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Written submission from David Winfield

Mémoire de David Winfield

In the Matter of the

À l'égard de

Royal Military College of Canada

Collège militaire royal du Canada

Application from the Royal Military College of Canada to renew its non-power reactor operating licence for its SLOWPOKE-2 facility

Demande du Collège militaire royal du Canada concernant le renouvellement de son permis d'exploitation d'un réacteur non producteur de puissance pour l'installation SLOWPOKE-2

Commission Public Hearing

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Comments on Application for the April 19, 2023 Renewal of the Class 1A Licence for the SLOWPOKE-2 Reactor Facility at RMC

Reference: CMD 23-H3

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Executive Summary

RMC SLOWPOKE-2 reactor facility is requesting (CMD 23-H3.1, revised with the 25 January 2023 letter): (i) a licence renewal period of 20 years and (ii) an increase in the excess reactivity to 4.3 mk. My comments for the Commission is that a 20-year licence period is warranted and can be justified. The intervenor is familiar with the technical aspects of a 4.3 mk excess reactivity and concurs with that request. Support for the licence period is based upon the intervenor's technical knowledge of the reactor design and operational record, including review of the last decade of annual compliance reports and the condition assessment provided in the 25 January 2023 letter. Section 1 provides more details. To save repetition, some of the intervenor's Polytechnique Montréal CMD 23-H2.2 submissions are also referred to, where information therein is equally applicable for RMC.

The intervenor also concurs with the CNSC Staff proposal (CMD 23-H3, Section 3.3.3.1) to remove the Operating Limits and Conditions (OLC's) from the licence, into the LCH. Deficiencies in the proposed OLCs are identified by the intervenor in Section 2. Four important omissions, Sections 2(i) to (iv), with practical implications for reactivity safety are recommended to be added to the OLCs, These significant omissions influence the design basis of SLOWPOKE-2. Among with the OLC omissions the intervener's opinion, Section 3, is that the Safety Analysis Report needs significant improvement in the longer term, to justify a licence lasting 20 years, to meet current the IAEA SAR safety standards by keeping up with content requirements, as well as editorial and presentation content improvements. CNSC staff CMD 23-H3.A, February 23 2023, Table 2, specifically notes that, as one of the key documents, the SAR should be maintained valid and up-to-date, regardless of licence period.

Section 4 and 5 comments, regarding document version control quality are of lesser importance than the SAR, but are nevertheless included to meet requirements for valid up-to-date documentation. The intervenor sees this as particularly important for future new staff in the longer term.

Section 6 is provided as an overall general observation; that the extent of the current required licensing documentation (182 pages for CMD 23-H3) does not, to the intervenor, display much evidence of a graded approach in the scope, level of detail and resource effort required. For a facility specifically designed for (and successfully operated for decades) with a very small staff complement, excessive non-prioritized documentation will inevitably lead to resources being spent on low value topics and documentation, but hopefully not, at the expense of more practical safety aspects.

Section 1. Review

General overview comments remain the same as those made for Polytechnique Montréal in CMD 23-H2.2 except to note some differences: (i) RMC's neutron beam tube design change (which does not effect the comments) and (ii) the date of RMC's first operation was 1985 and (iii) the expectation of no significant design basis changes now to 20 years, as opposed to 10 years, is also valid. The last Polytechnique Montréal Section 1 intervention paragraph regarding the choice of a license period also remains applicable to RMC. The condition of the beryllium reflectors, expected by the intervenor to be the components most vulnerable to irradiation damage, were

not explicitly mentioned in the 25 January 2023 letter. Pristine conditions however were reported for all the RMC reactor major components. This RMC inspection information, as well as the beryllium irradiation damage data supporting the intervenor's CMD 23-H2.2 Section 1 submission, suggest that any beryllium neutron fluence damage within the proposed 20-year licence period can reliably be discounted. As also mentioned in Polytechnique Montréal CMD 23-H2.2 Section 1 and also as implied in the RMC 25 January 2023 letter, continual good water chemistry control will still be essential to minimize potential ageing corrosion of the reactor container and its contents[1].

Section 2: CNSC Staff proposal (CMD 23-H3, Section 3.3.3.1, p 22) to remove Operating Limits and Conditions (OLC's) from the licence to the LCH.

The intervenor concurs with this CNSC staff proposal.

The intervenor disagrees however with CNSC staff (CMD 23-H3, page 22) that no changes should be made to the OLCs (CMD 23-H3, NRPROL-20.00/2023 Appendix A), other than for the proposed new 4.3 mk limit. The intervenor provides justifications (i) to (vii) below to support this position. Comments (i) to (iv) recommend additions to the five OLCs in Appendix A, in order of the most safety significance, from the intervenor's experience. These are focused on maintaining the safe operating envelope, all relevant to preventing situations leading to potential accidents or to effect mitigation of accident consequences. Comments (v) to (vii) relate to OLC documentation clarity and keeping up-to-date revision control.

