The Canadian Coalition for Nuclear Responsibility (CCNR)

comments on

The CNSC Staff Action Plan (INFO-0828)

http://tinyurl.com/ccqof7q

on recommendations made by

The CNSC Fukushima Task Force Report (INFO-0824)

http://tinyurl.com/7u2za8f

CCNR Comments Submitted to

The Canadian Nuclear Safety Commission (CNSC)

on April 5, 2012

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on CNSC Fukushima Task Force Recommendations (INFO-0824)

presented by Gordon Edwards, Ph.D., President,
Canadian Coalition for Nuclear Responsibility (CCNR)

submitted to the Canadian Nuclear Safety Commission (CNSC) on April 5, 2012

Introduction: Stating the Obvious

The Canadian Coalition for Nuclear Responsibility (CCNR) respectfully submits the following comments on the CNSC Action Plan on the Task Force Recommendations.

In general, we find that the CNSC Staff have not shown sufficient imagination in grasping the true dimensions of an unforeseen nuclear catastrophe such as the horrifying sequence of events that took place at Fukushima Dai-ichi reactors number 1, 2, 3, and 4.

The Task Force Report is hampered by a failure to honestly state and elucidate the fact that catastrophic accidents in CANDU reactors are in fact possible and may in fact occur, no matter what precautions are taken ahead of time. The nature of a catastrophic nuclear accident is that it is a totally unforeseen event and hence nothing can be ruled out ahead of time as a possibility. To deny this is to be blind to the lessons of Fukushima.

In order to profit from the lessons of Fukushima, one must begin with a frank admission that nuclear power is inherently dangerous -- as a number of responsible bodies have done in the past. We provide four examples in the appendix.

In the appendix we have included excerpts

> from the 1978 Report of the Ontario Royal Commission on Electric Power Planning, entitled “A Race Against Time”;
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> from the 1980 Report of the Select Committee on Ontario Hydro Affairs, entitled “The Safety of Ontario’s Nuclear Reactors”;
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> from the 1982 Report by the Department of Energy, Mines and Resources, entitled “Nuclear Policy Review Background Papers”; and
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> from a 1989 submission to the Treasury Board of Canada by the Atomic Energy Control Board, the predecessor of the Canadian Nuclear Safety Commission.

These documents all frankly admit that CANDU reactors can suffer catastrophic failures.

Now is the time for the CNSC to publicly admit that this is the case. The law that established the CNSC does not give it a mandate to provide bland assurances of safety based on factually incorrect statements. Rather, the CNSC is obliged by law "to disseminate objective scientific, technical and regulatory information to the public concerning . . . the effects, on the environment and on the health and safety of persons" of licensed nuclear facilities. [Nuclear Safety and Control Act, Article 9(b)].

Yet we read in the Task Force Report that "The main objective in submitting the *Task Force Report* to the public for comment was to assure Canadians that nuclear power plants in Canada are safe and able to withstand the conditions that led to the Fukushima nuclear accident . . . " Here the CNSC seems to be admitting that its main motive is not to arrive at the truth, not to protect the public and the environment, not to disseminate objective information, but to give assurances that nuclear power plants are safe. In our view, this means that the whole exercise is being conducted in bad faith.

Indeed, the sentence quoted above is blatantly incorrect and profoundly misleading. As Dr. Rzentzkowski has publicly admitted (during the recent Point Lepreau licensing hearings held in Saint John) CANDU reactors cannot necessarily "withstand the conditions that led to the Fukushima nuclear accident". On the record, he stated:

> . . . even if we will experience an extremely high magnitude earthquake here in Point Lepreau, approaching the level of that in Fukushima, the reactor will shut down safely; however, there will be some consequences. Definitely, the core will melt. Now the question is, if the molten fuel will be contained in the calandria. Probably not. It may be, but it cannot be guaranteed. So the worst-case consequence would be some level of unfiltered releases [of radioactivity] to the environment after maybe four to five days from the accident. That's the worst-case scenario. . . . which also includes large releases [of radioactivity], because we cannot preclude this if we have a seismic activity of that magnitude.

