radiation will eventually affect the human being by accumulated absorption increasing continuously over the years. The threshold hypothesis holds that low level dosage of radiation is not harmful below a certain critical or threshold level, but once the threshold is attained there the danger lies, e. g. a single dose of 800 rems would be fatal to everyone, of 400 rems to fifty percent of those exposed, and 200 rems are not fatal but will cause nausea and fatigue. (See Pryde, op. cit. p. 50). The alarmist usually points out to the linear hypothesis in order to produce the sweeping argument that all forms of radioactivity are harmful and that all kinds of nuclear reactors are dangerous

even if they produce low level radiation. If no is correct, then we shouldn't breathe anymore for we are bound to inhale some radioactive substances from natural surroundings or from cosmic rays to which we are exposed daily. Although there are many high intensity radioactive products of the fission process in nuclear reactors and in the explosion of nuclear bombs (utilizing uranium-235 or plutonium-239) in the testing of such explosives by members of the so-called "nuclear club nations", the one must not be confused with the other to give undue alarm to the public. The products of nuclear fission contained in the fuel rods are not released if there is no reprocessing, but the products of nuclear fission due to the exploding of nuclear bombs are released and are the real cause of danger. The spent fuel and radioactive waste of nuclear reactors can be stored or buried in burial sites.

Since a good amount of water is used by a pressurized water reactor, or PWR, either as coolant or moderator, and water from external source, such as the sea, is used for cooling the condenser, some apprehension of course may be raised. The water from the external source, such as the sea, is sucked in and discharged back into the sea and the effect is merely that the temperature around the discharged point may be raised a few degrees centigrade, about 5 degrees in fact. Studies have been made in which it can be shown that not only does this not have any adverse effect on fish and marine life around, but that in fact the warm water

attracts the fish and this is beneficial to fishermen around. The water that runs in the first loop (the reactor loop) and in the second loop (the turbine loop) are demineralized for possible decontamination. All this is done according to regulation. The running of a nuclear power plant is the most regulated operation in industry to avoid possible dangers, and while some leaks may occur, and are expected, constant monitoring and precaution against maximum radioactive pollution is a routine procedure in any nuclear plant. People must understand that due to oil shortage, the Philippines needs a major source of bulk power which today is the nuclear power reactor, even temporarily. Who knows, perhaps someday several years from now another source of bulk power, such as more efficient utilization of solar energy, or even fusion power, may be perfected as substitute to fission reactor power.

When almost all the nations in the world are resorting to nuclear power for their needs and industrial progress and to light their homes, shall the Philippines reject the use of nuclear power? What shall we tell the next generation if we remain behind and other nations advance industrially, shall we say we were afraid? Being in a democracy, let our people choose, but let them not be swayed or influenced by all sorts of fears without reasoning them out. People are often afraid of what they do not understand. Recent developments indicate that the questions regarding the proposed Bataan nuclear power plant are no longer on the

radioactive hazards, if any, that the power plant operation may pose or the radioactive waste products that the single power plant may produce. Westinghouse, PAEC, NRC and the Ministry of Health have given ample assurance on radioactive safety, and the NPC will comply with safety regulations or lose their jobs. Neither has the Three Mile Island reactor accident anything much to do with the Westinghouse-designed Bataan nuclear power reactor, for not only has Westinghouse not designed the TMI reactor but that the Westinghouse reactor to be constructed in Bataan is of a different and safer design. Moreover, contrary to popular misconceptions raised by panic news on the TMI accident which were completely exaggerated, no deadly leakage of radioactivity took place at TMI. The dam accident in India killed thousands of people and the TMI accident didn't, in spite of that no one is terribly afraid of dams as they are of nuclear reactors.

Instead, there is much fuss over the imagined dangers arising from supposed volcanic eruptions and supposed big earthquakes when none has occurred in Bataan. But the modern study of earthquakes, the science of seismology, is becoming more and more sophisticated, and one thing is coming to the fore--that earthquakes may soon be predicted and thus people may be protected ahead of time. The Philippines, like Japan, lies on the Pacific earthquake belt, and so also is Taiwan. But many nuclear reactors have been constructed in Japan, and Taiwan has four. Japan has experts on earthquakes, one came to the Philippines and gave splendid lectures.

to the Physics Society on the analysis and prediction of earthquakes, using highly advanced mathematics dealing with quantum mechanical analysis of waves, for earthquakes are scientifically revealed by P (for push) waves, S (for shake) waves, and L (for large) waves produced. Indeed, the advance of the science of earthquakes, seismology, is making earthquakes to be understood by scientists who are familiar with advanced mathematics and advanced technology, not those whose knowledge of earthquakes is based on the swinging of chandeliers and photographs of fallen buildings after the event. (Rued Kosyrev, N., On the Interaction between Tectonic Processes of the Earth and the Moon as included in Symposium No. 47 Proceedings on THE MOON, published by D. Reidel Publishing Co. Dordrecht-Holland, 1972. This is an advanced study of the earthquake relations and predictions between the earth and the Moon with experiments made possible by Apollo space landings on the moon.)

