Supplementary Submission from the Canadian Coalition for Nuclear Responsibility

To: CNSC Commissioners
From: Gordon Edwards, Ph.D., President,
Canadian Coalition for Nuclear Responsibility (CCNR)
Date: January 13, 2013

Re: ***Failure to provide factual answers to questions posed by the Chairman during the December 3-6 Hearings on the EA for OPG's proposed refurbishment and continued operation of the Darlington reactors.***

(1) This memo is a Supplementary Submission from the Canadian Coalition for Nuclear Responsibility (CCNR) in connection with the December 3-6 Public Hearings on the OPG Environmental Assessment of the Proposed Refurbishment and Continued Operation of the Darlington nuclear power reactors.

(2) Due to the failure of the proponent and the CNSC Staff to provide factual answers to three specific questions posed by the Chairman during the hearings – questions of crucial importance for assessing the potential environmental impacts resulting from realistic accident scenarios – CCNR considers it unacceptable for the panel to approve the EA for the proposed refurbishment and continued operation of the Darlington reactors based on the record of the public hearings. A full EA panel review will be required to fill in the gaps in information needed to adequately assess the potential impacts on human health and the environment associated with the proposed refurbishment of the Darlington reactors and their continued operation, particularly in light of the post-Fukushima emphasis on preventing large radioactive releases. The three questions posed by the Chairman that were not factually answered by either the proponent or the CNSC Staff are:

QUESTION 1: What is a scenario that will result in a large radioactive release?
QUESTION 2: Are the shutdown systems of a CANDU reactor sometimes unavailable?
QUESTION 3: Is the use of low-void-reactivity fuel safer than using the current fuel?

(3) The Chairman states on the record that the primary concern of the CNSC is to prevent large, potentially catastrophic, releases of radioactive materials into the environment, regardless of the calculated probability of such an event. *"Even if the plant is ruined, even if the plant is melted, as long as you can prevent [an] extreme release of radiation – that has always been our concern. Post Fukushima that's all we've been doing,"* he said. *"I don't care what [probability] level it is, negative 7, negative 8, negative 10."* [Transcript, December 5] Here, the phrase *"negative 7"* refers to one chance in 10 million, *"negative 8"* refers to one chance in 100 million, and *"negative 10"* refers to one chance in ten billion, per reactor per year.

(4) In this statement, the Chairman makes it emphatically clear that the prevention of an *"extreme release of radiation"* is a matter of paramount importance, no matter what the calculated probability – or improbability – of such an event may be.

QUESTION 1: What is a scenario that will result in a large radioactive release?

(5) Here is Chairman Binder's question: *"What I want to know is, what is a scenario that actually will result in a release? I'm still not there. Because they, according to the improvements that I've been hearing about, with all the offsite facility, with all the mobile facility, with all of that, I just don't see a scenario where you're going to give a release . . ."*

(6) A minute or two later, the Chairman repeats his question with the words, *"So that's what I'd be interested in reading, would this scenario actually cause a large release?"* The scenario under discussion is one of those itemized in the OPG document entitled 'Darlington NGS Risk Assessment: Summary Report'. That report confirms a large release of radioactivity for this scenario, with an estimated probability of 5 times 10 to the negative six – that is, five chances in a million per reactor per year.

(7) The proponent Ontario Power Generation (OPG) does not answer the Chairman's question in spite of the Chairman's having stated the question twice. OPG does not even try to address the question, despite its critical importance in assessing the environmental impacts of postulated accident scenarios. Here are the two statements by OPG spokespersons immediately following the Chairman's question:

> **MR. TREMBLAY (OPG):** Pierre Tremblay for the record, you know, I guess what I would say is the issue here is, you know, that whether it's an analysed scenario or not an analysed scenario, things could happen, and that means not only do you have to have this mitigating equipment, but you need to be prepared and the video pointed this out very well, to act and to respond to an event should it occur.
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> So it may be to that point. I'll ask Laurie Swami to talk a little bit about that aspect of it because really, that's the natural transition to this discussion.
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> **MS. SWAMI (OPG):** Laurie Swami for the record. I understand all of the discussion we've had from an EA process. I agree with Dr. Thompson's comments with respect to the planning tool, looking at possible mitigation, so if we take that one step further, one of the mitigations that's available is to implement the emergency response plans. And we've talked at great length already about the 5.7 millisieverts at the 1 kilometre level and we've talked about the sheltering that we've – that has been fully assessed in this environmental assessment. In addition to that, we have assessed what the evacuation would look like should there be one in the Darlington area and you'll see that in our technical support documents on human health.
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> We've actually discussed that. We've included in our assessment the evacuation time estimate studies very similar to the work that we did on Pickering when we looked at the nuclear accidents. So all of that work while I understand that it's not as – not in the same way that the sheltering was because that actually was included in the final environmental assessment report. We do have a discussion of this. We do talk about evacuation and we do talk about the effects that that could have on the community, as well as in the environment. So I think that is covered in our work.
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> And from an accident analysis itself, I agree also with Mr. Elliott's comments that this is the process that we're in, where we do studies. We look for improvements and we implement those improvements, and that is what we're talking about today.
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> I hope that answers your question. I'm not sure I was as short and brief as I could have been. *[Transcript, December 5]*

(8) But OPG did not answer the Chairman's question. The Chairman originally asked how a large release of radioactivity could possibly result from the scenario specified in the OPG document. Yet no effort was made by OPG to provide such an explanation or even to describe any such scenario.

