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Written submission from Frank Greening

Mémoire de Frank Greening

In the Matter of

À l'égard de

Ontario Power Generation Inc.

Ontario Power Generation Inc.

Application to renew the Power Reactor Operating licence for the Darlington Nuclear Generating Station

Demande concernant le renouvellement du permis d'exploitation pour la centrale nucléaire de Darlington

Commission Public Hearing
Part 2

Audience publique de la Commission
Partie 2

November 2-5, 2015

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<u>**Written Intervention for the Darlington Relicensing Public Hearings (Ref: 2015-H-04)**</u>

Submitted by: Dr. Frank Greening on September 25, 2015

Introduction:

The most important issue to be considered in any debate on the relicensing of Darlington NGS is OPG's plan to refurbish all four Darlington Units at some point during the proposed licensing period. In this regard it is essential to take a precautionary approach to granting OPG an operating license because OPG is in the business of running power stations – *<u>not rebuilding them</u>*. And the CNSC needs to recognize that the refurbishment of a large CANDU reactor creates a heightened potential to expose workers to radiological hazards that are *<u>not</u>* present during the day-to-day operation of a reactor. To make matters worse, OPG has already contracted out most of the refurbishment work to third-party engineering companies such as SNC-Lavalin and AECON Industrial and these companies are now in the process of hiring hundreds of construction workers, *<u>most of whom have no prior training in radiation protection</u>*. And let's keep in mind that the history of reactor refurbishments in Canada - going back to Pickering A in1985 and culminating with Bruce A in the period 2007 to 2011 - is filled with a litany of problems associated with the release of airborne particulate containing species such as C-14, Fe-55, Pu-239, Am-241 and Cm-244, that resulted in the contamination of hundreds of refurbishment workers.

But what is most disconcerting about these past exposure events is that the regulatory body responsible for ensuring the safety of refurbishment workers was, at the start of each of these projects, *<u>totally unaware of the presence of the radiological hazards that led to these exposures</u>*. Indeed we may justifiably conclude that our nuclear regulators have proven themselves to be the *<u>worst</u>* judges of potential radiological hazards in refurbishment projects. Thus, for example, in 1985 the presence of solid carbon-14 on the outside surface of pressure tubes in the annulus gas system proved to be hazardous – something that was "missed" by the AECB. And in 2009, alpha-emitting transuranic isotopes on the inside surfaces of feeder pipes proved to be a major radiological hazard that was "missed" by the CNSC.

But to be absolutely clear what I mean when I say major radiological hazards were "missed" by our nuclear safety regulators during past refurbishment operations, it is useful to consider the following:

At the September 2014 Public Hearings into OPG's proposed DGR project, Dr. Gordon Edwards suggested that the safety of nuclear facilities in Canada has been thrown into doubt by the 2009

Bruce alpha-contamination event. By way of a rebuttal, Dr. Thompson, Head of the CNSC's Environmental and Radiation Protection and Assessment Directorate, responded:

> "*The Bruce alpha-event was unforeseen (*and*) there was no evidence that there was a potential for this event, so it's not something that Bruce Power or its employees decided to ignore*."

This statement clearly demonstrates that the CNSC believes that *the Bruce alpha event could not have been prevented because it was "unforeseen"*; and let's not forget that this lack of foreknowledge evidently includes *everyone* at the CNSC, despite the fact that this organization is entrusted with the task of *recognizing and controlling radiological hazards in Canada's nuclear facilities*.

But to fully understand the implications of the mass contamination of more than 500 workers at Bruce A we need to look at the CNSC's regulatory position with regard to the safety of the Bruce refurbishment project. This was clearly stated in the May 2006 Public Hearing on the Safety and Environmental Impact of the project. Thus, in a Section from the May 2006 Hearing entitled: *Radiation and Radioactivity*, we read the following:

The Commission sought information on the protection of workers to radiation exposure during the refurbishment. In response, Bruce Power assured the Commission that the entire project will be managed according to the ALARA (As Low As Reasonably Achievable) principle. Thus appropriate planning and training, remote execution of activities and providing adequate shielding would ensure that time, distance and shielding principles would be respected. CNSC staff stated its satisfaction with the proposed controls to keep worker exposure to radiation to a minimum, in addition to existing mitigation measures already in place at the Bruce NGS A.