The Task Force Report has concentrated attention too narrowly on the machinery: equipment maintenance and the potential for equipment failures. While these are undoubtedly important aspects of accident prevention, they do not address the onsite and offsite consequences of an unanticipated catastrophe resulting in core melting, partial or complete containment failure, and massive releases of radioactive materials into the environment. In the absence of such considerations, we are simply not dealing with the lessons of Fukushima, but are engaged in an exercise of denial, refusing to admit that there are lessons to be learned from the Fukushima catastrophe.

There is in the Task Force Report no realistic assessment of the sheer magnitude of the problems that will have to be dealt with under catastrophic circumstances. In this document we delineate some of the many aspects that we feel have been overlooked.

(1) CONTAINING RADIOACTIVELY CONTAMINATED WATER

During the Fukushima Dai-ichi accident, enormous volumes of contaminated water were dumped into the ocean adjacent to the plant. Yet the Task Force Report does not even address the question of what might happen with similar huge volumes of contaminated water in the event of an analogous catastrophic accident at a CANDU reactor.

During the Point Lepreau licensing hearings in Saint John it was stated by the licensee that any contaminated water used to reflood the core of a badly damaged CANDU reactor could be recycled – pumped back through the core of the reactor over and over again, without releasing that water to the outside environment. But is this actually possible? Has CNSC carefully studied this scenario? What about the temperature build-up? What about the debris? What kind of on-site water purification capability is there?

At Fukushima Dai-ichi, recycling water through the core was not possible for a very long time. The debris-clogged water could not be pumped back through the core of the reactor until a special filtration and decontamination system was installed, and that was not accomplished for many months following the accident. In the meantime, there was nowhere to store the filthy contaminated water so it had to be dumped into the nearby receiving waters, which were ocean waters, while the core continued to be flooded with ocean water or fresh water taken from an uncontaminated and unclogged source.

In Canada, an analogous situation could result in huge volumes of heavily contaminated water being dumped into Lake Huron, or Lake Ontario, or the St. Lawrence River, or the Bay of Fundy. This would be an environmental catastrophe of the first order. The drinking water for millions of people could be seriously affected, not to mention the contamination of aquatic biota.

Why has the Task Force not even addressed this question? Are there any plans at all to temporarily store huge volumes of debris-filled radioactively contaminated water to prevent it from going into our precious waterways in the event of a catastrophic CANDU accident? If not, why not?

(2) PREVENTING AIRBORNE RELEASES FROM SPENT FUEL POOLS

During the Point Lepreau licensing hearings in Saint John it was admitted by the licensee that uncovering and overheating of the irradiated fuel in a CANDU spent fuel pool could trigger a strongly exothermic chemical reaction between the zirconium cladding and the steam. This would produce both heat – driving the temperature upwards rapidly – and hydrogen gas – setting the stage for a possible chemical explosion – as well as liberating substantial amounts of fission products in the form of gasses and vapours. These fission gasses and vapours would enter the outside atmosphere relatively easily due to the lack of any carefully designed containment envelope or any sophisticated atmospheric filtration system for the spent fuel pool.

Why has the Task Force not seen fit to require a negative pressure containment envelope for all CANDU spent fuel pools?

Has CNSC staff even studied the potential for unfiltered atmospheric releases from a catastrophic overheating incident in the spent fuel pool? Can CNSC staff provide any assurance that the potential unfiltered atmospheric radioactive releases from a fuel pool overheating will not far exceed the potential unfiltered atmospheric radioactive releases from overheating of the core of the reactor?

(3) ADDRESSING THE ISSUE OF ZIRCONIUM FIRES

During the Point Lepreau licensing hearings in Saint John the licensee denied the possibility that an actual zirconium fire might take place involving the zirconium cladding of the uncovered and overheated irradiated fuel in a damaged spent fuel pool.

While zirconium is known to be highly pyrophoric and even explosive in a finely divided state – which is why zirconium is used as the combustible material in the old-fashioned "flash cubes" that were popular for cameras in years gone by – it appears that CNSC staff and CNSC licensees are oblivious to the very real possibility of an extremely energetic fire starting in an overheated spent fuel bay – with or without steam – at temperatures close to 1000 degrees C.

