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Written submission from David Winfield

Mémoire de David Winfield

In the Matter of

À l'égard de

McMaster University

Université McMaster

Application to renew its McMaster Nuclear Reactor Class IA non-power reactor operating licence

Demande concernant le renouvellement de son permis d'exploitation d'un réacteur de catégorie IA non producteur de puissance pour le réacteur nucléaire McMaster

Public Hearing - Hearing in writing based on written submissions

Audience publique - Audience fondée sur des mémoires

April 2024

Avril 2024

Comments on June 21, 2024 Application for the Renewal of the Non-Power Operating Licence for the McMaster Nuclear Reactor at McMaster University, Hamilton, Ontario

Reference: CMD 24-H100

D. J. Winfield

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Executive Summary

The MNR facility is requesting a licence renewal period of 20 years. My overarching comment for the Commission is that such a period is warranted and can be justified. Section 1 provides details.

The intervenor concurs with the CNSC staff summary recommendation CMD 24-H100.A Section 6, for a mid-term performance update after 10 years, but suggests an opportunity for public intervenor input be included. MNR's currently proposed long-term experimental and commercial activity commitments, now needing an increased permanent operating schedule of 5 MW 24/5 operation, will likely be the highest level of MNR production capacity since installation. As a result, the intervenor views attention to ageing management of SSC's to be of significant importance. Section 2 provides some recommendations for the proposed 10-year mid-point performance update, the structure and content of which was not prescribed in CMD 24-H100.A.

With the limited PFP resources available, the intervenor reviewed only on a few selected documents: 2019 to 2022 Annual Compliance Monitoring and Operational Performance Reports (ACRs) [1]; Operating Limits and Conditions (OLCs) [2], and Status of MNR Structures, Systems and Components (SSCs) [3]. These documents were judged to provide adequate insight, suitable for a 65-year old research reactor. The intervenor did not request a facility tour, hence the intervention is based only on documentation. Section 3 provides details.

In summary, the intervenor finds the MNR information quite satisfactory. In particular the important OLCs [2] admirably meet, in the intervenor's opinion, the current IAEA research reactor international safety standards [4] for both structure and detailed content. Section 3.2 provides details. Additionally the extensive use of the IAEA Ageing Management safety standard [5] is commendable. Section 3.3 provides details.

1. Licence renewal period of 20 years

The intervenor concurs with the MNR licence renewal request (CMD 24-H100.1) and the CNSC Staff proposal (CMD 24-H100.A) for a 20-year licence period. This support is based upon information derived from (i) the licence renewal request, (ii) recent Annual Compliance and Operational Performance reports [1], (iii) Operating Limits and Conditions (OLCs) [2] and (iv) Status of MNR Structures, Systems and Components (SSCs) [3].

The intervenor also refers to Commission questions from the 27 April 2022 CMD 22-H8.14 p. 175-177 intervention transcript, regarding the length of another licence renewal period, approved by Record of Decision DEC 22-H8, 21 June 2022. Posing the same question to MNR, my response regarding longer licensing periods would be the same as given in this transcript; that a 10-20 year period is acceptable.

A more recent longer license renewal application that the intervenor also participated in, resulted with the Record of Decision 19 June 2023, DEC 23-H3, paragraph 17, with the RMC SLOWPOKE-2 reactor being granted a lengthy research reactor licence period of 20 years[1].

2. CNSC staff request for a 10-year performance update

CMD 24-H100.A Executive Summary and Section 6 Overall Conclusions and Recommendations, recommended actions to the Commission for a mid-term license period performance update, but did not specifically include any opportunity for public participation at that time. The intervenor suggests public intervention participation be made possible at the 10-year mid term licence period.

The intervenor suggests that the mid-term performance update should, during the next year or so, clarify what is meant by update. The ACRs already provide voluminous short-term (annual) performance updates, mainly representative of reactive-type routine licensing requirements. The objective therefore of a 10-year performance update seems then unclear, in view of the annual performance updates with multi-year trending, already being provided by the ACRs. The intervenor suggests therefore that IAEA guidance in [6] be considered to define the basis of a 10-year performance update. Although not mentioned in CMD 24-H100.A, in the context of CNSC being an active international participant with the IAEA, reference [6] was specifically intended for use with about 10+ year intervals for older research reactors with decades of operation[2]. Thus reference [6] already provides a comprehensive research reactor framework with well-defined safety criteria for periodic safety reviews (PSRs).