These statements show that in 2006 *the CNSC was completely satisfied with the safety measures proposed by Bruce Power for its planned refurbishment project*. However, consider what was subsequently concluded in the CNSC's *Review of Bruce Power's S-99 Additional Information Report*, issued in April 2010:

> *The Bruce A Restart Radiation Protection Program was inadequate to anticipate, monitor, evaluate and react to an alpha airborne particulate hazard.*

And page 4 of this document adds the following items as additional contributing factors to the event:

> *1. Alpha OPEX (Operating Experience) was not integrated into the existing radiation protection program.*

2. Feeder pipe source term information was not used to contain the hazard and protect workers from alpha exposure.

3. Radiation safety criteria for airborne particulate were not established for performance testing of J-prep tooling.

4. Radiation Exposure Permits were issued and approved without the requirement for airborne radiation surveys in the breathing zone.

5. High Hazard Work criteria did not recognize the potential for loose or airborne particulate during refurbishment operations.

6. Accountability for oversight of the Restart Radiation Protection Program was inadequate, not documented, communicated or implemented.

But it is important to remember that all of these failures and safety infractions occurred *under the watchful eye of on-site CNSC inspectors*. However, while these safety violations are of great concern, what is even more alarming about the 2009 alpha contamination event is the following additional statement made by the CNSC in its *Review of Bruce Power's S-99 Additional Information Report*:

The information gathered during the investigation and the complete Root Cause Report were not made available to the CNSC staff. Therefore CNSC staff is unable to comment on the appropriateness of the causes identified

Thus we have the remarkable admission from our nuclear regulator, (made in 2010), that CNSC staff are unable to independently determine what caused the 2009 alpha contamination event at Bruce NGS - a situation that prevails to this day. Nevertheless, having been privy to the contents of the *Root Cause Report*, I can state *with certainty* that the root cause of the Bruce contamination event is that Bruce Power deliberately ignored data showing the presence of airborne alpha particulate in the Unit 1 vault in order to complete feeder pipe replacement work as expeditiously as possible. Thus, production took precedence over the need for respiratory protection of over 500 refurbishment workers.

And it is very significant that OPG has already made it clear to the companies contracted to carry out the Darlington refurbishment that a slowdown or budget overrun by any one of them could affect the overall timeline and budget and therefore must be avoided at all cost. Therefore, these companies know full well that they are being held accountable and will not be allowed to simply pass additional expenses on to ratepayers. Thus we see OPG putting project management, supply chain considerations, cost and business risk above safety in developing its refurbishment implementation plan – See OPG Report N-REP-00120.3-10000-R001: *Darlington*

Refurbishment Business Case Summary, issued November 2013. And it is noteworthy that *radiation safety* is not even mentioned in OPG's *Refurbishment Business Case*.

But now that the CNSC is being asked to approve more refurbishments, I am wondering what else the CNSC doesn't know about refurbishment hazards that could prove detrimental to worker safety. Most regrettably, based on the Pickering and Bruce refurbishment experiences, it appears that the CNSC is quite content to deal with such problems *after* they appear. Nevertheless, before we charge headlong into more "unforeseen" radioactive particulate uptakes by trusting refurbishment workers, may I suggest the CNSC needs to evaluate the following issues concerning the refurbishment of Darlington Units 1 to 4:

1. The alpha source term for all four Darlington Units
2. Radiation field data for all four Darlington Units
3. The training that will be given to Darlington refurbishment workers

These topics are considered in detail below.

1. The Darlington Alpha Source Term

As with Bruce Unit 1, which experienced serious fuel damage early in its operational history leading to the release of transuranic radionuclides to the Unit's PHTS, Darlington had a similar incident in channel N12 of Unit 2 in 1993, just 2 years after Unit start-up. The Darlington fuel failure was precipitated by coolant induced acoustic resonance leading to fuel bundle endplate cracking, followed by bundle disassembly. The acoustic resonance was caused by the original design of seven vane impellers on the primary heat transport system pumps – a design flaw that has now been fixed. However, it has been reported that there were residual effects on Darlington fuel bundles well beyond 1993 leading to increased fuel failure rates through to at least 1995. Thus, significant levels of alpha-emitting radionuclides are expected to be present on the PHTS surfaces of all Darlington Units, especially Units 2 & 3.