(9) CNSC Staff also failed to answer the Chairman's question. CNSC Staff made these two statements very shortly after the two OPG statements quoted above:

> **MR. JAMMAL (CNSC Staff):** Mr. President, if you allow me, sir, I want to try to take an attempt at this without the numbers or anything. The study that is out is identifying a release. ***We agree that there is a release***. *[EMPHASIS ADDED]*
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> Now, as part of the design change for this refurbishment, the improvement that's taking place, that is what we are talking about right now. So with the improvements that's going to be installed as part of the refurbishment, or even before the refurbishment is going to be done, that's the release that's going to – ***the added mitigation measures is going to protect and provide mitigation for that release***. *[EMPHASIS ADDED]*
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> So I'm trying to give it without going through the numbers. So in summary, this was done without any improvements. Now, once you put the improvements in place, that is going to be the release. I'll pass it on to Mr. Frappier if he's got anything else to add.
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> **MR. FRAPPIER (CNSC Staff):** Perhaps just real quickly, Gerry Frappier, Director General of Assessment and Analysis.
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> ***So the report that Mr. Stensil is making reference to, we are very, very aware of. We've gone through it in detail.*** In fact, it is an outcome of the process that CNSC has put in place with the requirement of S-294 and the creation of a detailed probabilistic safety assessment. *[EMPHASIS ADDED]*
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> The reason for that – and as was mentioned by OPG, the demonstration that it works – is exactly what we're talking about here, ***a release category that perhaps was possible, although very, very, very unlikely,*** through this process, has now been shown to be something that OPG has now put a design fix in place. *[EMPHASIS ADDED]*
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> So whereas when that report was released that Mr. Stensil is making reference to, OPG had that as ***one of the potential release paths***. *[EMPHASIS ADDED]*
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> With the design changes that are going to be put in place as part of this enhancement to the facility, ***that is no longer considered a possibility and it is no longer one that has to be considered***. *[EMPHASIS ADDED]*

(10) These responses by CNSC Staff fail to describe any scenario or any sequence of events that will result in the large release of radioactivity described in the OPG document. But that is what the Chairman was asking for. He wanted details about *"the potential release path"*. He was seeking a description of the mechanism or mechanisms by which such large releases might occur. Can they happen when ventilation dampers become jammed in the open position, as they did during the 1952 NRX reactor accident at Chalk River? Might they happen when personnel airlock doors are not properly sealed, as has often happened in OPG reactors? Could they happen when one, several, or many of the hundreds of penetrations of the containment wall are not airtight? Will they happen if there is a failure of negative pressure in the vacuum building? Or might they happen as a result of other causes not listed here?

(11) By failing to answer or even address the Chairman's direct question, both OPG and CNSC Staff have in effect prevented the Chairman and the other Commissioners – as well as the intervenors in this public hearing – from gaining an understanding of the mechanisms by which large releases of radioactivity are possible. Without that understanding, Commissioners cannot objectively judge the claims of OPG and the CNSC Staff that such releases are "*no longer considered a possibility"* and can therefore be excluded from further consideration.

(12) So let's take a look at the OPG Report that CCNR Staff is *"very, very aware of"* and has *"gone through in detail."* It is the Darlington 2012 Probabilistic Safety Analysis (PSA) Summary Report, and as Mr. Webster of OPG noted during the hearings, the document *"is already on the [OPG] website"* at **http://tinyurl.com/awloq2x**.

(13) Here's what the OPG Report say about large releases of radioactivity. On page 100, the top line of Table 16 of the Report addresses the largest radioactivity release category that is considered possible by OPG. It is coded as D-RC1, presumably meaning "Darlington Release Category 1". Table 10 of the same Report tells us what the D-RC1 code represents: it refers to *"a release of airborne fission products from the containment to the environment large enough to require prolonged population relocation."* Evidently such a large radioactive release would play a major role in judging the acceptability of OPG's EA for the refurbishment and continued operation of the Darlington reactors.

(14) The Chairman's earlier remarks referencing the Fukushima disaster underscores the importance of acknowledging and preventing a D-RC1 type release: *"Even if the plant is ruined, even if the plant is melted, as long as you can prevent [an] extreme release of radiation – that has always been our concern. Post Fukushima that's all we've been doing."*

(15) In Table 16, OPG states that its "baseline analysis" shows a very large radioactive release – category D-RC1 – is predicted to occur at Darlington with a frequency of about 5 times in a million reactor-years. This frequency may sound low, but it is in fact 5 times higher than OPG's *"safety target"* of no more than once in a million reactor-years for a large radioactive release (as laid out in Table 11). Moreover, this predicted frequency is only marginally better than OPG's absolute *"safety limit"* of 10 times in a million reactor-years for a large radioactive release (also in Table 11). Far from being unthinkable, a large radioactivity release is therefore not only possible but also probable. While the calculated probability is low, it is not zero – and it is actually higher than the best current safety practices would demand.

(16) Table 16 also states that using an *"enhanced model"* – a different mathematical treatment utilizing different assumptions – the predicted frequency of occurrence of a large D-RC1 radioactive release can be reduced to about 8 times in 10 million years – and that's without making any *"safety opportunity improvements"* (SOIs). In other words, the actual safety of the plant is completely unaltered; the only thing that has changed is how the arithmetic is carried out by OPG's analysts. If SOIs (safety

improvements) are carried out, and the enhanced mathematical model is also used, then the predicted frequency of a large D-RC1 radioactive release can be reduced further to about 5 times in 100 million reactor-years.

(17) But why was none of this communicated to the Commissioners in response to the Chairman's question regarding large radioactive releases? Both OPG and CNSC Staff indicated that they are well aware of the document and its findings. Table 16 clearly states that a large radioactive release from Darlington – one that would "*require prolonged population relocation"* – is a possibility regardless of safety improvements. What changes is only the calculated probability of that event, and the Chairman made it clear in advance that this does not diminish the importance of the issue: *"I don't care what [probability] level it is, negative 7, negative 8, negative 10"* he said.

(18) This failure to communicate goes beyond the question of the professionalism of the OPG and CNSC experts at the hearings. It touches on the single most important issue regarding public health and the other social and environmental impacts of nuclear power reactors. ***CCNR considers it unacceptable for CNSC to approve the EA for the proposed refurbishment and continued operation of the Darlington reactors given the failure of all the professionals involved to thoroughly inform the Commission on the one issue that the Chairman himself has identified as being of paramount importance.***

QUESTION 2: Are the shutdown systems of a CANDU reactor sometimes unavailable?