This possibility has been studied by the U.S. National Academy of Sciences in their report entitled *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report.* In Finding 3B, the authors point out that encountering a "partially or completely drained spent fuel pool could lead to a propagating zirconium cladding fire and the release of large quantities of radioactive materials to the environment. Details are provided in the committee's classified report."

The National Academy's Report, cited above, includes the following recommendations:

> RECOMMENDATION: The Nuclear Regulatory Commission should undertake additional best-estimate analyses to more fully understand the vulnerabilities and consequences of loss-of-pool-coolant events that could lead to a zirconium cladding fire . . . .
>
> RECOMMENDATION: . . . the Nuclear Regulatory Commission should ensure that power plant operators take prompt and effective measures to reduce the consequences of loss-of-pool-coolant events in spent fuel pools that could result in propagating zirconium cladding fires.

It is amazing that the Task Force makes no mention of this important phenomenon. It is alarming that neither the CNSC Staff nor the licensees seem to even regard zirconium fires as a genuine possibility. Surely this hazard requires very close and serious attention. It should be noted that the heat generated by a self-propagating zirconium fire can be roughly equivalent to the heat load from freshly discharged LWR fuel assemblies, which in turn is considerably greater than the heat load from freshly discharged CANDU fuel bundles. Thus an uncontrolled zirconium fire can drive the temperature of irradiated fuel up very quickly, and may even trigger episodes of fuel melting.

It should also be noted that zirconium fires can also take place in an overheated CANDU core. This possibility should be an important part of the analysis of any severe core damage scenario in CANDU reactors. In this connection it is important to note that there is far more zirconium in the core of a CANDU than in any comparable LWR core.

(4) **MISUSING PROBABILITY CALCULATIONS**

One clear lesson from the Fukushima disaster is that anything that can go wrong in principle may well go wrong in practice, no matter how small the probability may seem to be before the event. It is therefore irresponsible to use a small calculated probability as a substitute for thinking about and planning for the consequences of a highly improbable catastrophic accident. Yet this important lesson is nowhere discussed in the CNSC document under consideration.

At the December 2011 CNSC Hearings into the relicensing of the Point Lepreau reactor, Dr. Binder stated: "we're going in circles about probabilities here and rolling of the dice and gambling, and all this stuff. But I think Dr. Edwards had it right; we don't care how you get there. The question in front of us, in terms of safety is . . . what would be the consequences?" [Transcript, Dec 2, p. 212]

(a) Even under the best of circumstances, probability has no predictive power when it comes to individual events. Properly carried out, probability can predict the relative frequency with which some anticipated event may occur, but it gives no information whatsoever as to ***when*** such an event may occur. Every number on a roulette wheel carries the same small probability – or improbability – yet one of those numbers will certainly "come up" on the next spin of the wheel, no matter how improbable it may seem in advance.

(b) Probability calculations are based on an analysis of possible outcomes. These outcomes are, in effect, the anticipated events. But probability has nothing whatsoever to say about unanticipated events. If an outcome if not considered to be even possible, then its calculated probability will necessarily be "zero". From this point of view, it can be argued that all major nuclear accidents that have occurred so far had "zero probability" prior to their occurrence – simply because the particular chain of events that transpired was not even included in the list of possible outcomes imagined by the people who calculated the probabilities.

Did any analyst conceive of the possibility that all three backup feedwater pumps at the Three Mile Island plant would be unavailable at the same time, due to a simple failure on someone's part to re-open a valve after a maintenance shutdown? Did anyone conceive that a triangular piece of metal that was not even included in the blueprints of the Fermi I nuclear reactor would come loose and block the flow of coolant during operation, causing a partial meltdown? Did anyone conceive ahead of time that so many safety systems at the Chernobyl reactor might be simultaneously and intentionally disabled? Did anyone think that all the power supplies to the Fukushima Dai-ichi power station could be simultaneously disabled for several days in a row?