OPG Report NK38-REP-09071-10002-R000: *Alpha Hazard Characterization Report – Darlington Nuclear 2010,* issued November 2010*,* discusses recent attempts to characterize alpha contamination at different work locations in Darlington Units 2 and 3. The report notes that for 21 smears collected between April and August 2009 the gross beta to alpha ratio ranged from a low of 39 to a high > 21000. Nevertheless, the report recommends the use of fission product "beta-emitting surrogates" measured in surface contamination smears for the internal dosimetry of alpha emitting transuranics, thereby avoiding the need for expensive and time consuming alpha spectrometric analyses of Darlington samples.

This recommendation is very questionable because it suggests that the authors of the 2010 *Alpha Hazard Characterization Report* for Darlington are unaware of previous studies of alpha contamination in CANDU stations. In particular, mention should be made of a 1980s Ontario Hydro study of beta/alpha activity ratios in air filter and surface contamination smears collected in Bruce Units 2 and 4 and Pickering Unit 3 – See Ontario Hydro SSD-88-5 Report N-REP-03420-0018829: "*Characterization of Transuranic Alpha-Emitter and Sr-90 Air and Surface Contamination at Ontario Hydro's Nuclear Power Generating Facilities*" issued in 1988. This study analysed data from 34 samples and found beta/alpha activity ratios ranging from a high of 4300 to a low of 5. Because of the wide dispersion of the data, it was recommended by the author of the 1988 study "*that actual measurement of alpha activity on air or smear filter papers be made to quantify the air and surface contamination levels of transuranic alpha-emitters and **surrogate measures** in the form of fission product gamma/beta to transuranic alpha ratios **not be used***". (My emphasis)

The detailed radionuclide-specific analyses of the Darlington smears discussed above are available in two COG reports: TN-10-3019 and TN-10-3020, issued in August 2010 and October 2010, respectively.

The TN-10-3020 report notes:

> "*The presence of high activity of Cm-244 and relatively low Am-241 and Pu-239/240 in the samples indicates that the origin of the alpha contaminants at these sample collection locations is high burn-up fuel.*"

This is another questionable assertion because a comparison of the measured Darlington smears activity ratios to the expected activity ratios of Cm-244 to Am-241 and Cm-244 to Pu-239/240 in high burn-up fuel shows that the measured ratios are *much higher* than the ratios for very high burn-up Darlington fuel. Furthermore, the measured activity ratios vary considerably from sample to sample. Thus, the transuranic activities found in irradiated fuel with a normal 1-year exposure in a CANDU reactor core exhibit a Cm-244 to Pu-239/Pu-240 ratio less than 0.1. By comparison, a number of the Darlington smears exhibit a Cm-244 to Pu-239/Pu-240 ratio greater than 40. This suggests that some of Darlington's surface contamination contains highly irradiated "tramp" uranium of uncertain provenance. Clearly therefore, it is not possible to predict values for Darlington actinide isotope ratios in airborne particulate samples – ratios that would be required for dose assessments in the event of refurbishment worker exposures to airborne alpha contamination.

After the alpha-contamination incident in Bruce Unit 1in 2009, Bruce Power embarked on a very extensive alpha source term characterization campaign for all of its Units and fuel handling areas – a study that was long overdue. As a result <u>*hundreds*</u> of smear samples were analysed for the full spectrum of radionuclides produced in a CANDU PHTS. However, the highest gross alpha activity found on 22 Bruce Unit 3 & 4 vault smears was only 0.3 Bq. By comparison, a gross alpha activity of 42 Bq was found on the outside of a Darlington Unit 2 PHTS purification filter, and yet OPG appears to be satisfied with the results of this cursory look at the Darlington alpha source term. This is not acceptable, especially when alpha-emitting radionuclides are always detected in Darlington ALW samples on the rare occasions that such samples are checked for alpha activity – See, for example, the 2003 report COG-03-3046. And finally, I would like OPG to explain why an air filter sample from a Darlington stack monitor, collected in June 2002, showed the presence of 0.33 Bq of gross beta and 0.1 Bq of gross alpha activity, indicating airborne particulate with a gross beta to alpha ratio of 3.3.