(i) The OLCs do not include the historical licence conditions for authorizing reactor operation at power without a licensed operator in attendance in the facility. This historical licensing item, initiated in 1972, eventually progressed over a number of years into conditions specified in CPSR-362 Rev. 2, 1984. CPSR-362 is still listed as a licensee document (CMD 23-H3, page 22). It is though not known if any update of CPSR-362 still contains this item, as the licence provides no date or latest revision for CPSR-362. This is a key OLC, internationally unique to SLOWPOKE reactors (and some of the MNSRs) and is perhaps one of the most important OLC that could be envisaged. From the public perspective this significant SLOWPOKE feature is often quoted in the literature and was quite recently quoted in the press from the design authority[2]. Having deleted OLCs or outdated revisions of OLC's in different documents, if this is the case, should be avoided. For unattended operation (a more appropriate title perhaps than 'Remotely Attended Operation') SEP-5, Section 5.2.1c lists in detail the four conditions allowing this, still identical to those in

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[1] Given the overarching vital importance of water chemistry specifications and procedural control for long term ageing management, the intervenor notes that neither SEP-5 nor CMD 23-H3, page 31, provide the reader with direct references to the various chemistry technical specifications and related operating procedures.

[2] A recent November 2021 US NRC Public Discussion Paper *"Ground Rules for Regulatory Feasibility of Remote Operations of Nuclear Power Plants"* also specifically highlights that Canada's SLOWPOKE-2 reactor is licensed for unattended operation in automatic mode, noting that this is the closest available international comparison to remote reactor operation; the topic of the Discussion Paper.

the 1984 CPSR-362 report revision. In view of transparency to the public and as unattended operation at power is still permitted, the intervenor submits these four licence conditions should be visible in the LCH as an OLC. There is no need for OLC details to be in SEP-5. Duplication merely complicates revision control and risks inconsistency.

(ii) There is no current OLC for limiting the amount of fissile material that may be irradiated. The intervenor submits this is a significant omission that should be rectified[3]. A mass limit on fissile material irradiations is fundamental to the safety design configuration control of the reactor. See also the comment in Section 3, p.8 below: *"Limits on the mass of fissile irradiation samples"*.

(iii) SLOWPOKE-2 has no automatic trip system. The minimum number of auxiliary shutdown system (ASDS) cadmium capsules, the minimum reactivity worth required to shutdown the reactor and a mandatory requirement for at least one annual test of the ASDS, should all be collected and listed in one OLC. SEP-5, Section 5.2.4 does specify the ASDS tests, but this important requirement is not in the current OLC list. Section 3.2.4.2 also specifies the capsule's mk worths, but does not explain how these values show that the ASDS shutdown margin is acceptable.

(iv) The maximum number of irradiation sample vials that are allowed simultaneously in the inner irradiation sites should be specified in an OLC. The purpose is to ensure the ASDS cadmium capsules are capable of shutting down the reactor with an acceptable shutdown margin, during sample irradiation activities.

(v) SEP-5 contains no collective mention of OLCs and does not provide, as a minimum, a reference to the current list of OLCs. This is not compliant with IAEA NS-G-4.4, para.1.5 requirement; the current international safety standard for research reactor OLCs[4].

(vi) There should be no other 2023 license-related documents that present different versions of OLC's. CMD 23-H3, page 90 notes the OLCs are also listed in the Reactor Operating Manual. There should be only one version of the current OLCs if they are listed in other licensing documents as well as the LCH. Clear presentation and avoidance of ambiguity are important factors in the use of OLCs; IAEA NS-G-4.4, para. 2.18.

(vii) The LCH Section 4.7 title should reflect the full descriptor for Operating Limits and Conditions, consistent with other LCH references to the OLCs.

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[3] The mass limit of 10 mg ^{235}U for irradiating fissile material has been a historical operational safety limit, recommended to the licensing authority by the reactor design authority in CPR-26, Description and Safety Analysis for the SLOWPOKE-2 Reactor, Section 5.4.1.2, 1977.

[4] This 2008 Safety Standard, IAEA NS-G-4.4 being dedicated to the topic of OLCs, indicates the high importance given by the IAEA to OLCs as an essential part of a research reactor licence.