Before these accidents occurred they had probability zero, being totally unanticipated. In retrospect, they can be seen to have had quite a high probability, had we only known how to visualize the circumstances that led to those accidents beforehand.

This is not to say that probability calculations are of no use. They are very useful in comparing different designs, and in imagining different scenarios. They should be an integral part of reactor design and accident analysis. But they must not be used as an excuse for neglecting to address in a realistic way and plan for the consequences of a truly catastrophic nuclear accident.

This could be one of the most important lessons from the Fukushima disaster, but it is nowhere addressed in the CNSC discussion document.

(5) **PLANNING FOR THE OFF-SITE CONSEQUENCES OF A NUCLEAR DISASTER**

One lesson that seems clear from the Fukushima disaster is that evacuation cannot be the total extent of off-site planning – nor can proper evacuation procedures be laid down ahead of time. Due to weather patterns prevailing at the time, large numbers of people in the Fukushima evacuation zone were moved almost directly into the path of the radioactive plume from the stricken reactors. This regrettable mistake was due to a failure on someone's part to communicate relevant information to the authorities.

Various sub-populations may require special consideration, such as pregnant women, nursing mothers, and small children. In addition, specific advice about dietary choices and careful monitoring of susceptible foodstuffs is essential. For example, since radioactive iodines are known to concentrate in cow's milk, susceptible individuals can be advised to switch to powdered milk prepared before the accident occurred – at least for a period of weeks. With this knowledge, parents can limit the potential exposure to the thyroid glands of embryos, babies and small children from milk consumption. Iodine pills would still be useful to limit exposure from inhaled or ingested radioactive iodine.

Each region may have foods that are especially susceptible to radioactive contamination of one kind or another. In Japan, substantial quantities of beef contaminated with radioactive cesium were bought and consumed by families before the problem was identified by authorities and the practice was halted. The cattle had been eating contaminated fodder. Many broad-leafed plants such as tea and spinach were radioactively contaminated by deposition on the leaves, and seaweed was found to be very efficient at concentrating radioactive cesium (as had been the case in the coastal regions of England following the Windscale reactor accident of 1957).

Following a nuclear disaster, there is undoubtedly a need for nuclear engineers, physicists and technical specialists to work on the physical plant and the machinery, struggling to get the reactors under control, maintaining cooling to the core, limiting releases to the environment, managing the workforce, and so on. But there is also a need for another team of experts – biomedical specialists, environmental scientists, specialists in meteorology, agriculture and food, to work with the population affected by the disaster, providing clear information and advice that will help to prevent some of the negative impacts and minimize radioactive exposures from the event.

As part of emergency preparedness, nuclear power plant operators should be required to go through the exercise of assembling such a team and providing them with resources to prepare themselves in a very detailed fashion to respond to such a nuclear disaster if and when it should ever occur. Methods need to be developed for communicating useful information to the population in a timely and helpful way – for example, how to avoid inadvertently tracking contamination indoors, or how to teach children to avoid touching their shoelaces with bare hands in case they have been contaminated with radioactively contaminated soil. The documentation resulting from this exercise and the process of assembling such a team will provide a valuable resource in case of an actual disaster at a nuclear power plant, when such teams will have to be ready to spring into action on relatively short notice.

If the CNSC feels that this activity goes too far beyond the agency's mandate or capabilities, then a report should be made by the CNSC to the parliament of Canada laying out the need for such a capability to be developed in this country as an essential part of responsible emergency planning.

(6) **MITIGATING THE POSITIVE VOID COEFFICIENT**

One safety consideration that must never be underestimated in the case of CANDU reactors is the positive void coefficient (PVC) of reactivity. Yet nowhere is this vexing characteristic of CANDU reactors discussed in the proposed CNSC Action Plan. It is astonishing and profoundly disappointing that one of the principal features of CANDU reactors that could possibly contribute to a catastrophic nuclear accident is simply ignored by the authors of the report.