2. Darlington Radiation Fields

A detailed knowledge of the radiation fields at every work location in a reactor vault is crucial for the safety and dose minimization of Darlington refurbishment workers. It is of course quite possible to accomplish such radiation surveys after each Darlington Unit has been shut down to be prepared for refurbishment. However, these measurements do ***not*** provide information on the fields that may develop at a particular location as the result of opening up a system and carrying out refurbishment work.

A good example of how radiation fields can quickly become problematic is seen in the Bruce refurbishment experience. Pressure tube removal in Unit 2 was initially expected to take approximately one month; however, pressure tube removal took 86 days or almost three times longer than expected because of unanticipated problems with the pressure tube volume reduction system (VRS). After only 30, (out of 480), pressure tubes had been removed, the VRS failed because pressure tube debris became jammed in the VRS cutting assembly. In addition the VRS transfer cans were frequently damaged due to misalignment problems with the retube tool carrier or RTC. Smears of the VRS transfer cans performed early in the Unit 2 pressure tube removal operations measured contact dose rates ~ 30 mrem/h. However, radiation surveys carried out several weeks into Unit 2 pressure tube removal operations measured 800 mrem/h on contact with the inside (unloading end) of a transfer can, showing how easily radiation hazards could appear in a refurbishment work area.

Bruce Power eventually discovered that the source of the high contamination levels found on VRS equipment was activated rust, ("red iron oxide"), which coated the annulus gas region of the fuel channels. The annulus gas system (AGS) of a CANDU reactor consists of an approximately 1 cm annular space between the outside of a pressure tube and the inside of the adjacent calandria tube. These tubes are terminated by metal bellows which are connected to narrow bore pipe work that carries a gas mixture, (e.g. CO_2 and O_2), to and from each fuel channel. In the event of a pressure tube leak, heat transport D_2O enters the AGS and collects near the carbon steel radiation shielding sleeve and bearing journal located at the outboard end of the pressure tube end-fitting. In a wet oxidizing environment, such as an AGS with a leaking pressure tube, hydrated ferric oxide ("red iron oxide") tends to form on carbon steel components.

In the case of Bruce Unit 2 there was a major pressure tube failure in channel N06 in 1986 which eventually flooded the entire AGS. A pressure tube was removed from channel K03 of Bruce Unit 2 in October 1991. The removal operation was accompanied by the dispersal of a fine red dust into the reactor vault and a cleaning bung that was pushed through the open K03 channel after the pressure tube removal operation exhibited a very high radiation field (>10 R/h). I analysed some of the red dust from this bung and issued a report in February 1992: "*Characterization of a Bruce Unit 2 end-fitting smear*" – See OHRD Report C92-10-K. In this report I show that the red oxide activity was mainly due to Fe-55 which was present at the very high concentration of about 3×10^{10} Bq/g.

Eighteen years after this discovery, and by the time Bruce A was being refurbished, Bruce Power had apparently forgotten about the presence of this high specific activity material in Unit 2. Nevertheless, very large amounts of this red oxide were observed in *every* channel during Unit 2 pressure tube removal operations. Furthermore, a significant amount of this material became trapped underneath the calandria tube scraper tool causing high radiation dose rates to emanate from the west pallet's push heads. Indeed, contact dose rates on these heads were found to be as high as 30 Rem/h. It is therefore not surprising that by the time pressure tube replacement operations in Unit 2 had finished in mid-2009 the total accumulated dose to the refurbishment workers involved in this operation was 15,318 person-mrem, *or almost <u>four times</u> <u>the target dose</u>*.