Section 3: SEP-5

The IAEA considers safety analysis as one of the most important parts of a research reactor licensing process[5]. Because of this importance the intervener provides some comments on SEP-5. Due to the lack of review time these comments do not at all represent a comprehensive review and are very limited, listed in bullet format. Focus was limited to LEU fuel and closely related reactivity safety items. The intention was in regard to the 25 January 2023 submission letter to the CNSC that the RMC SLOWPOKE-2 has kept up with the evolving regulatory requirements and standards. The intervenor leans towards IAEA research reactor standards, as evolution is mainly from the IAEA, particularly after Fukushima. SEP-5 is an update of CPR-26 the original generic safety analysis for the HEU SLOWPOKE-2 reactor. CMD 23 H-3.A, Section 3.2 stressing the process alignment with international practice with regard to research reactor licensing is not, from the intervenor's very limited review, particularly well reflected with the current content and layout of SEP-5 compared with IAEA SSG-20, (footnote 5), the latter document and its earlier revisions being in the public literature for over 30 years.

Specific comments:

- SEP-5 pages 7 and 69 state the SLOWPOKE-2 design is inherently safe. Historically this claim has been made in early publications. IAEA literature does not support this claim implying absolute inherent safety, for any operating reactors. In the current public climate the intervenor submits this key licensing document should not make this claim. The inherent safety features of the reactor are maintained via design features and the operating envelope defined by OLCs. The various inherent safety features of the SLOWPOKE-2 are well documented in SEP-5. No analysis is presented to justify total inherent safety.

- Despite the SEP-5 title, highlighting the '*Operating Envelop (sic)*', the intervenor could find no further reference to the concept of an operating envelope in SEP-5. The Operating Envelope is set, according to IAEA standards by the OLCs which collectively developed, represent all the operating/design envelope parameters[6].

- Closely related to the topic of inherent safety features is SEP-5 Section 1.2.2(b) Consequent Unusual Features of this Reactor[7]. The intervenor suggests however for completeness and public transparency that for the next revision para. 1.2.2(b) take into account IAEA SSR-3, Specific Safety Requirements, Safety of Research Reactors, Requirement 46: Reactor shutdown systems, para. 6.150, *"At least one automatic shutdown system shall be incorporated into the design".* SLOWPOKE design does not meet this SSR-3 safety requirement. SEP-5 Section 1.2.2(b) provides perfectly valid arguments, demonstrated by many

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5 Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, IAEA Specific Safety Guide SSG-20, 2012, paragraph 1.5.

6 IAEA, Operational Limits and Conditions and Operating Procedures for Research Reactors, Safety Guide NS-G-4.4, 2008, paras. 1.12 and 2.1-2.10.

The section title is not perhaps entirely illustrative for a reactor type that has now been in successful service for over 50 years. What might be claimed as an unusual feature is the historical licence to operate at power with no operator in attendance, see Section 2 (i), although this too has also been well known for over 50 years.

reactor-years of experience why the SLOWPOKE design is able to establish a safe reactor state, the goal of para. 160, without the need for a fast-acting wide-scale neutronic trip system. These valid arguments should be discussed with direct reference to IAEA Requirement 46.

- SEP-5 page 6 states the 2021 LEU fuelling has no impact on the document. Table 4.8.2 and Section 3.2.3.1 quote the 2021 fuel loading of 196 elements presumably obtained from the source reference [11][8]. The 2021 LEU loading is then different from the RMC 198 element loading of 1985 and also from the identical 198 LEU element loading of Polytechnique Montréal in 1997. The intervenor agrees that there would no safety concern expected with this difference. However, with the great detail provided on reactivity in SEP-5 Section 4.2 it would though be expected, post-LEU fuelling, that the 2021 loading difference be explained. Current criticality predictive accuracy is well within one fuel element.

- Table 4.8.2, page 101, quotes the fuel enrichment as 19.86 % ^{235}U. This value is not consistent with the more precise 19.632% specification quoted in Section 3.2.3.1.1. The definitive source reference for the as-built enrichment value should be provided for the future facility staff reader. Table 1, page 93 gives the 1985 core fuel enrichment as 19.89% ^{235}U. This could easily be confused with the Table 4.8.2, page 101 value of 19.86% as the two tables have the same legend title. The '10.6??' fuel density quoted in Table 4.8.2 is also not consistent [9] with the Section 4.8.2 fuel density specification range of 10.66 - 10.72 g•cm^{-3}.

- Table 4.8.2, page 101, total ^{235}U mass of 1.117 kg is not consistent with Section 3.2.3.1.1, given the precise quote of 5.795 gm ^{235}U per element, giving 1.136 kg total ^{235}U.

- Table 5.4.1 discussing irradiation of fissile samples in Section 5.4.1.2, but could not be found.