In any reactor having a PVC, a Loss-of-Coolant Accident (LOCA) will cause an increase of reactivity in the core. In other words, a PVC implies that when you lose the coolant you get a power surge. This is because, when the coolant is lost (or when voids – pockets of air or steam – are created in the coolant), the number of thermal neutrons in the core of the reactor actually increases. With more thermal neutrons, more uranium atoms are split, more energy is released, and the power level goes up.

Now, as everyone in the nuclear business knows, an unterminated nuclear excursion (a Loss of Regulation Accident leading to a power surge that is not immediately arrested) will cause "core disassembly" [severe core damage]. The accumulation of broken irradiated fuel elements in the core makes effective cooling difficult or impossible. In the case of a CANDU, the rupture of pressure tubes containing the nuclear fuel can cause expulsion of the moderator water due to a sudden pressurization of the calandria, setting the stage for a full-scale core meltdown. ["Calandria" is the word used by the CANDU industry to describe the cylindrical vessel that contains the fuel and moderator.]

The positive void coefficient is an undesirable characteristic of most pressure-tube reactor designs, because it means that one kind of accident – a loss of coolant – can trigger another kind of accident – an unterminated power excursion.

This combination – LOCA plus Power Excursion –is what caused the world's first major nuclear accident at Chalk River in 1952. The NRX reactor underwent a series of powerful explosions that threw the four-tonne gasholder dome four feet through the air where it lodged in the superstructure. The highly radioactive NRX core, with its vertical pressure tube design, was totally destroyed and the reactor vessel had to be replaced. The cleanup operation involved about 600 men from the U.S. nuclear navy, including young Jimmy Carter, who would later serve as U.S. President during the Three Mile Island partial meltdown in 1979.

The positive void coefficient also played an important role in the destruction of the Lucens research reactor in Switzerland in 1969. It was a gas-cooled, heavy-water moderated pressure tube design. It was completely destroyed by a loss-of-coolant accident that triggered a power excursion due to the positive void coefficient.

The most famous nuclear accident that turned catastrophic because of the positive void coefficient was the Chernobyl disaster in 1986. It involved a graphite-moderated pressure-tube reactor using natural uranium fuel. A LOCA triggered a power surge. The soaring temperatures ignited the graphite moderator, and enormous radioactive releases ensued – a total of 3 to 5 percent of the radioactive inventory in the core became airborne and the resulting contamination was measured around the world.

In the context of CANDU safety analysis, the seriousness of this phenomenon (PVC) has been underestimated time and again by Canadian designers and regulators.

It took years for the Canadian nuclear establishment to realize that the "moderator dump" mechanism in the original Pickering reactors was too slow a shut-down system to prevent severe damage to the core in the case of a LOCA. This realization led to the requirement for two fully independent fast shutdown systems in all subsequent CANDU designs: (1) the shut-off rods – spring-loaded and driven into the core with great force – and (2) the "poison injection" system – liquid gadolinium nitrate rapidly injected through nozzles into the moderator. Both shut-down systems are designed to rapidly absorb neutrons and choke off the chain reaction completely in less than two seconds.

It took years more for Canadian nuclear analysts to discover that the original low-pressure gravity-fed Emergency Core Cooling System (ECCS) was inadequate to cope with the overheating of the core in all cases following a LOCA. All CANDU reactors had to be refitted with a high-pressure emergency-coolant injection system, to complement the low-pressure "steady-state" ECCS. The realization didn't emerge until the late 1970s. It was for this reason that Douglas Point was derated to 70 percent of full power in 1977 – without anyone informing the Ontario Royal Commission on Electric Power Planning, where public hearings into nuclear safety were taking place at that very moment.

Following the Chernobyl disaster, there was increased pressure from the international nuclear marketplace to avoid reactors having a positive void coefficient. In particular, neither the USA nor the UK would license reactors that had this characteristic. This spurred CANDU designers to attempt to overcome the PVC curse by designing a new reactor – the Advanced CANDU Reactor or ACR – that would reduce or eliminate the positive void coefficient.

It was only recently – in the last decade – that Canadian safety analysts discovered the inadequacy of previous calculations that had predicted CANDU safety systems could handle the power surge and overheating following any Large-Break Loss of Coolant Accident (LBLOCA). The large margins of safety that had previously been thought to exist seemed to suddenly evaporate; those margins of safety turned out to be unsupportable, using the analytical methods of the day.