(19) In the Transcript of December 6, after hearing from intervenor Dr. Gordon Edwards that the CANDU fast shutdown systems are sometimes unavailable even when the reactor is operating, the Chairman asked: *"Staff, would you ever allow for unavailability of the shutdown systems?"* The staff's answer to this question is initially unequivocal:

> **MR. JAMMAL (CNSC Staff):** Ramzi Jammal for the record.
>
> The answer is no. We will not allow them to operate without the availability of the shutdown systems. But I would like to counter Dr. Edwards.
>
> He is manipulating – a lot of the reports were after the fact. When there is a mention – as you mentioned, there are multiple safety systems, okay? And ***the key element is, no reactor will be allowed to operate without the safety system is fully functional or in operations.*** *[EMPHASIS ADDED]*
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> **THE CHAIRMAN**: But is there are a time when one sort of failed and then you had to do an outage?
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> **MR. JAMMAL (CNSC Staff):** Of course, that's why the reactor always goes into a shutdown state. I'll pass it on to Dr. Rzentkowski, Director General of the – Director of Power Regular. As a matter of fact, we can pass you to Mr. Webster who's Director of the Darlington.
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> **MR. WEBSTER (CNSC Staff):** Thank you Mr. Jammal. It's Phil Webster, the Darlington Director.
>
> Let me try to sort through the issues here. There are four special safety systems; two shutdown systems, emergency coolant injection, and containment. And there are many thousands of tests every year. Essentially every shift in the station tests some

> part of one of the special safety systems. When a test is being performed on a shutdown system, for example on one of the channels, the channel is set to a tripped state before it's tested. So in other words, this is set to the safe direction before the test is performed. This sometimes leads to announcing it as a serious fault on another channel while the test is being performed. If there is an unavailability, especially of the ECI *[Emergency Coolant Injection, otherwise known as the Emergency Core Cooling System]* or the containment system – and by unavailability, I normally refer to a loss of redundancy or perhaps a reduction in its full capability – the rules require that to be fixed within a defined time – often 8 hours or 24 hours – or the station must be shut down.
>
> ***So the station never operates without shutdown systems. It may operate for a very short period with a reduced availability of emergency coolants or containment.*** And it's not the full containment. It's often something like an airlock door seal *[that has failed to inflate]*. *[EMPHASIS ADDED]*

(20) In its response, the CNSC staff denies that either of the two shutdown systems (SDS-1 and SDS-2) is ever unavailable when the reactor is operating. Mr. Jammal states so categorically. Mr. Webster goes into more detail. He points out *"There are four special safety systems; two shutdown systems, emergency coolant injection, and containment."* He admits that two of the four – the emergency coolant system and/or the containment system – may sometimes be unavailable while the plant is operating, but he adds that *"the rules require that [unavailability] to be fixed within a defined time – often 8 hours or 24 hours – or the station must be shut down."* But he implies that the shutdown systems are always available. *"So the station never operates without shutdown systems. It may operate for a very short period with a reduced availability of emergency coolants or containment."*

(21) Some time later, Dr. Edwards made a commitment to the Commissioners:

> I have statistics from the past showing, on a yearly basis, for the different reactors, the unavailability of the four primary safety systems – which are the emergency coolant injection *[ECCS]*, the containment *[CONT]*, and the two fast shutdown systems, SDS-1 and SDS-2. I will send those to the Commission through Dr. Binder.

(22) Immediately after Dr. Edwards' promise to supply the Commissioners with data on the past unavailability of all four safety systems, the CNSC Staff volunteered additional information that seemed to contradict some of their previous assertions:

> **MR. WEBSTER (CNSC Staff):** Sure, it's Phil Webster, for the record.
>
> As the Commissioner is aware, we have a regulatory document, S-99, that requires certain things to be reported by the licensees to the Commission.
>
> One of those things is ***an annual reliability report that includes the unavailability, the actual past and the predicted future unavailabilities of the four special safety systems***. *[EMPHASIS ADDED]*
>
> **DR. EDWARDS:** ***Oh, all four of them!***
>
> Okay! So there ***are*** unavailabilities! *[EMPHASIS ADDED]*
>
> You see, the reason why this is important is that, in the probabilistic safety analysis, you have to assign a probability for a safety system failing. And that probability has to be measured against actual performance.

> So if you're going to say that a safety system will fail only once every 100 reactor years, or once every 1,000 reactor years, or whatever, then you have to be able to verify that against the actual record. That's why you need to have these unavailability numbers. ***Without the unavailability numbers you cannot really test the realism of the probability calculations***. *[EMPHASIS ADDED]*
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> **MR. WEBSTER (CNSC Staff):** Phil Webster, again, for the record.
>
> ***Yes, absolutely. That's why they are measured by the licensees and reported to the regulator.*** And we have our annual report on the safety performance of the nuclear power stations. And what we report in there – and I can't be too clear on the specifics – is where systems have been unavailable. The Darlington –- *[EMPHASIS ADDED]*
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> **DR. EDWARDS:** Oh.
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> **MR. WEBSTER (CNSC Staff):** –- ***special safety systems, all four, have to meet a target of 10 to the minus 3 – that is they must be*** –- *[EMPHASIS ADDED]*
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> **DR. EDWARDS:** Right.
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> **MR. WEBSTER (CNSC Staff):** –- ***unavailable, less than one one-thousandth of the time***. *[EMPHASIS ADDED]*

(23) The data promised by Dr. Edwards have since been sent to the Commissioners in a memo dated Dec. 9, 2012, posted at *http://ccnr.org/Safety_Systems_Memo_2012.pdf* . The memo is based on a chart that details the recorded unavailability of all four of the special safety systems at Bruce NGS "A" – including the fast shutdown systems SDS-1 and SDS-2 – during the three-year period 1976-78 inclusive. (The chart was filed as an exhibit by the Atomic Energy Control Board (AECB) on August 2, 1979, during the 1979-80 Hearings held by the Select Committee on Ontario Hydro Affairs.)

(24) The chart shows that both shutdown systems were occasionally unavailable during operation, often for hours, during those years. As pointed out by Mr. Webster in the December 6 Transcript, all four principal safety systems are required to be unavailable no more than one one-thousandth of the time. So each safety system is "allowed" to be unavailable for not more than 7 hours per year, assuming an 80 % capacity factor – or 9 hours per year, assuming the plant never shuts down, even for maintenance. (Incidentally, this means that Mr. Webster's earlier comment that unavailabilities have to be corrected within 24 hours is totally out of line with the 7 to 9-hour regulatory targets governing the allowed unavailability of safety systems.)