If there is no real danger to the reactor coming from possible earthquakes or volcanic eruption, what conditions should still be considered necessary for the Batran nuclear reactor to be within reasonable risk?

Although Westinghouse Corporation may be deemed to have the experts in reactor construction, and the design of the proposed Batran reactor has been found to be in accordance with the safety requirements known during the time of its initiation, several years have already passed and surely new insights into improved reactor construction should be taken into consideration, particularly in the light of the Three-Mile Island accident, for whatever lessons may be derived from it,

without exaggerating the extent of the accident as some alarmists are prone to do. It may be well to note that right at the start of the nuclear plant investigations, members of the Physics Society of the Philippines (Samahang Pisika ng Pilipinas, 5 July 1979) submitted ten conditions as necessary for the Bataan nuclear reactor to be within reasonable risk.

Those conditions were orally discussed and defended by Prof. Salvador Roxas-Gonzalez, professor of theoretical physics at the De La Salle University, the secretary-general of the Society, as the group's spokesman. Among those who signed to document were: Bayani Rivero, Ph. D. assoc. professor of nuclear physics and head of the physics dept. and Alberto Campos, Ph. D., assoc. professor of nuclear engineering, both of De La Salle University; Rufino Ibarra, Ph. D., professor of atomic physics, and Lorenzo Chan, Ph. D., assoc. professor of elementary particle physics, both of the University of the Philippines (Diliman); Amando Kapauan, Ph., D., professor of chemistry, and Jesus Rivas, M. A. T., assoc. professor of physics, both of the Ateneo de Manila University; Ester Garcia, Ph. D., assoc. professor and chairman of the chemistry dept. of the University of the Philippines (Diliman); and Manolito Natera, Ph. D., acting director of the nuclear research reactor at P.A.R.C. The following is the entire reproduction of the short straightforward document presented by the society in a manner more of a scientific journal report than in the often long and wordy legalistic form.

COMMENTS OF MEMBERS OF SAMAHANG PISIKA NG PILIPINAS  
(PHYSICS SOCIETY OF THE PHILIPPINES) REGARDING THE BATAAN  
REACTOR

We, the undersigned physicists and professors of physics and/or allied sciences, consider the following conditions as necessary for the Bataan nuclear reactor to be within reasonable risk:

- 1) Additional warning devices and automatic safety devices that will further minimize dependence on human operation and therefore lessen dangers from human failures, such as a gauge indicating the approximate extent to which a valve is closed or blocked, should be studied and installed.
- 2) A simulator should be made available to the staff of the Bataan reactor.
- 3) Westinghouse should maintain a staff in the country composed of competent personnel to help remedy any accident, and the Philippine government should set aside ₱100 million for such emergency (this is not exorbitant, when one considers the \$1.1 billic. cost of the reactors and the welfare of the people.)
- 4) The local sites for storing the radioactive wastes should be indicated even before the reactor is put into operation by the National Power Corporation.
- 5) Constant monitoring of radioactive and heat effects on the environment should be made daily for the protection of the environment and the public.
- 6) There should be additional personnel for replacement in critical posts, and all newly hired operators should be subject to as rigorous a training program as that of the initial batch of operators.
- 7) Personnel training in physics and reactor operation should be started in the Philippines. There should be created an Institute of Advanced Study for Physical Sciences and Mathematics to continue research in advanced

physics, particularly in nuclear physics and its applications, in the Philippines.

- 8) Up-to-date and advanced nuclear information from abroad should be made available to the technical staff and personnel of the reactor, and frequent up-dating seminars offered without, however, disrupting the work of running the reactor.
- 9) Public information on the nature, uses and precautions on radioactivity should be disseminated by the Ministry of Public Information, with the technical cooperation of the Philippine Atomic Energy Commission and the Ministry of Health, through mass media.
- 10) Greater security should be enforced at the reactor site, and proper and clear warning devices to warn the public in case of danger in the areas surrounding the reactor should be installed, similar to the air-raid signals to warn inhabitants in case of bombing.

We believe all this answers the questions of the Commission.

Lorenzo Chan, Ph. D	Salvador Raxas Gonzalez M. A., M. Sc.
Danny Yanga, M. Sc.	Manolito Natera, PH. D.
Alberto Campos, Ph. D.	Bayani Rivero Ph., D
Jesus Rivas, M. A. T.	Luzviminda Rivero, Ph. D.
Marlene Ignacio, B. Sc.	Rufino Ibarra, Ph. D.
Ester Garcia, Ph. D.	Amando Kapauan, Ph. D.
Claro Llaguno, Ph, D.	Victoria Vicente, Ph. D.