It is finally worth noting that each of the four Darlington Units will be fully operational right up to the time they are shutdown for refurbishment. This means that the average radiation field in each Darlington vault is likely to be much higher than the fields experienced in Bruce Units 1 & 2 in 2009 because these Bruce Units had been laid up for almost ten years prior to their refurbishments thereby allowing significant decay of species such as Co-60 and Zr/Nb-95, the major contributors to CANDU radiation fields. Thus, for example, gamma radiation surveys conducted after Unit 1 feeder pipe cutting operations in 2009 showed dose rates up to100 mrem/h on contact with the capped ends of cut feeder pipes. By comparison, as reported in COG-08-3024: "*Characterization of Reactor Face Radiation Fields*" issued in September 2009, Darlington Unit 3 exhibited reactor face radiation fields up to 168 mrem/h in 2006, and are likely to be even higher by the start of refurbishment operations in 2016. Of additional concern are the 960 Darlington end fittings which also have to be removed and replaced for each Unit's refurbishment. Radiation dose rates as high as 500 mrem/h have been measured 1 meter inboard of the closure plug face of these components.

3. Training for the Refurbishment Project

Of the many tasks that are required for the refurbishment of a large CANDU reactor, pressure tube and feeder pipe replacement operations - referred to by the acronym *RFR*, meaning *Retube and Feeder Replacements* - are by far the most difficult, dangerous and costly. In addition, the RFR work package is almost always on the critical path of the Darlington refurbishment project.

Most of the contract workers hired for Darlington's RFR project, which is slated to start on Unit 2 by the end of 2016, *have never been in a nuclear plant* and are therefore in dire need of extensive radiation protection training. As it now stands, this training is provided in the form of the so-called "Orange Badge Qualification" which is a three day "crash" course on basic radiation safety – See Darlington Report N-TQD-502-00001, (Qualification No: 35845) . The suitability of this training for the Bruce refurbishments in 2007 - 2011 was reviewed by the Radiation Safety Institute of Canada which concluded that the material presented to the workers was "insufficient". For example, references to alpha radiation did not appear at all in the training material. Regrettably, having taken this course myself (in 2010), I can attest to the inadequacy of this type of training – the main problem being that the training is totally "task" oriented and does not provide information on station OPEX or plant history.

This approach, which is so favored by the nuclear industry, has the impressive sounding appellation: *Systematic Approach to Training* or SAT and is based on the individual *tasks* needed to accomplish a particular goal, be it the measurement of the pH of a liquid sample or the gamma-spectrometric analysis of a filter. Under the SAT approach these quite different goals are rated as being equally difficult because they involve the same number of steps, or *tasks*, such as turning on the instrument, positioning the sample, recording the data, etc, etc. The reality is, however, that gamma spectrometry requires an extensive background in radiation physics and chemistry, while pH measurements may be carried out without much difficulty by a high school student. The overall consequence of this method of training refurbishment workers is that it turns out robots, lacking in critical thinking skills – rather than workers who are able to notice anomalies and deal with unusual circumstances.

Even in the case of *Health Physicists*, the inadequacy of a "systematic approach" to radiation protection training was recognized by the Radiation Safety Institute of Canada when it stated in its July 2011 Report: *Independent Review of the Exposure of Workers to Alpha Radiation at Bruce A, Reactor Unit 1*:

1. *A specialized short course on the origin of alpha activity and other important radionuclides and their transport and deposition throughout station systems (referred to as "activity*

transport") was delivered in December, 2010 to a group of five relatively inexperienced Health Physicists from across the site. This course was developed and delivered by Dr. Frank Greening, Senior Radiochemist on the Radiation Protection Recovery team. Part of this lecture was observed by the Radiation Safety Institute. Based on discussion during the lecture itself and a follow-up discussion by the Radiation Safety Institute observer with the students, it was clear that they found this type of information critical and that their previous training was felt to be inadequate to support their role as Health Physicists at Bruce Power.