There are two approaches to this problem.

One is to try to eliminate, as far as possible, the PVC characteristic. According to the industry, this can be accomplished by using Low-Void-Reactivity Fuel (LVRF). Instead of a homogenous fuel bundle using natural uranium throughout, LVRF would have an inhomogeous fuel bundle with slightly enriched uranium in some of the pins and "burnable poisons" in the other pins. The combination of extra reactivity (providing extra neutrons) coupled with neutron-absorbing materials ("poisons") in the same fuel bundle can apparently overcome the positive void coefficient. Such an advanced fuel choice would contribute to the "passive safety" of the CANDU reactor by eliminating the possibility of a power excursion following on the heels of a loss of coolant.

The other approach is to keep the fuel exactly as it is now, but use better mathematical calculations to show that the CANDU reactor really can control the power surge that might result from a loss-of-coolant. Strictly speaking, this does not contribute to the passive safety of the reactor, because the safety of the plant will require the intervention of active fast shutdown systems in order to prevent core disassembly.

Although CNSC staff, including the CNSC President, have described these two shutdown systems as "passive safety systems" since they are activated automatically without human intervention, I do not believe that this is technically correct.

> "Passive nuclear safety is a safety feature of a nuclear reactor that does not require operator actions or electronic feedback in order to shut down

> safely in the event of a particular type of emergency (usually overheating resulting from a loss of coolant or loss of coolant flow). Such reactors tend to rely more on the engineering of components such that their predicted behaviour according to known laws of physics would slow, rather than accelerate, the nuclear reaction in such circumstances. This is in contrast to some older reactor designs, where the natural tendency for the reaction was to accelerate rapidly . . . such that either electronic feedback or operator triggered intervention was necessary to prevent damage."
>
> *http://en.wikipedia.org/wiki/Passive_nuclear_safety*

The fact that each of the two fast shutdown systems in a CANDU reactor are sometimes found to be "unavailable" indicates that they cannot always be counted upon to provide a fast shutdown of the reactor. Such being the case, they are not truly "passive" safety systems. On the other hand, if LVRF is used, then by the laws of Physics, it is not possible to have a power surge following a LOCA. This is truly a "passive" safety feature, in contrast to the fast shutdown systems.

It is essential that CNSC address the question of the positive void coefficient in relation to the potential for catastrophic accidents in existing CANDU reactors. In light of the chequered history of reactors with positive void coefficients, in light of the history of miscalculations on the part of CANDU analysts relative to the PVC, in light of the level of public concern over the subject of nuclear safety following the Chernobyl and Fukushima disasters, and in light of the potentially ruinous consequences of a single catastrophic reactor accident in Canada, CCNR strongly recommends that CNSC not allow the continued operation of existing CANDU reactors unless the operators are required to use Low-Void-Reactivity Fuel in order to minimize or eliminate the PVC.

(7) **ADMITTING CANDU NUCLEAR REACTORS ARE INHERENTLY DANGEROUS**

If the Fukushima disaster has taught us anything, it is that technology is not the supreme arbiter of safety. Japanese people both inside and outside of the nuclear industry have been shaken to their core by this horrifying event. People feel betrayed by their scientists and political leaders who always told them that nuclear power is safe, safe, safe. They feel that they have been lied to – and indeed, in the wake of the disaster, the authorities have been proven wrong over and over again.

The President's Commission on the Accident at Three-Mile Island arrived at the following conclusions:

> To prevent nuclear accidents as serious as Three Mile Island, fundamental changes will be necessary in the organization, procedures, and practices -- and above all -- in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical, of the nuclear industry. . . .
>
> *http://www.pddoc.com/tmi2/kemeny/overall_conclusion.htm*

> After many years of operation of nuclear power plants, with no evidence that any member of the general public has been hurt, the belief that nuclear power plants are sufficiently safe grew into a conviction. One must recognize this to understand why many key steps that could have prevented the accident at Three Mile Island were not taken. The Commission is convinced that this attitude must be changed to one that says nuclear power is by its very nature potentially dangerous, and, therefore, one must continually question whether the safeguards already in place are sufficient to prevent major accidents.
>
> *http://www.pddoc.com/tmi2/kemeny/attitudes_and_practices.htm*

CCNR has been an observer of the nuclear scene in Canada for almost four decades. It seems crystal clear to us that the CNSC staff and the technical people involved in the nuclear enterprise in Canada are absolutely convinced of the safety of nuclear power. In our view, and in the view of the Kemeney Commission, this is a dangerous attitude.

