KRONOS FUSION ENERGY

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The Sub-100 MW Byproduct-Material Thesis: Why a Compact Spherical-Tokamak Breeder Licenses Under NRC 10 CFR Part 30 Rather Than Part 50

The regulatory pathway is as decisive for a fusion plant as its physics, and it is not chosen by assertion: it is fixed by the statutory definition of the facility and, for the...

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BY P I FORD

2026 · EDITORIAL EDITION

THE OFFICIAL RECORD

What this document is, and how to read its numbers

This is a combined editorial. It gathers, in one volume, the two design studies Kronos Fusion Energy released in 2026 — a compact spherical-tokamak tritium/helium-3 breeder and a deuterium–helium-3 tandem-mirror generator — together with the intellectual-property estate, the people, and, in the internal edition, the full commercial case. The scientific text is the same text that appears in the arXiv preprints and the journal submissions; the editorial adds the apparatus a reader needs to hold the whole program at once, and nothing in the physics is altered to fit it.

THE HONESTY STANCE IS THE ASSET

Every headline quantity carries an **evidence class** — DERIVED RECOMPUTED MEASURED REQUIREMENT — and, where a number is a modelled extrapolation rather than a demonstrated value, it is labelled as such and its downside is shown next to it. Several quantities in the underlying corpus moved after first publication; where a value has been withdrawn or restated, the record says so plainly. This is deliberate: a diligence team will find the load-bearing assumptions, so the document surfaces them first.

TWO EDITIONS

This volume is issued in two editions. The **public edition** (light) carries the physics and the design only — no dollar, price, or per-kilogram figure appears anywhere in it. The **internal edition** (dark) adds the economics, the funding architecture, and the defense-commercial analysis, and is marked *Confidential* accordingly; it is not for public distribution. Where the commercial case rests on a modelled assumption rather than a demonstrated one, it is labelled as such and its downside is shown alongside it, on the same terms as the physics.

TITLE	The Kronos Fleet — Hyperion · Aegis · MetroVolt: A Combined Design & Commercialization Study
AUTHOR	Priyanca Ford, Founder & CEO, on behalf of Kronos Fusion Energy
EDITION	2026 Combined Editorial · first issue
COMPANION WORKS	The five-paper arXiv drop — (1) Breeder, (2) Burner, (3) REBCO magnet & tape, (4) Direct Energy Conversion, (5) AI/ML/Quantum control — with matching numbered Zenodo deposits, plus the IOP journal and IAEA-FEC submissions. Patents were filed before the drop.
NAMING	Hyperion = the breeder; Aegis (defense) and MetroVolt (data-center) = one generator in two housings. Internal mode letters (D1, L) do not appear on public surfaces.
STATUS	Conceptual design & simulation study. Nothing herein is a construction commitment.

HOW TO READ THIS VOLUME

The fleet at a glance, and the way its numbers are marked

This volume opens with *Orientation*, presents the five research papers as a bound sequence, and closes with the *Apparatus*. *Foundations* sets out the three general results both machines rest on. *Paper One* is the Hyperion breeder; *Paper Two* the Aegis / MetroVolt generator; *Papers Three, Four and Five* are the enabling science — high-field REBCO magnets and tape, direct energy conversion, and the AI / ML / quantum control stack. A *Digital Twin & 3-D Model* part follows, then the *Environmental* profile. The *Economics* and levelized cost and the *Business Case* and diligence record appear in the internal edition only; the *Simulations* proof record and the Apparatus — patent portfolio, team, limitations, and sources — close both editions.

THE FLEET AT A GLANCE

	HYPERION	AEGIS	METROVOLT
Role	Strategic-isotope foundry	Defense installation power	Campus power
Machine	**Spherical tokamak**	**Tandem mirror**	**Tandem mirror**
Fuel	Deuterium–tritium	Deuterium–helium-3	Deuterium–helium-3
Delivers	Tritium · ^{3}He · 14 MeV n	Resilient installation power	Firm campus power
Physics bar	**Fusion gain only**	Closure (gates named)	Closure + lunar ^{3}He
In the fleet	Breeds the fuel	Proves the generator	Commercial destination

HOW THE NUMBERS ARE MARKED

Every headline quantity carries an evidence class — DERIVED from first principles, RECOMPUTED from raw data, MEASURED in hardware, or a REQUIREMENT yet to be met. Financial figures carry a case label and are confined to the internal (confidential) edition. Values that moved after first publication are shown as withdrawn or restated rather than quietly changed. A capability you can evaluate is one whose limits are on the page.