The use of the fourteen Safety Control Areas (SCAs), as pointed out in CMD 22-H8.14 Section 2 seems to be a modified version of the fourteen safety factors used in [6]. The IAEA safety factors were though introduced by the IAEA only as topics to be assessed for research reactors, specifically for licence renewals or for long-term reviews of 10+ years periodicity. These IAEA safety factors were not designed for, nor intended to be used for research reactor annual performance reports, due to the substantial resources and time needed for a meaningful review of, in the main part, issues of longer-time concern[3]. The origin of the SCA safety factors is not known to the intervenor, as no Reg. Doc. providing the basis seems to be available. Reference [6] lists many contributing topics for each IAEA safety factor, all defined in detail along with evaluation criteria to enable a global assessment of facility safety. Relevant resources for a PSR program are also described. IAEA INSARR missions may also provide useful independent reviews at 5-10 year periodicity. These are typically short-term, 1-2 weeks

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[1] CMD 24-H100.A also notes in Table 5-1 recent examples of other Canadian nuclear facilities granted with similar increases in licence periods and provides in Table 5.2 relevant assessment criteria and notes a similar trend aligning with current international practice.

[2] The IAEA's Code of Conduct for Research Reactors [7] also states that regulatory body should require the operating organizations to undertake period safety reviews at intervals determined by the regulatory body. Some member state regulators mandate PSRs in licenses.

[3] Detailed review criteria for the IAEA PSR safety factors are provided in Technical Safety Review (TSR) Service Guidelines, Periodic Safety Review, IAEA Working Document, July 2nd, 2020.

only, and tend to have a fairly general focus, unless a major safety concern was to be investigated in detail. Topic-focussed IAEA missions can then be used [8].

Current international experience even for small research reactors <10 MW, is that an overall fully-comprehensive PSR process for fourteen safety factors, overall might take up typically ≈2-3 years. In view of the extensive detail already provided in ACRs the intervenor suggests some use should be made of the IAEA PSR process for a 10-year update, prioritizing topics for proactive items relevant for life extension. MNR's ongoing ageing management program and the 10-yearly SAR review are typical examples of such longer-term PSR topics. Both are already implemented by MNR, sections 3.6.3.1 and 2.5.1 of CMD 24-H100.1, as part of this application. The intervener suggests these be continued, as seems to be the intention.

Some thought might be given to decreasing the voluminous reporting nature of the majority of SCAs generally summarizing routine operations which tend to change very little and focus on longer-term proactive PSR topics for a multi-annual 10-year 'update'. Progress with such topics, prioritized to provide a continual assurance of fitness for long-term service can be periodically summarized into the ACR format.

Some examples of type of proactive safety topics that do not routinely surface, despite periodic SAR updating, that might be considered as longer term activities are:

- Status of and discussion of facility safety features, with respect to current IAEA safety standards.
- Analysis effort reviewing historical safety design features for unrevealed potential design flaws. These may still arise after many decades, although less likely than in more complex power reactors.
- Global review of SSC testing, maintenance and inspection procedures for completeness, functionality and frequency.

3. Documentation review and comments

3.1 Annual Compliance and Operational Performance Reports

ACRs from 2019 to 2022 were reviewed. The MNR information provided and the various parameter trends seem entirely satisfactory for annual performance and historical parameter trends. The intervenor provides only one specific recommendation, section 3.1.2, suggesting additional information be provided in future ACRs regarding water chemistry control.

3.1.1 General comments on SCA format/use

The intervenor refers to previous intervention comments, CMD 22-H8 and CMD 23-H3.2, that the intervenor submits, remain relevant for the current intervention. These concern the use of the SCA format that CNSC requires for ACRs, respectfully noting that CNSC, in Record of Decision DEC 23-H3 para 29, was to consider the intervenor's previous comments as part of CNSC's continuous improvement activities.

Briefly these earlier comments had suggested that using the SCA format used to derive, in Regulatory Oversight Reports, annual safety performance ratings/rankings, is likely to give rise to an overall conclusion (which may be subjectively correct) but which is not supported, or auditable, by standard decision analysis ranking methodology. The 2020 decision to discontinue the CNSC's 'Fully Satisfactory' (FS) subjective assessment ROR rating[4] demonstrated, in the intervenor's opinion, this deficiency. The rating format assumes the importance ranking of each SCA topic is the same, which is not the case[5]. As an MNR example, Physical Design SCA is not a useful parameter to use for a 65-year old research reactor of a mature, fixed design, as a measure contributing to an annual safety performance rating.