In light of the Fukushima disaster, it is time to put aside these comforting illusions that CANDU technology is somehow exempt from the problems that bedevil all existing nuclear power reactors, including the potential for catastrophic accidents. When the Ontario Hydro Board of Direcrtors shut down seven nuclear reactors in 1997, it was because they had been informed by an outside panel of experts (from WANO) that Ontario's reactor fleet was very close to being unacceptable from a safety point of view. It was not the regulatory agency, AECB, that shut these reactors down, but Ontario Hydro itself. This does not paint a reassuring picture of the efficacy of nuclear regulation in Canada.

CCNR suggests that CNSC deliberately undertake an exercise in skepticism. In order to really test the limits of CANDU safety – at least on an intellectual level – choose a team of clever and knowledgeable people and give them the assignment of figuring out how to make a CANDU reactor malfunction in the worst possible way. Tell them not to focus on how safe the plant is, but just how dangerous it can become with a little effort. Then, if such results can be brought about by a group determined to make it happen, one can step back and ask whether those same results could happen by accident.

Needless to say, this exercise should not be a public one – for obvious reasons. But it would provide a real learning opportunity for the CNSC staff and the CANDU industry generally, by searching out the weak spots in the CANDU design and gaining insight into the ways in which a catastrophic accident could possibly come about.

It might also serve to temper the unquestioning optimism that CANDU supporters have come to display with a tiny bit of skepticism about the ability of engineered systems to meet all challenges and prevail under all circumstances.

CONCLUSION

Thank you for taking the time to entertain these suggestions and reflections.

CORE MELTDOWNS IN CANDU REACTORS – KNOWN FACTS

compiled by G. Edwards Ph.D., President, Canadian Coalition for Nuclear Responsibility

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QUOTATIONS FROM:
The Safety of Ontario's Nuclear Reactors (1980)
by the Select Committee on Ontario Hydro Affairs (Ont. Legislature)

"It is not right to say that a catastrophic accident is impossible . . . . The worst possible accident . . . could involve the spread of radioactive poisons over large areas, killing thousands immediately, killing others through increasing susceptibility to cancer, risking genetic defects that could affect future generations, and possibly contaminating large land areas for future habitation or cultivation."

"The AECB should commission a study to analyze the likelihood and consequences of a catastrophic accident in a CANDU reactor . . . directed by recognized experts outside the AECB, AECL and Ontario Hydro*." [NOTE: this study has never been done]*

QUOTATIONS FROM:
A Race Against Time – Report on Nuclear Power in Ontario (1978)
by the Ontario Royal Commission on Electric Power Planning

"When we talk about the safety of a nuclear reactor, we are referring essentially to how effectively the fantastic amount of radioactivity contained in the reactor core can be prevented from escaping into the ground and atmosphere in the event of major malfunctions."

"Clearly, if a major release of this accumulated radioactivity occurred, as discussed in the previous section, the consequences would be extremely serious and could involve several thousand immediate fatalities and many more delayed fatalities."

"Assuming, for the sake of argument, that within the next forty years Canada will have 100 operating reactors, the probability of a core meltdown might be in the order of 1 in 40 years, if the most pessimistic estimate of probability is assumed."

CORE MELTDOWNS IN CANDU REACTORS – KNOWN FACTS

QUOTATIONS FROM:
Submission to the Treasury Board of Canada (1989)
by the Atomic Energy Control Board (predecessor of the CNSC)

"When modern nuclear power plants were being designed in Canada two decades ago, their complexity and potential for catastrophic consequences were recognized. . . ."