(25) In any event, the AECB chart shows that in 1978 each of the four safety systems at Bruce "A" NGS – including the two shutdown systems – was unavailable for much longer periods of time than allowed in 3 of the 4 reactor units. In unit 4, for example, the second shutdown system (SDS-2) was unavailable for about 50 hours in 1978, while the first shutdown system (SDS-1) was unavailable for more than 15 hours. Meanwhile, the containment in unit 4 was unavailable for about 20 hours, and the emergency cooling system was unavailable for more than 147 hours – almost a week.

(26) In all four Bruce "A" units, the chart shows that SDS-2 was unavailable for more than 10 hours per year in both 1977 and 1978. In three of the four units, SDS-1 was

also unavailable for more than 10 hours in 1978. The other two safety systems – emergency cooling and containment – were unavailable much more often than the target throughout the entire two-year time period 1977-78. This past experience is in sharp contrast to what Mr. Webster says of the Darlington reactors, that "*special safety systems, all four, have to meet a target of 10 to the minus 3 – that is they must be unavailable less than one one-thousandth of the time*." This claim deserves checking.

(27) Of course the figures cited in paragraph 26 are old. They are the only data that I have access to. But data does exist for the unavailability of the four principal safety systems for each year of operation in each of OPG's CANDU reactors, as confirmed by Mr. Webster in the Transcript. In any event, CNSC Staff failed to give a factual response to the Chairman's question about unavailability of fast shutdown systems, until Dr. Edwards indicated that he had data and would send it to the Commissioners.

(28) It is difficult to understand why CNSC Staff would not be willing or able to provide frank and accurate answers to a direct question put to them by the CNSC Chairman during a public hearing, especially when such information deals with essential safety systems during hypothesized accident scenarios. Without such basic technical information, it is impossible for the Commissioners to objectively assess the safety of the Darlington reactors or the plausibility of large radioactive releases.

(29) It is likewise difficult to understand why OPG would choose not to recognize the meaning of the term "unavailability" as it is so widely used in the nuclear power industry, and why OPG would allow such statements as the following to stand unchallenged and uncorrected in the record of the proceedings:

> **MR. ELLIOTT (OPG):** Can I just make one other comment? I have to correct the intervenor about operating without shutdown systems. I've been a shift supervisor at Pickering, I've been a shift supervisor at Darlington, I've been a site Vice President, and as Chief Engineer, ***we would never operate a reactor with the shutdown systems unavailable. That would not happen.*** *[EMPHASIS ADDED]*

(30) No doubt Mr. Elliott means *"we would never* **knowingly** *operate a reactor with the shutdown systems unavailable"*. In a similar way, when Mr. Jammal earlier said that "We will not allow them to operate without the availability of the shutdown systems", his statement was also missing the word "knowingly". The unavailability of a safety system is never knowingly tolerated. It is an undesirable condition that develops unexpectedly and escapes notice for a certain period of time. It is normally discovered during operation or after a planned or unplanned outage. As Mr. Webster remarked: *"the rules require [such an unavailability condition] to be fixed within a defined time – often 8 hours or 24 hours – or the station must be shut down."*

(31) A safety system that has been characterized as "unavailable" is not necessarily ***completely*** unavailable. Mr. Webster points out that *"by unavailability, I normally refer to a loss of redundancy or perhaps a reduction in its full capability."* Referring

to unavailability of containment, Mr. Webster adds *"It's not the full containment. It's often something like an airlock door seal."*

(32) Nevertheless, even partial unavailability of a safety system can have major repercussions. When the NRX reactor at Chalk River underwent a power surge following a loss-of-coolant accident in 1952 and failed to shut down fast enough – leading to a series of powerful explosions and the destruction of the reactor core – the shutoff rods were only partially unavailable. Some of them descended fully into the core, but others did not. Moreover the containment was only partially unavailable – nevertheless the ventilation dampers jammed in the open position, leading to offsite atmospheric radioactive releases. In addition, a million gallons of radioactively contaminated water was drained into shallow earthen trenches onsite. Luckily, the NRX reactor was only about one five-hundredth as powerful as any one of the 4 Darlington reactors, or the consequences would have been much worse.

QUESTION 3: Is the use of low-void-reactivity fuel safer than using the current fuel?

(33) During the Hearings on December 6, Dr. Edwards raised the question of a generic safety issue afflicting all CANDU reactors:

> **DR. EDWARDS:** I'd like to mention one other issue as well. It is a generic CANDU safety issue that has been struggled with for decades. And that is the Positive Void Coefficient of Reactivity *[PVCR]*, which means that when you have a loss of coolant accident *[LOCA]* you get a power surge at the same time.
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> For this reason we have two independent, fast-acting shutdown systems in order to try and ensure that this power surge will not get out of control. Because ***it is well recognized that if the reaction were not to be terminated within two seconds, you could have very serious consequences.*** *[EMPHASIS ADDED]*
>
> ***Well there are, as I understand it, technical means for eliminating this problem at the source by using different fuel. It's called Low Void Reactivity Fuel.*** The CNSC and the Proponent have decided not to do that, but to live with the risk of this positive void reactivity coefficient, by putting all their reliance on the mathematics of their analysis and also on the efficacy of these fast shutdown systems. *[EMPHASIS ADDED]*
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> I think that is something that deserves to be considered at a political level. Does society want to insist that the problem be eliminated? ***Or is society willing to live with the problem hoping that these not-always-available shutdown systems will function infallibly in the case of an accident***? *[EMPHASIS ADDED]*

(34) Immediately following the inervenor's presentation, Commission Member Barriault asked CNSC Staff to clarify the question of Low Void Reactivity Fuel.

> **MEMBER BARRIAULT:** The intervenor mentioned the Low Void Reactivity Fuel. I guess it begs the question, why isn't it being used in our reactors? Or is there a need for it?
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> **MR. JAMMAL (CNSC Staff):** It's Ramzi Jammal, for the record.
>
> Let me start first by complimenting Dr. Edwards on the way he presents the information, in a manner that probably the public understands; but it's not really presenting the whole fact relating to the PCR *[Positive Void Coefficient of Reactivity]*.
>
> The mention of the positive coefficient reactivity – which is, as he accurately calls, the generic action item – has been raised internationally and has been closed internationally by the CNSC.