3.1.2 Water chemistry

MNR's 65+ year operational history demonstrates that water chemistry control specifications and adherence to associated procedures would seem to have been very satisfactory in limiting SSC ageing. Given the overarching vital importance of water chemistry specifications and procedural control for long term ageing management[6], the intervenor notes that, apart from the important mention in [2], section 7.6 PCS, and a general mention in the LCH (draft) section 2.1(k) Chemical Control, there seems to be no other mention of water purification systems, providing rationales or details. Such details including also, albeit of less safety concern, secondary cooling system chemistry, would be appropriate in the LCH[7]; e.g. whether there is continual monitoring or just periodic sample taking and whether chloride ion, or other specific ion concentrations, should also be specified[8]. It is recommended that annual summary information of PCS chemical control be included in future ACRs. The replacement of carbon steel with stainless steel mentioned in [3] section 5.1, noting corrosion has been reduced, seems to have been part of a successful longer term ageing management refurbishment plan, initiated by reference [1] of [3]. A reference to a report providing scope and details of such a plan would have been useful.

3.2 Operating Limits and Conditions

Reference [2] is seen to satisfactorily and closely follow, in both format and content, the recent 2023 revision of the 2023 IAEA research reactor OLC safety standard, [4]. It would therefore have seemed useful for CMD 24-H100.A to make reference to this

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[4] CMD 22-H8 A Risk Ranking.

[5] Some have very little relevance to annual safety performance. Additionally, some topics are not independent.

[6] The limiting lifetime for many ageing research reactor SSC's has been and continues to be, corrosion and degradation of materials interacting with their local chemical environment including irradiation, mostly in difficult-to-repair high radiation field locations, resulting from poor water chemistry control or use of incompatible materials.

[7] Alternatively in the SAR, but the intervenor did not review this.

[8] In particular acute and chronic high chloride content should be avoided to prevent potential stress corrosion cracking of beam tubes.

important IAEA safety standard as an example of the international scene participation. OLCs are considered by the intervenor to be the most relevant operational document providing the detailed criteria determining the overall licensing basis[9]. Listing OLC's in a stand-alone document makes any significant changes needed to the OLCs, expected to be fairly infrequent after revision 9, a much simpler process than amending a licence and is also consistent with para 3.15 of Safety Standard [4].

Reference [2] is very comprehensively and clearly written and after nine revisions appears very mature. A minor comment the intervenor would make is that it would have been clearer if Section 5.2, rather than stating 6.1 m above the core, had referenced the operationally-measurable parameter that actually defines the minimum pool height above the core. This parameter is later provided in Section 10 by the scram trip point, set at a low pool level 32 cm below the gutter.

3.3 Status of MNR Structures, Systems and Components Report

The comprehensive use by MNR of the IAEA ageing management guidance in [5] should be commended. The SCC program appears to have been initiated, reference [1] of [3], in 2010 at the time the IAEA issued the first dedicated safety specific standard guidance for ageing managing of research reactors. Reference [3] then provides a timely update of subsequent progress for the licence extension since Revision 0 of [3].

The intervenor's review of [3] raises only one topic for attention; related to life extension during the next licence period: the condition of two safety critical SCC's of Table 4-1: the pool concrete structure and beam tubes. Their current condition assessments have the potential for ageing issues important for more decades of life extension. Generic documented experience of these two SSC's for research reactors over 65 years experience is quite limited[10]. The ageing mechanisms of the remaining SSCs of [3] Table 4-1 however all appear to be manageable for many more years through planned inspections and periodic replacement programs already in place.

Reference [3] section 4.1.1 mentions (i) the historical pool water capillary leakage, since initial construction, (ii) the potential degradation of the pool concrete structure and (iii) the periodic maintenance campaigns undertaken to reduce the pool water leak rate. Section 4.1.1 only considers concrete and steel rebar degradation mechanisms from this pool leakage. Potential degradation that is not mentioned is external corrosion of beam tubes and coolant system piping embedded in the concrete bio-shield from the possible combined presence of radiation, and water. Capillary water leaks into the concrete have the potential for and have caused time-delayed, sometimes by decades, external corrosion of metal tubes embedded in concrete. There are numerous examples in open-pool research reactors of such degradation from external corrosion in embedded tubes and piping that have led to very lengthy extended shutdowns for expensive repairs,

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[9] Reference [2], section 1.2.4 also confirms the high order of precedence given by MNR to OLCs.