- SEP-5 currently provides no mention of the current ONB and OSV up-to- date thermal hydraulic safety limits for SLOWPOKE-2 LEU fuel, which are now available in the public literature.

- It is not typical for a SAR to include a collection of correspondence, Appendices, copy of a conference paper, photographs of some randomly-chosen schematics and electrical wiring and have non-sequential figure numbering (e.g. Figs 1, 3.19 (unreadable), 3.22 and 3.22a). Review and use of the SAR then becomes very difficult as topics become disconnected from the main text. External hazards for example should be integrated into the IAEA SSG-20 SAR format and content, not as attached copies of internal correspondence. The SAR

[8] Intervenor did not request a copy of the 2022 commissioning report, SEP-5 Reference [11] due to review time constraints.

[9] SEP-5 Table 4.8.2, page 101, '2asu' should be corrected to read ^{235}U. The Total Mass unit should be corrected to read ^{235}U (kg), not 2asu/kg. In the same table the density, specific heat and thermal conductivity refer to the fuel, but could be confused as referring to the cladding, being listed directly underneath that name.

is not the document where detailed operating procedures should be provided (e.g. Sections 5.2.1-5.2.2). The combined use of both mk and the obsolete alternative, %, for the important reactivity parameter is confusing. For future newer RMC staff this confusion should be eliminated.

- The SAR content has a number of important topic and content omissions not seemingly being kept up with a number of research reactor SAR topics specified by the IAEA (footnote 5).

- Section 3.1 Remote Shutdown Switch. The intervenor notes that is not usual practice, to have a remote shutdown switch, for use in some emergency or unforeseen conditions, in a cabinet that is kept locked.

- **Limits on the mass of fissile irradiation samples**
  SEP-5, Section 5.4.1.2 states: *'it is recommended that the maximum amount of any fissile material that the licensing authority permits to be irradiated in any part of the reactor normally be limited to 10 mg'.* This 10 mg limit is then qualified with the statement: '*For owners possessing the need, and the expertise to assess the safety of the irradiation this quantity may be increased'.* Section 5.4.1.4 is then referred to: *'...100 mg is the maximum quantity of any fissile material that may be irradiated in any location of the reactor...',* which then notes that administrative approval for any fissile material irradiation is required from the Director with the condition that '*The Director will ensure the total quantity of fissile material in all irradiation sites does not exceed 1.0 gm'*[10]. The intervenor submits there is sufficient lack of clarity in the these fissile material limits[11] and their authorisations that careful review of all documents involving fissile material irradiations is recommended, particularly operational procedures, to avoid confusion and lack of consistency. Clear presentation and avoidance of ambiguity are important factors in the use of OLCs, IAEA NS-G-4.4, para. 2.18, (footnote 6). As proposed in Section 2(ii) this topic should be an OLC. To minimize updating and possible inconsistencies between documents it is preferred to have one location for OLC details, i.e. the LCH, other documents can simple refer to the LCH for details.

Section 4. CPR-77

The intervenor was surprised to see the 1985 CPR-77 report still listed as a licensee document for 2023[12]. The intervenor's CMD 23-H2.2 submission provided detailed arguments for its removal as a licensee document for Polytechnique Montréal. Those arguments are equally valid for RMC, but are repeated here as other RMC licensee documentation makes use of CPR-77, which Polytechnique Montréal does not.

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[10] These three fissile irradiation mass limits are quite small, but the significance is that they range from 10 mg to 100 mg to 1 g, which is a two orders of magnitude variation.

[11] The statement in Section 2.3.5 Operating Limits and Conditions, CMD 23-H3.1 March 2022 that this (i.e. the container design) eliminates the possibility of RMC staff increasing the fuel content of the reactor is not strictly valid. While fissile samples are not reactor fuel they contain fissile material. Section 5.4.1.4 allows up to 1 g of fissile material, under only administrative control; this is not eliminating the possibility.

[12] CMD 23-H3.A Section 3.2 para. 2 statement on CNSC indicating updated documentation ensures continued compliance with the licensing basis remains valid, contrasts with the arguments provided in (i) to (iv) below.

(i) Despite its title implication, CPR-77 did not provide safety analysis. Its purpose was to predict the number of LEU fuel elements required for the first fuelling of the RMC SLOWPOKE-2 reactor in 1985. The most basic rationale to remove CPR-77 as a licensee document is that it did not, in 1985, predict the correct RMC LEU fuel element content in the reactor, nor the correct element configuration. The 180-element LEU core prediction of CPR-77 was known to known to be in significant error, by 18 fuel elements, since the 1985 RMC LEU commissioning. Some calculations also appear to be derived from an unrealistic 100-element core; this possibly a typographical error but never corrected.