> The CNSC is a signatory to the convention of nuclear safety – and the technical debates take place by peer review, by independent – other countries. And at the last convention of nuclear safety, the CNSC presented its action and its – the systematic approach and what's being done with respect to the positive coefficient reactivity – and the issue internationally has been accepted and closed. So the PCR itself, the generic action item is a – it's a thing that's always being raised by Dr. Edwards and it is closed internationally now.
>
> On the specific, I will ask Dr. Rzentkowski or Dr. David Newland or actually Michel Couture – Dr. Couture to provide the specificity with respect to the PCR. This is not a new phenomenon. We know the process.
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> **DR. COUTURE (CNSC Staff)**: Thank you. Michel Couture, Director of the Physics and Fuel Division, for the record.
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> Short answer – and then I'll explain a bit more – the use of Low Void Fuel would not eliminate the fact that the CANDU has a positive void reactivity coefficient.
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> ***As Dr. Edwards has mentioned, what does it mean to have a positive cooling void reactivity coefficient? It means that if you have a Loss Of Coolant Accident [LOCA], the voiding will translate into an increase in the number of neutrons, which translates into a number increased in fissions, and therefore a power surge***. *[EMPHASIS ADDED]*
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> As the safety analysis demonstrates, the shutdown system will be activated. Current safety analysis demonstrates that the shutdown system will be activated and safety limits will be met.
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> Now the concept of the Low Void Fuel is to have, essentially, the same – it's a 37-element bundle and a central element is – we – the designer introduced some neutron absorbents – absorber materials that absorb neutrons in the central element. And in order to compensate for that, they had to increase the enrichment. So it's about 1.2 percent enrichment for the rest of the bundle.
>
> ***This bundle has no effect during normal operation but if you had a Loss Of Coolant Accident, what would happen is that***, like I said, the neutron population increases but now, since you have an absorbent at the centre of your bundle, these neutrons would be absorbed. So what it does is, ***the power surge would still be there but at a much lower rate and the shutdown system would be activated. And your safety limits would be met but with a large margin.*** *[EMPHASIS ADDED]*

(35) Dr. Couture's initial answer is clear: he says the use of Low Void Reactivity Fuel would have no effect during normal operation, but in the event of a loss-of-coolant-accident this fuel would greatly reduce the inevitable power surge, thereby providing a larger safety margin than would otherwise be the case. This is good news. For even if the shutdown system happens to be partially unavailable at the moment of the accident, as per the preceding section of this submission, with a dash of good luck the reactor may still be able to shut down fast enough – within seconds – so as to prevent the destruction of the core and the release of an enormous amount of radioactivity into the reactor building. Given the dire consequences of an uncontrolled power surge, the larger the safety margin the better.

(36) But following Dr. Couture's initial explanation, a chorus of voices arose – first from OPG and then from CNSC Staff – to make the issue seem much more complicated than it is; even going so far as to deny that the use of low-void-reactivity fuel would ultimately be any safer than the status quo.

> **MR. TREMBLAY (OPG):** Just to get back to the matter at hand and the question that the Commission asked. ***I just want to make a point that, you know, the Darlington Plant and the Safety Case is assured. The plant has adequate margins. It meets all the safety requirements.*** We have fast acting safety systems and we meet all the requirements. And so that's an important point that we need to understand and put on the table. *[EMPHASIS ADDED]*
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> In terms of Low Void Fuel and that issue, let me just ask Mark Elliott, our Chief Engineer, to talk a bit about the work we've done in this area.
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> **MR. ELLIOTT (OPG):** Mark Elliott for the record.
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> ***To go to a new type of fuel would be a major change in our design.*** It would require some enrichment. We've talked a lot about natural uranium fuel. So this would be a major change and when you look at the safety margins that we have, they're solid. *[EMPHASIS ADDED]*
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> Every time we look at this issue, we're looking at it again from a point of view of large-break LOCA *[Loss Of Coolant Accident]*. That's an issue that has come before you before. When we've looked at that in detail, we still have significant margin.
>
> ***So this is not an issue that affects our safety goals***, as Mr. Tremblay mentioned. We meet those with margin ***and there's really just no reason to go to Low Void Reactivity Fuel.*** *[EMPHASIS ADDED]*

(37) In effect, Mr. Elliot is saying that OPG doesn't want to change because the Darlington nuclear reactors are safe enough already without the additional passive safety margin provided by the use of low-void-reactivity fuel. In effect, he says there already is a margin of safety that is considered fully acceptable to both OPG and CNSC and *"there's really just no reason"* to go for an even larger margin of safety.

(38) At this point the Chairman enters the discussion. He poses a question about low-void-reactivity fuel point-blank to the assembly of experts from OPG and the CNSC Staff. But the answers to his perfectly clear question are perfectly unclear:

> **THE CHAIRMAN:** So just to close this, because we should move on to other items that Dr. Edwards raised. ***I'd like a clear statement. Is the low void reactivity [fuel] with enriched uranium a safer system than the current existing system?*** *[EMPHASIS ADDED]*
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> **MR. COUTURE (CNSC Staff):** Michel Couture, Director of Physics and Fuel Division for the record. The – the safety – if you're asking if it's safer, the experience we had so far was – was with two channels in Bruce Power. ***We've never looked at the whole safety case of the Low Void Fuel,*** so the safety – if you ask if it's more, it's safer, we would have to look at all the implications of changing the fuel to a Low Void Fuel.
>
> **THE CHAIRMAN:** Dr. Edwards seemed to indicate or at least suggest that it would be a safer system –-
>
> **MR. COUTURE (CNSC Staff):** Well, like I mentioned that the – ***the idea behind the Low Void Fuel is, as an absorbent, would reduce the – the power surge. So if you ask if that – that is safer, that would certainly accomplish that task.*** But you have to look at the whole thing. Do we have already enough margin? *[EMPHASIS ADDED]*
>
> There's a whole project right now looking at the large LOCA [Loss of Coolant Accident]. And we are looking at a new analysis framework because the current analysis framework has a lot of, various assumptions and they're – like instantaneous break of large pipes. Of course, if you put that in your analysis, instantaneous breaks