[10] A number of parameters other than age are though also relevant; neutron fluence being one of the important ones. A more recent reference than section 4.1.1 of [3] for reactor concrete degradation is: (https://www.hindawi.com/journals/mse/2016/4165746/)

sometimes threatening long term continued operation. In most examples though the embedded metal was aluminum, corrosion being initiated due to the presence of water/moisture in the surrounding concrete, accentuated by local high radiation fields. Other examples have been galvanic corrosion in the presence of moisture due to dissimilar and incompatible metal usage with stainless steel and aluminium interfaces. In some cases coatings of tar or organic-based materials used for corrosion protection, on the outside of concrete-embedded metal components, have accelerated corrosion because of the combination of water and radiation with the coating material. Sources of undesirable water content in the concrete have included historical pool overflow operational events, chronic water leaks from pool walls or through a pool liner and, in some locations, moisture in humid climates. External corrosion of embedded components is usually difficult to detect and inspect, due to high radiation fields and accessibility.

3.3.1 Pool concrete structure SSC recommendation

Reference [3] section 4.1.1 indicates there is likely no mechanism that would produce a major pool water concrete leakage. The pool reinforced concrete structural condition is then claimed to be good on the bases that the leakage is manageable and the surface deterioration is minor and repairable. The intervenor agrees with the section 4.1.1 assessment in that there is likely no mechanism that would produce a major pool water concrete leakage of safety concern. This could perhaps be inferred, to some degree, from the generic international experience of older research reactor concrete bio-shielding[11]. Regardless, generic experience, surface inspection and leakage control activities are not assessment methods that provide actual evidence and assurance of the bio-concrete structural condition, regarding compressive strength.

It is recommended therefore, before the next mid-term licence period, concrete condition assessment activities are expanded to include more a more probing condition assessment with perhaps some non-destructive testing, focussed on the 65+ year old pool concrete. IAEA, reference [9], provides relevant information, intended for application in reactor facilities.

3.3.2 Beam tubes SSC recommendation

Reference [3] section 4.1.4 states that the condition of the beam tubes is good on the bases: (i) that there are no ageing mechanisms to degrade their safety and also from (ii) recent examination of some undefined irradiated components from the NRU reactor that showed no ageing effects. The intervenor submits that it is indeed quite possible that the claim of ‘good’ is valid for the beam tubes, presumably meaning for a period of 10+ years or so. As noted above in section 3.3.1 the bases (i) and (ii) do not though provide actual evidence and assurance of good condition for the beam tubes.

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[11] Not including fast reactors where ageing effects from fast neutrons are more severe than thermal reactors.

The intervenor questions that there are no ageing mechanisms to degrade beam tube safety. Irradiation-assisted stress corrosion cracking (IASCC) for instance is an age-related degradation mechanism that can degrade, from the moderator side as well from concrete embedment, with increasing fluence[12]. Vibrational fatigue is possible but less likely with stainless steel; aluminium being more susceptible. The low coolant flow in MNR and many decades of experience likely could discount this failure mode.

It appears, subject to the limited information the intervenor has, that the MNR stainless steel beam tube design is more robust than most other research reactor types. Stainless steel types are less susceptible to corrosion in both water and embedding in concrete than is aluminium. Stainless steel beam tubes, in the absence of any type of contact with aluminum[13], as footnote 13 notes are though susceptible to stress corrosion cracking, which is also temperature dependent, in the event of poor pool water chemistry. It also appears no corrosion-resistant outer coatings were used on the beam tubes in the original construction. This absence would then preclude external corrosion failures that have been accelerated in a number of research reactor beam tubes, by the use of such coatings in the presence of water and radiation. It also appears that the top of the reactor concrete shield gutter design and operational procedures, including a high water level alarm, provide adequate protection to mitigate any pool water overflow events (experienced by other pool-type research reactors) onto the biological shield that might otherwise potentially add to water ingress in the concrete. No pool water overflow events have occurred in MNR operating history.

Importantly, reference [3] Table 4-1 notes that MNR changed two beam tubes, one in 2013 and the other in 2020, for experimental purposes but not because of degradation or corrosion. There is no mention of the visual condition of these two extracted tubes and no UT wall thickness measurements. As the extracted tubes are stored at MNR it would seem very useful if a detailed inspection of these extracted tubes was made, with appropriate attention to wall thickness data, as well as the inside/outside surface visual conditions. This type of inspection would presumably provide some valid evidence of continued longevity for beam tubes still in situ.

There are also four stainless steel coolant system pipes embedded in concrete in the pool floor, [3] Figure 2-2. Reference [3] Table 5-1 does not specifically address their condition, which might be more susceptible to external corrosion than elsewhere in the coolant piping system. The intervenor suggests these embedded parts of the PCS would be appropriate to include in Table 4-1 safety critical SSCs.