". . . through the combination of a series of comparatively common failures which, on their own, are of little consequence, accidents can develop in a myriad of ways (as demonstrated most vividly at Three Mile Island and Chernobyl). This makes the calculation of consequences of potential accidents very difficult."

"The consequences of a severe accident can be very high. The accident at Chernobyl has cost the Soviet economy about $ 16 billion including replacement power costs. The accident has generated anti-nuclear sentiment in the USSR and throughout the world. Three Mile Island has cost the USA $ 4.8 billion . . . ."

"The likelihood of serious accidents cannot be judged from statistics . . . and CANDU plants cannot be said to be either more or less safe than other types."

QUOTATIONS FROM:
Nuclear Policy Review Background Papers (1982, Report ER81-2E)
by the Dept of Energy Mines and Resources, Government of Canada

"Core meltdown accidents of the type to be described here have never occurred in any commercial power reactor, although the sequence of events at Three Mile Island went partway along the path. Nor has any study on core meltdown accidents been done for the CANDU reactor. . . ."

". . . if the ECCS *[EMERGENCY CORE COOLING SYSTEM]* failed to act, melting of metallic components of the core and eventually

of the uranium oxide fuel itself would probably occur. . . . [or] if the reactor fails to shut down or the decay heat removal systems fail, melting of the core would ensue.”

“Much larger consequences could be associated with core meltdowns which also cause failures in the containment structure above ground. If the containment sprays malfunction or are damaged by flying debris (generated by a LOCA *[LOSS OF COOLANT ACCIDENT]* or transient) the steam being released from the reactor core would not be condensed.”

“This steam, along with various vapours and noncondensible gases, could cause failure of the containment structure due to overpressurization. Hot zircaloy from the fuel sheaths and steel would also react with water to produce large volumes of hydrogen. Detonation of this hydrogen (reacting with oxygen) might damage the containment or, if not, the heat of combustion combined with high steam pressure would at least add to the pressure loads on the structure.”

“A further contributor to containment pressurization would be the large quantities of carbon dioxide generated as the molten core melts through the concrete base slabs. Another possibility is one in which the molten fuel falls into the pool of water in the bottom of the reactor vessel with the formation of flying debris which could, in turn, damage the containment structure. All post-meltdown occurrences which threaten to damage or breach the containment structure can result in the release of substantial amounts of radioactive material to the environment.”

“The Reactor Safety Study *[by the U.S. NRC]* calculated the health effects and the probability of occurrence for many possible combinations of radioactive material release magnitude, weather conditions, and population exposure *[see the next page]* . . . . In addition to these health effects, a nuclear accident may contaminate the surrounding area and require relocation of the populace.”

CORE MELTDOWNS IN CANDU REACTORS – KNOWN FACTS

SOME BACKGROUND ON:
The Rasmussen Report (1974, "Reactor Safety Study", WASH-1400) by the U.S. Nuclear Regulatory Commission

G.A. Pon, Vice President of AECL Power Projects, said of WASH-1400:

> **"Although the study was prepared in the U.S. assessing the risks associated with their light water nuclear power plants, the findings should not be significantly different for the CANDU reactor."** ***Porter Commission, Exhibit 28 (1977), p.5***

In sworn testimony before the Cluff Lake Board of Inquiry into Uranium Mining in Saskatchewan, Dr. Norman Rasmussen -- the principal author of WASH-1400 -- commented about CANDU meltdown possibilities:

> **"although the Canadian design philosophy differs in some of its approaches . . . it achieves, in my judgment, about the same safety level as far as I can tell."** ***Transcript, Cluff Lake Inquiry, (1977)***

Worst case consequences as reported in WASH-1400 (1974):

45,000 cases of radiation sickness (requiring hospitalization)
3,300 prompt deaths (due to acute radiation sickness)
45,000 fatal cancers (over 50 years)
250,000 non-fatal cancers (over 50 years)
190 defective children born per year after the accident
$14 billion in property damage (1974 dollars; not insurable)

FOR MORE INFORMATION SEE http://ccnr.org