> of large pipes, you'll have huge loss of coolant. However we're looking at fracture mechanics, probability of breaks, is this realistic, and so on.
>
> So we're – we're looking into this. And the ***Low Void Fuel has been put as a – as a possible option should this analysis cannot be supported on the strong technical basis. So the work is underway right now. There's a huge effort in the industry.*** *[EMPHASIS ADDED]*
>
> **THE CHAIRMAN:** So, but if you actually reach the conclusion that it is – I'm still struck. So is it easy now to buy enriched uranium from the U.S. and ship it over to Canada if we needed to? I'm – just hypothetically?
>
> **MR. JAMMAL (CNSC Staff):** Well, I won't . . . it's Ramzi Jammal for the record . . . I won't call it, it is easier, well, it's, we will have to have the import/export agreements; but ***your question, "Is it safer?" The answer is going to be, "Just as safe as . . ."*** *[EMPHASIS ADDED]*
>
> ***At minimum, it's going to be as safe as what it is right now.*** Otherwise we're not going to allow it to – to be licensed. ***So the facility as licensed today is safe.*** Any new modification, enrichment or not, must be an equivalent to safety to what we currently have. ***The debate is it safer or not, the issue – that's not the issue here. Is it going to be safe? It must be at minimum equal to what we currently have in safety.*** *[EMPHASIS ADDED]*
>
> So regardless of what – what's in it or not, so the – the composition is not the issue here is, as Dr. Couture mentioned, it is the safety case, but it must meet the safety requirements, it doesn't matter what it is.

(39) Suddenly the simple explanation given earlier by Dr. Couture regarding the use of low-void-reactivity fuel has become fraught with confusion, complexity and contradiction. It is as if CNSC Staff are taking their cue from OPG and are now reinforcing OPG's message that the Darlington reactors are already "safe enough", so need not be made safer. However this is not answering the Chairman's question: is the use of low-void-reactivity fuel safer than using the current fuel, or not?

(40) Moreover, the comments from CNSC Staff are contradictory. Safety is not an absolute – there is always room for improvement. Hasn't OPG taken pains to outline a number of safety improvements that will be made to the Darlington reactors in response to the post-Fukushima action plan? Wouldn't the use of low-void-reactivity fuel be just one more example? Why are OPG and CNSC Staff so quick to dismiss this particular safety improvement? And why are they unable or unwilling to answer the Chairman's question with a simple "yes" or "no"?

(41) Indeed, Mr. Jammal says: *"The debate, is it safer or not – that's not the issue here"*. So instead of answering the Chairman's question, he rejects it as if it is somehow illegitimate to even ask such a question. In a court of law, such an attitude might well be regarded as "contempt of court". Shouldn't he, as a senior CNSC Staff person, give a straightforward answer to CNSC Chairman's straightforward question?

(42) In earlier testimony, Mr. Jammal dismissed concerns about the "Positive Void Coefficient of Reactivity" by saying that this "generic safety issue" has been fully resolved at the international level, and is no longer outstanding. The case is closed. Yet now, in the text quoted above, Dr. Couture says there is a *"huge effort in the*

industry" to re-analyse the consequences of a large loss-of-coolant accident (LOCA) and the resulting power surge. *"The work is underway right now,"* he says. So the generic safety issues related to CANDU's Positive Void Coefficient of Reactivity are apparently not resolved after all, in contradiction to Mr. Jammal's earlier assurances.

(43) Specifically, Dr. Couture says if the current effort at safety analysis "*looking at the large LOCA*" goes badly – in other words, if OPG's presumed safety margins "*cannot be supported on the strong technical basis"* – then "*Low Void Fuel has been put as a – as a possible option."* So, despite claims by both OPG and CNSC Staff that existing safety margins are adequate, and hence there is no need for low-void-reactivity fuel, Dr. Couture says that question remains unresolved. It may ultimately prove necessary to adopt the use of low-void-reactivity fuel in order to provide the Darlington reactors with a greater – and hopefully adequate – margin of safety.

(44) A close reading of the Transcript brings the reader to the inevitable conclusion that OPG does not want to spend the time or money to invest in low-void-reactivity fuel, even though there seems little doubt that such fuel will provide an additional safety margin. As Dr. Couture says in the text quoted above, "*the idea behind the Low Void Fuel is, as an absorbent, [it] would reduce the power surge. So if you ask if that is safer, that would certainly accomplish that task."* Unlike reactor safety systems, which are occasionally unavailable, the reactor fuel is always there in the core of the reactor. If the fuel itself can provide an additional margin of safety, provided it is of the right type, and if this additional margin is there with no chance of "unavailability", CCNR believes that CNSC should require that it be used – unless a convincing ***safety argument*** can be given by OPG to show why it should not be used.

(45) A careful reading of the December 6 Transcript indicates that there are still significant unresolved safety problems related to the consequences of a large LOCA in all of the existing Darlington reactors, refurbished or not. Dr. Couture says *"There's a whole project right now looking at the large LOCA [Loss of Coolant Accident]. And we are looking at a new analysis framework because the current analysis framework has . . . various assumptions – like instantaneous break of large pipes. Of course, if you put that in your analysis, instantaneous breaks of large pipes, you'll have [a] huge loss of coolant. However we're looking at fracture mechanics, probability of breaks, is this realistic, and so on."* It is also clear from this passage that CNSC Staff is under pressure to ignore certain accident scenarios (such as the guillotine rupture of a inlet header) in order to save OPG from having to use low-void-reactivity fuel.

(46) There is a major safety analysis currently underway concerning the safety of the Darlington reactors in the event of a large loss-of-coolant accident. The outcome of this massive effort is as yet uncertain. It may be that low-void-reactivity fuel will be required in future to compensate for shortcomings in OPG's safety analysis. OPG and CNSC Staff are agreed that such a change in fuel will require a total re-analysis of the entire safety case for the Darlington reactors, as the following citations show:

MR. COUTURE (CNSC STAFF): . . . the experience we had so far was with two channels in Bruce Power. ***We've never looked at the whole safety case of the Low Void Fuel***, so . . . we would have to look at all the implications of changing the fuel to a Low Void Fuel. *[EMPHASIS ADDED]*

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MR. RZENTKOWSKI (CNSC Staff): A reactor is a very complex system. It behaves in a complex way. It breaks in a complex way. We talk also about the probabilistic safety assessment. It has to be realized that ***in probabilistic safety assessment we evaluate hundreds if not thousands of different initiating events***. *[EMPHASIS ADDED]*

Now this is only one accident scenario we are discussing here, a result of Positive Void Reactivity. ***So that's why it's very important to assess the overall safety case in a very holistic way***. *[EMPHASIS ADDED]*

It also has to be recognized that Positive Void Reactivity manifests itself also for the enriched fuel – it manifests itself only during the over-cooling transient, not the overheating transient. ***So, once again, I would like to stress the fact that the overall safety case is what counts.*** *[EMPHASIS ADDED]*

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MR. ELLIOTT (OPG): To go to a new type of fuel would be a major change in our design. It would require some enrichment . . . So this would be a major change and when you look at the safety margins that we have, they're solid.