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[12] In 1985 an aluminum beam tube in NRU required an 8-month shutdown to replace, as result of stress corrosion cracking. Also in 1994 a stainless steel line in NRU required an 11-month shutdown to repair a stainless steel line with a stress corrosion cracking defect.

[13] Reference [3] section 4.1.4 does not though provide enough information on any possible contact areas between the stainless steel sleeve and removable aluminium liner to indicate whether any potential galvanic corrosion can be discounted. Aluminium alloys are more susceptible than stainless steel.

It is recommended therefore, before the next mid-term licence period, some more focussed condition assessment activities are made for the beam tubes and the concrete-embedded stainless steel line sections of the PCS in the pool floor.

3.4 Additional comment

The CNSC (CMD 24-H100.A) provides copious assurances of international scene participation, particularly for research reactor licensing (section 5.6.1), but does not mention the IAEA event data base INES, established in 1990, to which the CNSC contributes event information. MNR, CMD 24-H100.1 does though credit use of a number of IAEA safety guides.

The intervenor recommends, for public transparency, for the CNSC to provide information on any IAEA INES level event assignments to Table 3-1 events, with other historical events back to 1990[14], to give a longer-term picture of operational events. There are no significance rankings in Table 3.1 events and while some events appear to be of trivial concern, the 2014 fuelling error was highlighted, (e.g. CMD 24-H100.A reference [8]). INES however does provide criteria and a consistent way to stepwise rank safety related events. A January 1994 MNR fuelling event, for instance, was historically assessed at an INES level 2 (*incident*) giving credit for full containment provision and overall relatively smaller public hazard potential of the pool water research reactor, compared to a power reactor

4. Conclusions and recommendations summary

(i) Approval of a 20-year licence and a mid-term update are concurred with.
(ii) Public intervenor input be made possible in the mid-term 10-year licence update.
(ii) CNSC Staff define what is required at a 10-year ‘update’ and utilize some of IAEA PSR guidance in [6] to support the update, by prioritizing topics for proactive items most relevant for life extension.
(iv) Provide information in future ACRs and the LCH, regarding water chemistry control.
(v) Provide further analysis/inspection information for condition assessment assurance for the pool structural concrete, in-situ beam tubes and concrete-embedded stainless steel coolant line sections. Detailed inspection of the two removed and stored beam tubes should be considered.

5. Acknowledgment

The intervenor would like to acknowledge the Transition Director of the MNR for openness and transparency in providing information for the preparation of this review.

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[14] The IAEA INES public site removes events after 12 months but other data bases provide the historical INES data.

6. Intervenor conflict and background statement

The intervenor has no past or current direct financial interest in the McMaster Nuclear Reactor, nor has any indirect-financial interests (nearby property ownership, family, personal or professional relationships). The intervenor was a short-term academic user of MNR in the 1970's performing neutron beam physics research. I have CANDU power reactor and research reactor facility senior engineer licensed operational experience, research reactor safety analysis and licensing experience and have participated in 22 IAEA international research reactor safety review missions. One of these involved a detailed safety review of the TRR-1 research reactor, with the same original AMF design as MNR. The intervenor has also provided licensing assistance for the national regulator body overseeing the TRR-1, through a subcontracted EU-sponsored project. The intervenor was employed by the IAEA Vienna in the research reactor safety section and is currently an advisory member of a nuclear safety committee with a national nuclear regulatory body in Europe.

References

[1] MNR Annual Compliance Monitoring and Operational Performance Reports, 2019 to 2022.

[2] MNR Operating Limits and Conditions, AP-1111, Revision 9, April 5th 2023.

[3] Status of MNR Structures, Systems and Components, TN-2010-04, Revision 1, April 10th 2023.

[4] IAEA Safety Standard Series No. SSG-83, Operational Limits and Conditions and Operating Procedures for Research Reactors, Vienna 2023.

[5] IAEA Safety Standard Series No. SSG-10, Ageing Management for Research Reactors.

[6] IAEA, Safety Reports Series No. 99, Periodic Safety Review for Research Reactors, Vienna, 2020.

[7] IAEA Code of Conduct on the Safety of Research Reactors, Vienna, 2006.

[8] https://www.iaea.org/newscenter/pressreleases/iaea-issues-recommendations-regarding-temporary-restart-dutch-reactor
https://open.overheid.nl/documenten/ronl-archief-d59bc46d-685e-4287-99d7-8dde5cbcbbff/pdf

[9] IAEA Training Course Series No.17, Guidebook on Non-destructive Testing of Concrete Structures, Vienna, 2002.