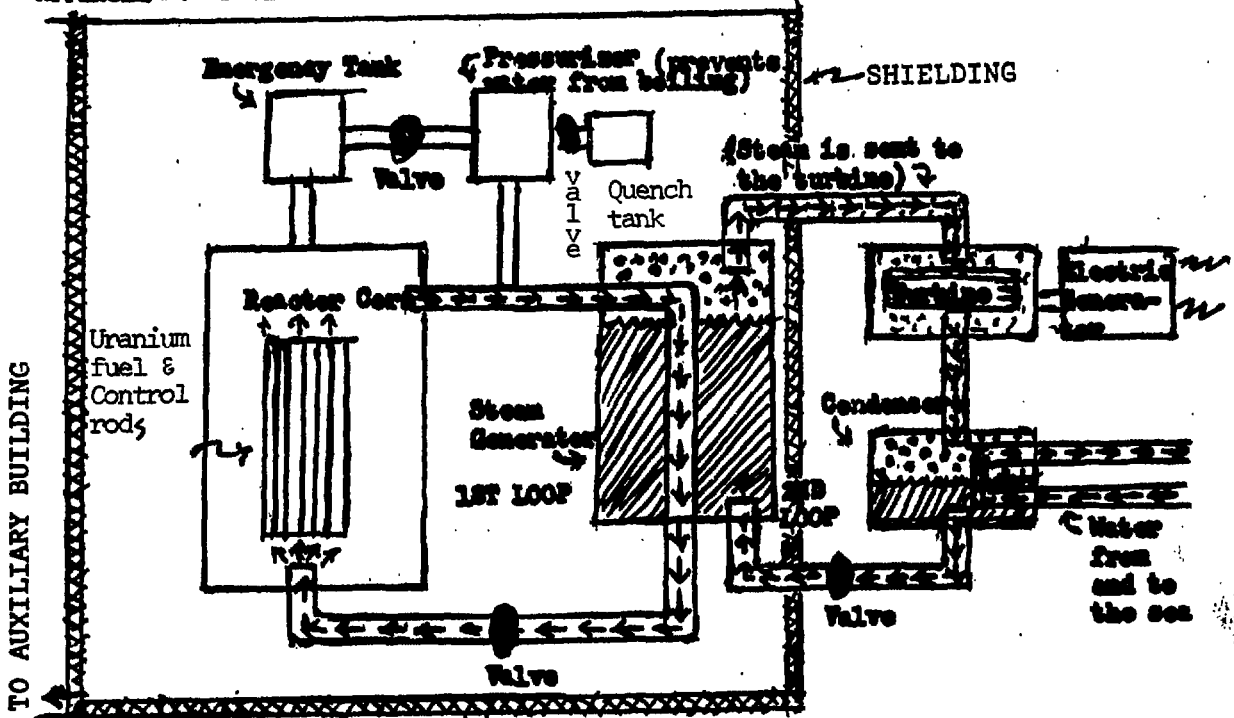
(Signatures of the above names appear in the original document.)



12. Hasn't the President of the Philippines permanently discontinued the construction of the Bataan nuclear plant as recommended by the Philippine Presidential Commission for the investigation into the safety of the plant headed by Hon. Ricardo Puno, Minister of Justice?

No. In fact what the President of the Philippines stated is that additional safety improvement should be incorporated so that the plant would be made safer still, and among them were precisely some (if not all) of the above-mentioned recommendations which the Philippine Physics Society had recommended to the Commission as early as 5 July 1979, right at the start of the investigation. Westinghouse Corporation, in statements published in the local press on 16 November 1979, one day after the order of the President to discontinue the construction of the plant until such conditions he deemed proper for the safety of the Filipino people were complied with, in effect agreed to make the plant "safer" to conform even with the United States Nuclear Regulatory Board's possible new requirements for safety. It may be good to include also placing the Philippine Atomic Energy Commission, which is the Philippine counterpart of a nuclear regulatory commission, under the Office of the President of the Philippines, as suggested in the (United States) President's Commission report on the Accident of the Three Mile Island on 30 October 1979, copies of which were provided to all U. S. embassies. This suggestion was also the suggestion of the Physics Society of the Philippines (Samahang Pisika ng Pilipinas) in the hearings held to make the Philippine Atomic Energy Commission an independent body subject only to the President of the Philippines. In fact, many of the suggestions in that report had been anticipated by the Physics Society of the Philippines' recommendation to the Philippine government. (SEE REPORT OF THE U. S. PRESIDENT'S COMMISSION ON THE ACCIDENT AT THREE MILE ISLAND, 30 OCTOBER 1979.)

APPENDIX A: BASIC ELEMENTS OF PRESSURIZED WATER POWER REACTOR:



APPENDIX B: CHAIN REACTION (SPLITTING OF URANIUM-235 BY NEUTRONS)