Every time we look at this issue, we're looking at it again from a point of view of large-break LOCA. That's an issue that has come before you before. When we've looked at that in detail, we still have significant margin.

So this is not an issue that affects our safety goals, as Mr. Tremblay mentioned. We meet those with margin and there's really just no reason to go to Low Void Reactivity Fuel.

(47) With so much uncertainty surrounding the analysis of rare but potentially catastrophic scenarios at Darlington – such as large LOCAs – and the failure of OPG and CNSC Staff to assess the important mitigating effects of using low-void-reactivity fuel, CCNR considers it unacceptable for CNSC to approve OPG's EA for the refurbishment and continued operation of the Darlington reactors.

Conclusion:

(48) The Transcripts of the December 3-6 Hearings contain ample evidence of a pervasive failure on the part of OPG and CNSC Staff to address the most important questions concerning the impacts on human heath, society and the environment. How exactly do large radioactive releases occur, and what kind of accident scenarios would be expected to result in such releases? No clear answer. Are the special safety systems of CANDU reactors sometimes unavailable? How exactly does such unavailability come about, and what would be the repercussions if a severe accident were to occur during such a time of unavailability? No clear answer. Would the use of low-void-reactivity fuel bundles provide an extra margin of safety in the event of a Loss Of Coolant Accident (LOCA) compared with the natural uranium fuel bundles that are currently used? No clear answer. If these questions cannot be authoritatively answered, then approval for the EA Report should not be give

To: The Commissioners of the CNSC
From: Gordon Edwards, Ph.D.
Date: December 9 2012

Re: The Unavailability of CANDU safety systems

I am writing to fulfill an obligation that I undertook during my testimony before the Commission on December 6, 2012. I promised to supply the Commissioners with data regarding the historical unavailability of the safety systems of CANDU reactors, including the fast shutdown systems.

In my testimony I mentioned that the two independent fast shutdown systems that are a feature of all operating CANDU reactors have not always been available even during operation.

I was surprised when Mr. Jammal contradicted my assertion. If I recall correctly, he declared that the fast shutdown systems are always available.

I believe this statement by Mr. Jammal to be untrue. Moreover I find it disturbing that Mr. Jammal would misinform the Commissioners on such an important topic, especially when this becomes enshrined as a matter of record in the transcript of the hearing.

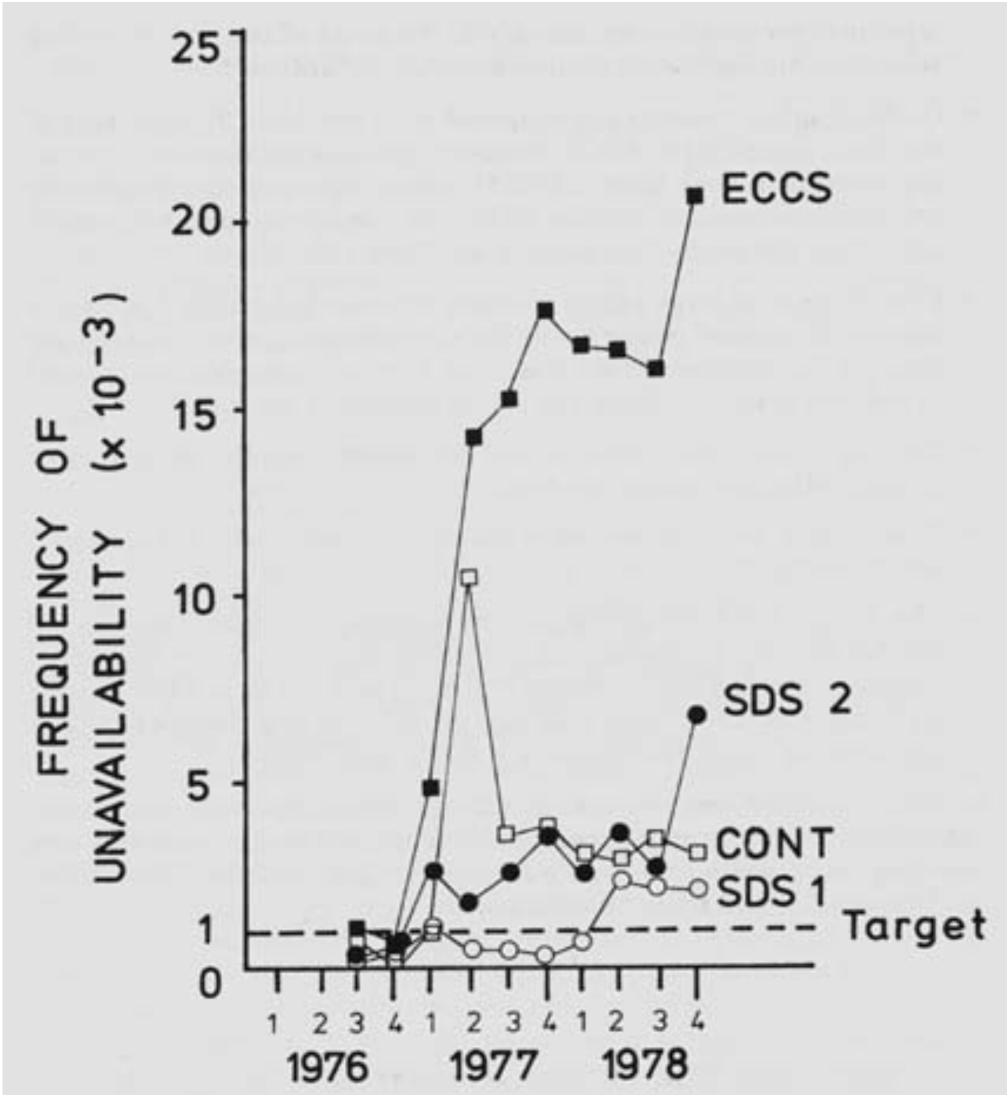
The chart reproduced below was filed as Exhibit E-71 by the Atomic Energy Control Board (AECB) on August 2 1979 during the 1979-80 Hearings on Reactor Safety – hearings conducted over a period of 15 weeks by the Select Committee on Ontario Hydro Affairs. The chart deals with the recorded unavailability of the four principal safety systems at Bruce NGS "A" during the three year period from 1976-78 inclusive.