It is important to add that the training of *management staff* involved in the Darlington refurbishment project is also an issue that needs to be addressed by OPG and the CNSC. This has been spelled out in no uncertain terms by two independent consultants – Burns & McDonnell and Modus Strategic Solutions – in their *Supplemental Report to the Nuclear Oversight Committee – 2nd Quarter 2014 Darlington Nuclear Refurbishment Project*, issued June 26, 2014. In this document we find the following criticisms of OPG's current efforts in training and oversight:

1. In a Section entitled *Staffing and Leadership*:

● *The Refurbishment Planning and Controls Risk Group is lean and staffed with relatively inexperienced individuals - several staff are Co-ops or interns.*

● *Training for Risk Management and related programs is occurring in an ad hoc manner, and the resultant issues addressed in this report reflect its ineffectiveness.*

●*The DR Team has struggled with defining its "oversight" role of the contractors. OPG needs to embrace "active management" of its contractors and apply lessons learned from early RFR work regarding benefits of active management vs. passive oversight.*

2. In a Section entitled OPG Contractor Management and Contractor Performance:

● *Based on the information we have reviewed, it is apparent that P&M[1] put excessive faith in the ESMSA[2] Contractors' ability to perform this work and an over-reliance on the perceived ability of the EPC[3] contracting model to shift project risk to the contractor and alleviate the need for active project management. As a result, OPG chose to provide oversight of the contractor's work at arm's-length.*

1. P&M: Project and Modifications

2. EMSA: Extended Service/Master Service Agreements

3. EPC: Engineer, Procure and Construct

● *In a recent self-assessment, the P&M Project team ("P&M Team") noted that at the onset of the Project, P&M believed "the EPC Process" would mitigate known risks via "project efficiency gains due to the expertise and autonomy of the contractor." This exemplified OPG management's initial hands-off approach to project management that P&M piloted under which the contractor was given autonomy to develop its own scope requirements without process monitoring. As noted in P&M's self-assessment, this model resulted in "unclear expectations, re-work, frustration."*

● *It is apparent that the P&M Team did not have the necessary experience, training or internal management direction to properly manage this work.*

● *In the management of the work, P&M:*

(i) Routinely accepted poor quality schedules and cost estimates without adequate vetting

(ii) Mischaracterized the nature of these estimates by assuming anything provided by a contractor was at a very high level of maturity

(iii) Failed to establish accountability standards for the contractors

(iv) Failed to identify or mitigate known risks

(v) Did not effectively react to problems when they materialized

(vi) The ESMSA contractors contributed to the problem by not transparently reporting or timely identifying how these projects were evolving and failing to provide any reliable metrics—cost, schedule or otherwise – that informed OPG of these brewing problems

(vii) Risk management training is virtually non-existent in the P&M organization in distinct contrast to several years ago when quarterly workshops were regularly conducted.

It is interesting to compare these comments by the Darlington Oversight Committee with OPG's own assessment of its ability to carry out the refurbishment of Darlington in a safe and expeditious manner. Thus we read in OPG's *Written Submission in Support of Darlington's Power Reactor Operating License* CMD 15-HB.1, issued in August 2015:

After six years of planning, 40 years of project management experience, ... OPG has built a strong foundation for a successful refurbishment based on:

- *Extensive benchmarking and continuous learning;*
- *Management capability;*
- *Extensive and detailed planning;*
- *Development of supplier and contractor relationships; and*
- *A robust management system*

OPG, as the licensee, retains overall responsibility for ensuring protection of workers, the public and the environment. This responsibility, whether the work is performed internally or externally, is ensured through a robust management system, including oversight of contractors.

This claim by OPG of full responsibility for and oversight of all refurbishment activities is contradicted by another statement by OPG contained in the same document:

> *The principal contractors will be allowed to use their own quality program and manage quality to all applicable standards. This allows the contractors to use the systems to which they are accustomed as they supervise the work to achieve cost, schedule and quality deliverables.*

I have to ask: Are any of these statements by OPG consistent with the comments (noted above) made by Burns & McDonnell and Modus Strategic Solutions in their 2014 *Report to the Nuclear Oversight Committee*? I think not – the Darlington refurbishment project is already out of control even before RFR work has begun! And would OPG like to comment on the number of injuries and "near-miss" incidents that have already occurred in the Darlington Energy Complex reactor mock-up facility.

Discussion:

A CANDU reactor refurbishment is a dirty and dangerous operation that inevitably spreads radioactive contamination throughout a reactor vault and needlessly exposes workers to severe radiological hazards. Worse yet, the history of reactor refurbishments or maintenance operations involving large scale fuel channel and/or feeder pipe replacements, is a history of radiation exposures of hundreds of workers caused by "unforeseen hazards".