ABSTRACT

The Sub-100 MW Byproduct-Material Thesis: Why a Compact Spherical-Tokamak Breeder Licenses Under NRC 10 CFR Part 30 Rather Than Part 50

The regulatory pathway is as decisive for a fusion plant as its physics, and it is not chosen by assertion: it is fixed by the statutory definition of the facility and, for the graded case, by a quantitative dose bound. We give a first-principles regulatory-strategy analysis for the Hyperion compact spherical-tokamak (ST) breeder (design point $Q = 3.076$, $P_{\text{fus}} = 85.04\,MW$, thermal power $P_{\text{th}} = 95.2\,MW$, $I_p = 9.66\,MA$, $B_0 = 8\,T$, negative triangularity $\delta = -0.30$, elongation $\kappa = 2.0$, major radius $R_0 = 1.20\,m$, aspect ratio $A = 2.5$, centrepost peak field $16.84\,T$). Following the 2023 U.S. Nuclear Regulatory Commission (NRC) determination and the ADVANCE Act (2024), fusion energy systems are regulated as *byproduct material* under 10 CFR Part 30, not as production or utilization facilities under Part 50/52. We show this is not merely permitted but quantitatively correct for a sub-100 MW machine. We formalise the licensing decision as (i) a statutory predicate under Atomic Energy Act §11 — fusion possesses no special nuclear material and no self-sustaining fission chain reaction, so it cannot be a utilization facility — and (ii) a dose predicate for the graded path: the maximum hypothetical accident (MHA) committed effective dose at the exclusion-area boundary must fall below the 1 early-phase protective-action guide. We derive the full source-term-to-dose chain in closed form — mobilizable tritium inventory, HTO chemical-form weighting, Gaussian-plume dispersion , and inhalation dosimetry — and evaluate it on the frozen design. The standing in-process tritium inventory is $\sim 675\,g$ (~ 6.5), held there by direct internal recycling and a permeation-reduction factor ~ 2000; with the design-basis released inventory confined to the gram scale, the 1 contour of the MHA sits at $239\,m$ (class F, 2 m/s), a modest exclusion area rather than a kilometre-scale emergency-planning zone. There is no fission-product source term, no criticality, and no decay-heat melt drive: post-shutdown decay heat is 0.95 MW at 1 s falling to 95 kW at one day, passively bounded below 710 °C. Neutron-activated structure classifies entirely at or below 10 CFR 61.55 Class C with no greater-than-Class-C waste. All quantities are frozen anchors in the Kronos de-risking register, reproduced on a GPU-accelerated OpenMC/depletion campaign. This is a regulatory-strategy analysis, not legal advice or a filed application; site-specific determinations remain for counsel and pre-application engagement.

Open-access deposit (code & data, CC BY 4.0): DOI 10.5281/zenodo.22645756 · Zenodo community *kronos_fusion_energy*. Explore it live: interactive 3-D model · physics validator.

Keywords: fusion licensing · byproduct material · 10\ · CFR Part\ · 30 · source term · tritium · atmospheric dispersion · low-level waste · spherical-tokamak breeder

CONTENTS

Table of Contents

NOMENCLATURE

Symbols, units, and the names of things

Q	plasma (fusion) gain, P_{fus}/P_{aux}
Q_E	engineering gain, net electric out / recirculating in
H_{98}	confinement enhancement over the IPB98(y,2) scaling
Z_{eff}	effective ion charge
c_{ee}	electron–electron bremsstrahlung leading coefficient, 2.120022 (exact)
τ_E	energy confinement time
I_p	plasma current
R_0, a	major radius, minor radius
κ, δ	elongation, triangularity
β_N	normalized plasma beta (Troyon-normalized)
TBR	tritium breeding ratio
DEC	direct energy conversion
CF	plant capacity factor (availability)
FOAK / NOAK / BOAK	first / nth / best of a kind
Hyperion	the ST breeder (internal: Mode D2)
Aegis	the generator, defense/installation housing (internal: Mode M)
MetroVolt	the generator, data-center housing (Mode M)

fusion licensing; byproduct material; 10 CFR Part 30; source term; tritium; atmospheric dispersion; low-level waste; spherical-tokamak breeder

§ 1

Introduction

THE PATHWAY PROBLEM

A fusion program that builds a working machine it cannot license has not built a deployable asset. Historically the regulatory pathway for fusion in the United States was ambiguous: fusion devices are not power reactors, but the Atomic Energy Act (AEA) and its implementing regulations were written around fission, and it was not obvious which framework a fusion plant would enter. That ambiguity was resolved in 2023, when the NRC determined that fusion energy systems are to be regulated under the *byproduct-material* framework of 10 CFR Part 30 rather than the production-and-utilization-facility framework of 10 CFR Part 50/52 [1]. The ADVANCE Act of 2024 [2] reinforced this determination in statute, directing the Commission to develop a risk-informed, technology-inclusive regulatory framework for fusion within the materials paradigm. The practical consequences are large: Part 30 is materials-oriented, is administered by 39 Agreement States as well as the NRC, carries no construction-permit / operating-license two-step and no mandatory adjudicatory hearing, and grades its requirements to the actual radiological hazard rather than to the accident phenomenology of a fission core [1,2].