Those safety systems are the Emergency Core Cooling System (ECCS), the two fast shutdown systems (SDS1 and SDS2), and the Containment System (CONT).

As Mr. Jammal confirmed during the December 9 hearings, the target unavailability of each of these four safety systems, as prescribed by the regulator, is 10^{-3} or 1 in 1000. In practical terms, this means that each year, each safety system is assumed to be unavailable no more than 7 hours per year, based on an 80% capacity factor.

As it happens, in the last three quarters of 1978 none of the four safety systems at Bruce "A" met this target. ECCS, for example, was unavailable for 39 hours during the fourth quarter of 1978; that is more than 22 times above the target (i.e. $^7/_4$ = 1.75 hours per quarter). In addition, 3 of the 4 Bruce "A" safety systems failed to meet the target in each of the four quarters of the year 1977 (as well as each of the four quarters of 1978).

Such data have important repercussions for the credibility of any Probabilistic Safety Analysis. For example, if the probability of a Loss of Coolant Accident (LOCA) is assumed to be 1 in 100 for a small pipe break, and the probability of no Emergency Cooling is assumed to be 1 in 1000, then the probability of a LOCA with no ECCS may be calculated to be 1 in 100,000 per year. But if ECCS is unavailabile 22 times more often than assumed, the probability of this accident is 1 in 4,550 per year – much higher!



The subject of unavailability of CANDU safety systems was introduced a couple of years earlier, in 1977, during my testimony before the Ontario Royal Commission on Electric Planning, presided over by University of Toronto Engineering Professor Arthur Porter.

Here are some verbatim excerpts from the 1978 Commission Report on Nuclear Energy in Ontario, entitled "A Race Against Time", directly related to the unavailability of CANDU safety systems – including the statistical unavailability of the containment system:

> *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.*

During normal operation, not only is a great deal of radioactivity created in the reactor core but also a great deal of thermal energy [heat]…. The purpose of the ECCS is to remove the heat from the core as rapidly as possible.

If, however, both primary coolant and emergency coolant fail there would probably be partial or complete melting of the reactor core. An uncontained complete core meltdown would almost certainly give rise to a large release of radioactivity, the consequences of which were discussed previously.

This would only occur, however, in the very unlikely event of the containment system – both reactor building and vacuum building – being breached. This could happen, for example, if the melted fuel were to fall to the reactor floor, melt through the floor, escape into the earth and contaminate a large area.

But both Ontario Hydro and AECL have stressed that, in their opinion, even in the highly improbable event of a core meltdown, the containment system would hold. The main reason for this high degree of confidence is the fact that the melted fuel would first fall into the large volume of cool heavy water moderator (about 400,000 litres). This would act as a heat sink – approximately four hours would be required to evaporate the water, during which period the decay heat of the fuel would be about 1 per cent of that at full power.

Furthermore, the designers contend that the cooling system embedded in the reactor floor combined with an external water source, which could be hooked up manually, would be able to cope with the residual heat.

Assuming absolute independence of the process and safety systems, the probability of a core meltdown per reactor at Pickering is said to be in the order of 1 in 1,000,000 years [once in a million years]. At Bruce, because there are two independent shutdown systems (i.e. shutdown rods and "poison" injection), the theoretical probability per reactor might be considerably lower, perhaps in the order of 1 in 1,000,000,000 years [once in a billion years].

However, two well-informed nuclear critics who participated in the hearings, Dr. Gordon Edwards and Ralph Torrie, have argued that the probability of a dual failure could be about 100 times higher than the theoretical levels. This estimate is based on failure rates in the high pressure piping of the primary heat transport system being 10 times higher than has been assumed, and also on the fact that the availability of the Pickering ECCS has been demonstrated to be 10 times lower than postulated by the designers.

We believe that the Edwards/Torrie estimate [of 1 in 10,000] is more realistic than the theoretical probability, not least because the Rasmussen Report has concluded that the probability of an uncontained meltdown in a light water (U.S.) reactor is 1 in 20,000 per reactor per year (it has been suggested, moreover, that this figure could be out by a factor of "5 either way").

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.

> *Evidence to support the Edwards/Torrie position, which is available in the Pickering Safety Reports, indicates that there were in fact (if the commissioning period is included) six loss of regulation accidents within four years. This compares very unfavourably with the design target of one in 100 years. However, as a result of a major study, involving Ontario Hydro and AECL, several improvements have been incorporated, and there has not been a loss of regulation accident since April, 1975.*
>
> *We have noted also that the emergency core cooling system has not met the design targets although there is evidence that the reliability of the system is improving.*
>
> *Of more serious concern is the fact that a leak was discovered in the wall of the Pickering unit 2 reactor building in June, 1974, and may have existed for one and a half years – this leak "would have reduced the ability of the containment system to limit radioactive release after any unit 2 accident since the beginning of 1973".*
>
> *Measures which have been taken subsequently have resulted in design target levels being achieved. But the concern nevertheless persists because, as Ralph Torrie has pointed out, the "Pickering unit 2 containment would have to operate within target levels for 500 years before the average annual availability would be back within the bounds of the annual regulatory limit".*
>
> *In assessing the legitimacy of the above limits it should be stressed that no study similar to the Rasmussen Study has been undertaken in Canada to assess the reliability of the reactor system as a whole and the consequences of major CANDU reactor accidents.*
>
> *From "A Race Against Time", pp.73-79*

I have said it before, and I will say it again – I do not believe that the Commissioners are getting good advice from the CNSC staff on several matters or great importance to public safety. But this example is much worse. For the CNSC Staff to tell the Commissioners that CANDU safety systems are never unavailable during operation is unacceptable.

I ask the Commission to make available to me the data on the unavailability of safety systems at all licensed CANDU reactors over the last 15 years.

Thank you.

Gordon Edwards, Ph.D.