For Pickering Units 1 & 2 it was C-14 dust in the annulus gas system; for Point Lepreau it was Cm-244 in pressure tube deposits; for Bruce Unit 1 it was alpha-contamination of feeder pipes; for Bruce Unit 2 it was Fe-55 "red-dust" in calandria tubes.

However, it should be emphasized that in the case of Pickering and Bruce, I had previously provided the station Health Physicist with early warnings of the hazards in question:

For C-14 at Pickering, see: *Analysis of Pickering NGS "A" Unit 4 N_2 Annulus Gas Filter Deposit.* OHRD Report C81-04-K, (January 1981).

For Alphas at Bruce, see: *Analysis of Bruce NGS "A" Particulate Samples Collected Nov/'79, Feb/'80 and April/'80.* OHRD Report 80-234-K, (June 1980).

For Fe-55 at Bruce, see: *The Characterization of a Bruce Unit 2 End Fitting Smear.* OHRD Report C92-10-K, (February 1992).

But in all these cases, the warnings were quickly forgotten by the refurbishment planners and their radiation protection "experts", an occurrence that is very troubling indeed. But of even greater concern is the fact that our nuclear regulator, the CNSC, was also totally unaware of the presence of these hazards in the reactors under its safe-keeping. Thus, it is quite clear that *the CNSC is not in a position to guarantee the safety of the proposed Darlington refurbishment operations* because of its lack of knowledge and understanding of the potential hazards lurking in all four Darlington Units. And this inconvenient truth also highlights the additional problem of the lack of subject matter experts (SMEs) in Canada in the area of CANDU refurbishment hazard assessment.

In the IAEA report: *Analysis Phase of Systematic Approach to Training (SAT) for Nuclear Plant Personnel*, IAEA-TECDOC-1170, issued August 2000, we find a definition of a SME:

SUBJECT MATTER EXPERT (SME) — A job incumbent qualified and experienced in performing a particular job. SMEs need to be senior, experienced individuals who are experts at the job for which training is to be developed.

SMEs are plentiful in the area of *routine* nuclear power station operations because Canada has experience in this regard going back at least 40 years. However, this is simply not the case with regard to the availability and quality of job incumbents or industry acknowledged experts in non-routine activities such as reactor refurbishment or decommissioning. This expertise gap - and the problems it engenders - has been ignored by Canada but is recognized by the nuclear industry worldwide. Thus, in the IAEA report: *Decommissioning of Nuclear Facilities: Training and Human Resource Considerations,* IAEA NUCLEAR ENERGY SERIES No. NG-T-2.3, IAEA, issued in 2008, we read:

Decommissioning of nuclear facilities is a process involving activities such as radiological characterization, decontamination, dismantling of facility systems and equipment, and the handling of waste and other materials. Many organizational and management needs arise during the course of decommissioning projects. While a significant amount of attention has been *focused on the technical aspects of decommissioning and many IAEA publications have been developed to address technical aspects, human resource considerations — particularly the training and qualification of decommissioning personnel — are becoming more paramount with the growing number of nuclear facilities of all types that are reaching or approaching the decommissioning phase. Training alone cannot ensure the required competence. Change management, human performance improvement and knowledge preservation policies and practices also need to be implemented to promote adequate performance of the personnel involved in decommissioning. Training of personnel for undertaking the decommissioning project should be viewed as an integral part of the human resource management process.*

During decommissioning many of the activities and tasks undertaken are very unique and only performed one time. In such situations, extensive job and task analysis, or job competency analysis, and training programme course development are usually not undertaken. Instead more detailed work planning is conducted by the operating organization to identify all of the steps involved in a particular decommissioning task. As part of this activity planning process, Job Safety Analysis (JSA), Job Hazards Analysis (JHA), Risk Assessment, and Hazard and Operability (HAZOP) Analysis have been developed.