This paper asks a sharper question than "is Part 30 available?" It asks *whether the byproduct-material framework is quantitatively the correct one* for a specific machine — the Hyperion compact ST breeder — and it answers by deriving and evaluating the radiological quantities that a regulator would use to decide. The thesis is that a sub-100 MW breeder, whose only significant radiological source term is a bounded, gram-to-\- kilogram-class tritium inventory and whose neutron-activated structure classifies as low-level waste, is not merely *allowed* under Part 30 but *belongs* there: its maximum credible accident produces a dose consequence that the graded, materials-oriented framework was designed to administer, and none of the mechanisms that make the Part 50 framework necessary — a fissile inventory, a chain reaction, a decay-heat-driven core melt — are physically present.

PRIOR ART

The technical basis for fusion's favourable safety posture is well established. The ARIES safety studies quantified the absence of a decay-heat melt drive and the low-activation waste route for large fusion power plants [19,20], and the ITER safety and licensing programme demonstrated, through MELCOR-for-fusion accident modelling [18] and the associated regulatory dossier, that the bounding public dose from a fusion facility can be held below evacuation thresholds [17,16]. The back-end material-management literature established that fusion structural waste, with an appropriate low-activation material set, is dispositionable as low-level waste through recycling, clearance, or shallow-land disposal rather than deep geological disposal [14,15]. The D–T fuel-cycle literature [13] framed the tritium inventory as the governing mobilizable hazard and the direct internal-recycling architecture as the primary means of minimizing it. What this body of work does *not* do is connect those quantities to the specific U.S. regulatory decision now in force for a specific compact machine: it predates the 2023/2024 determination, and it targets gigawatt-class plants rather than a sub-100 MW strategic-isotope breeder.

CONTRIBUTION

We supply that connection, and we do it quantitatively. Our contributions are: (i) a formalisation of the licensing decision as a two-part predicate — a statutory classification under AEA §11 and a dose inequality for the graded path (§2); (ii) a closed-form derivation of the source-term-to-dose chain for the tritium MHA, from the fuel-cycle standing inventory through HTO chemical-form weighting, Gaussian-plume dispersion, and inhalation dosimetry, together with the 10 CFR 61.55 waste-classification sum-of-fractions and the no-meltdown decay-heat bound (§3); (iii) a GPU-accelerated computational methodology — Monte-Carlo neutron transport with CAD-faithful geometry, matrix-exponential activation/depletion, and a fuel-cycle balance — that produces the frozen source-term inputs (§4); (iv) an evaluation on the frozen Hyperion design that quantifies the sub-100 MW thesis, including the 1 accident contour as a function of released inventory (§5); and (v) a benchmark of every headline number against the published fusion-safety and regulatory literature (§6). Every design quantity traces to a frozen anchor in the Kronos Physics De-Risking Register [27]; serial identifiers (e.g. BR-SX-17) are given inline so each number is auditable. This is a regulatory-strategy analysis, not legal advice and not a filed application (§7).