(ii) CPR-77 did not correctly predict the design basis for the LEU core and was not used to support the 1985 LEU 198-element core fuelling of RMC. This was based upon CPR-81,'*SLOWPOKE Nuclear Reactor (LEU fuel) Commissioning and Maintenance*'. Additionally, the (non-conservative) 1985 prediction of the LEU coolant temperature reactivity coefficient of CPR-77 was not validated by future experimental results and not in agreement with current improved calculations for this most important inherent safety feature. This should invalidate the use of CPR-77 as an up-to-date 2023 licensing document.

(iii) CPR-77 provided no new thermal hydraulic safety analysis for the LEU core, other than to quote the same Critical Heat Flux (CHF) criteria from 1977 for HEU fuel. Significant analytical and experimental progress for establishing thermal hydraulic safety limits for SLOWPOKE LEU fuel has since been made over the subsequent 45 years. Well-established and acceptably-validated thermal hydraulic safety limits, ranging from Onset of Nucleate Boiling (ONB) through Onset of Significant Void (OSV) up to CHF, are now available in the LEU SLOWPOKE literature, obsoleting the 45 year old HEU CHF information in CPR-77.

(iii) Deleting CPR-77 would simply remove the incorrect inventory documentation discrepancy with the current LEU fuel loading of 196 given in SEP-5. As SEP-5 makes significant references to CPR-77 the intervenor recommends these should also be removed. Updated physics and thermal hydraulic analyses using validated code predictions are already in the literature for LEU-fuelled SLOWPOKEs applicable to RMC. Current use of CPR-77 as a licensee document in 2023 would appear to be non-compliant with document version control, as well as with LC 5.1 Design Program and LC G.2 Notification of Changes.

(iv) And lastly, with respect to LC 13.1, Safeguards and Non-Proliferation, the intervenor submits the use CPR-77 as a current licensing document is also not desirable, again due to its incorrectly-specified complement and configuration of the current LEU fuel elements in the fuel cage. IAEA historical safeguard inspections have been known to query SLOWPOKE licensing documentation discrepancies of a single fuel element, subsequently requiring documentation correction. Deleting CPR-77, as a licensee document and its active use in SEP-5, would remove the incorrect inventory documentation discrepancy from the safeguards aspect.

Section 5. REGDOC-367 Design of Small Reactor Facilities

The intervenor's comments in CMD 23-H2.2 questioning the absence of REGDOC-367 in CNSC licensing documentation, remain unchanged. Inclusion of REGDOC-367, being particularly based upon IAEA Safety Standard, NS-R-4 (now updated to SSR-3), Safety of Research Reactors, would seem to the intervenor to have merit for a longer term 20-year licence, with respect to CMD 23-H3.A Section 3.2 promoting alignment with international practices.

Section 6. Graded approach and the SCA process

For longer term CNSC staff consideration the intervenor's comments in CMD 23-H2.2 regarding the graded approach and the SCA process, remain unchanged. The intervener submits the artificial SCA approach, provides no prioritization or ranking of topic area. Hence documentation importance with regard to key safety issues, tends to be lost, obscuring the most important version-controlled licensing documents from those with little or no practical relevance to operating a research reactor.

Section 7. Conclusions and main recommendations summary

(i) Approval of a 20-year licence request is concurred with, subject to longer-term updating of the SAR in alignment with international practices.

(ii) Approval to increase the excess reactivity to 4.3 mk is concurred with.

(ii) Moving OLCs from the licence to the LCH is concurred with.

(iii) The proposed list of OLCs, without changes, is not concurred with. Recommended additions are listed in Sections 2(i) to 2(iv). OLC documentation revision control improvement recommendations are listed in 2(v), (vi) and (vii).

(iv) CPR-77 should not be included in the LCH as a 2023 licensee document. It does not and never did reflect the actual LEU fuel content and configuration. All SEP-5 references to CPR-77 should be updated with current LEU analysis[13].

(v) Lack of inclusion of CNSC RegDoc-367 is questioned.

(vi) Intervenor comments from CMD 22-H8.14, regarding the graded approach and the SCA process are considered to be still relevant for licensing activities of RMC in the longer term.

Section 8. Intervenor conflict and background statement

The intervenor's conflict and background statement provided for CMD 23-H2.2 remains unchanged, other than being applicable to the RMC SLOWPOKE.

[13] For example the December 2017 SLOWPOKE-2 LEU analysis used in the CMD 23-H3 RMC submission of 23 February 2022 as reference [8], page 87. This analysis supported the safety case for the 4.3 mk excess reactivity request.