A job hazard analysis is a technique that focuses on job tasks as a way to identify hazards

before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment. Ideally, after one identifies uncontrolled hazards, the steps to eliminate or reduce the hazards to an acceptable risk level are taken. One of the most important elements of controlling the risks and making sure that the controls identified are used properly is the provision of information, instruction, and training to those doing the work. The control or elimination of hazards through measures other than training is normally the preferred option. When this is not completely possible, training of workers must be provided. In order for the JHA process to work effectively, subject matter experts, training personnel and workers must all be involved in the Job Hazards Analysis process working together as a team.

Even though a large number of training courses from operating reactors are applicable, including those for radiation safety training, it is usually necessary to place much more emphasis on radiation worker training due to the more significant radiological challenges encountered during decommissioning activities and the greater potential for exposure of personnel during specific decommissioning tasks. The radiological surveillance completed during the operational phase of a facility would have been based largely on routine surveys confirming steady state known conditions. In decommissioning, the requirements are to supplement this routine monitoring with task specific radiological monitoring of constantly *changing conditions where the radiological hazards can be unpredictable. It is important to provide this enhanced training so that the workers and supervisors recognize this change, and will be better prepared to perform the radiological work. A growing shortage of trained skilled workforce in the nuclear industry in general, and nuclear decommissioning in particular, is a real problem in this regard.*

From this review of the IAEA's concerns about training for the decommissioning of nuclear reactors, we note that precisely the *same* concerns must be addressed for *refurbishments*, since both activities involve cutting open highly radioactive systems and dealing with the resultant dirty and dusty highly radioactive waste.

Conclusions:

As pointed out at the start of this submission, the most important question to be resolved in considering the relicensing of Darlington is; Assuming Darlington *is* relicensed to operate, would it be wise for OPG to also proceed with the refurbishment of all four Units? This is not a trivial question because the proposed refurbishment of Darlington will not only cost over $ 10 billion, but will also put hundreds of workers in harm's way and generate thousands of tons of highly radioactive waste.

And, even though the CNSC is yet to approve an operating license renewal for Darlington, OPG has already awarded several $100 million contracts to its nuclear industry friends, and preparations for the Darlington refurbishment project are well underway. But reading the IAEA's warnings noted above about the difficulties of finding and training temporary staff to carry out "heart-replacement surgery" on aging nuclear reactors, and thinking about the hazards associated with such activities on all four Darlington Units, I am requesting that any activities involving the removal of radioactive pipe work from Darlington Units *should be deferred until the following three actions have been undertaken and completed*:

1. The currently "closed" – as declared by the CNSC – investigation into the root cause of the alpha-contamination event in Bruce Unit 1 in 2009 must be re-opened and new evidence, previously ignored by the CNSC, should be accepted as crucial to the root cause analysis.

2. As part of this new evidence, the existence of Bruce Unit 1 CM-11 alpha contamination data from November – December 2009 must be acknowledged and the data reviewed.

3. Plant-history-based training, delivered by SMEs, must be implemented at Darlington so that refurbishment workers may better understand and protect themselves from radioactive contamination in each reactor slated for refurbishment and its environs.

The reasons for requesting that these issues be addressed are as follows:

Throughout several Public Hearings into the Bruce alpha-contamination event, Bruce Power has insisted that it did *not* have the capability to monitor for airborne alpha particulate in the Unit 1 vault during its refurbishment. This claim is demonstrably false: Bruce Power had perfectly adequate CM-11 alpha detectors that recorded the presence of airborne alpha activity in the Unit 1 vault starting on November 28th, and ending on December 21st, 2009. Gross alpha levels as high as 147 Bq/m^3 were measured in that time period which is well above the level for which respiratory protection of workers is required. Nevertheless, Bruce Power chose to ignore this data, an action that has never been questioned by the CNSC.

Because of this denial of what *really* happened at Bruce in 2009, the root cause of the alpha contamination event has never been publically elucidated. In addition, no one has been held accountable for the contamination of over 500 refurbishment workers and, as a consequence, *there have been no lessons learned*. Therefore, without steps being taken to remedy this situation, the safety of future CANDU reactor refurbishments remains very questionable because the Canadian nuclear industry and its *faux* regulator, the CNSC, *cannot be trusted to protect refurbishment workers from harm*.

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