§ 2

The regulatory decision as a formal problem

THE STATUTORY PREDICATE

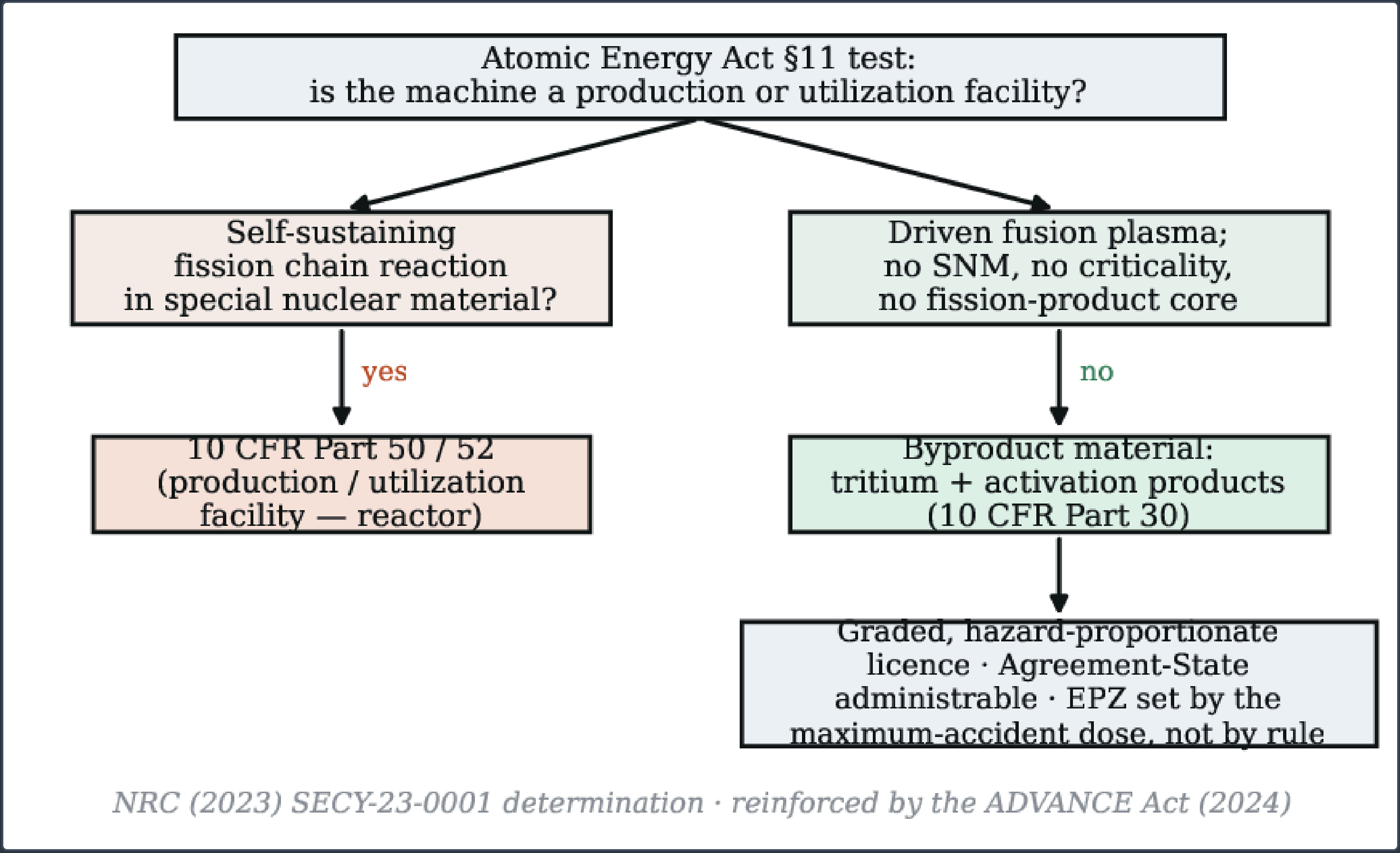
The first question is categorical, not quantitative. Under the AEA, the Part 50/52 framework applies to a *production facility* or a *utilization facility* as defined in §11 of the Act [3]. A utilization facility is, in essence, an apparatus that uses special nuclear material (SNM) in a configuration capable of a self-sustaining fission chain reaction. Write the statutory predicate as a Boolean map on the facility F:

$$\Pi_{50}(F) \;=\; \big[\exists\,\text{SNM in } F\big] \;\wedge\; \big[\exists\,\text{self-sustaining fission chain reaction in } F\big].$$

For any fusion device, both conjuncts are false: the fuel is hydrogenic (D, T, ^{3}He), which is not special nuclear material, and confinement of a driven fusion plasma is not and cannot become a fission chain reaction. Hence $\Pi_{50}(F) = \text{false}$ for the breeder, and the facility is *not* a production or utilization facility. The radioactive material it does create — tritium bred in the blanket and structure made radioactive by 14 MeV neutron activation — is *byproduct material* within the meaning of AEA §11e, as expanded to accelerator- and other-produced radioactive material by the Energy Policy Act of 2005 [4]. The classification therefore resolves to

$$\text{class}(F) = \begin{cases} \text{Part\,50/52 (reactor)}, & \Pi_{50}(F) = \text{true}, \\ \text{Part\,30 (byproduct material)}, & \Pi_{50}(F) = \text{false} \;\wedge\; F \text{ possesses byproduct material}, \end{cases}$$

and the breeder falls in the second branch. This is exactly the branch the NRC selected for fusion generically in 2023 [1] and Congress codified in 2024 [2]. Figure 1 renders the predicate as a decision tree; Table 1 contrasts the two frameworks on the attributes that matter for a compact machine.



(Schematic.) The licensing decision as a statutory predicate. The Atomic Energy Act §11 test (equation 1) turns on the presence of special nuclear material in a self-sustaining fission chain reaction. A driven fusion plasma satisfies neither conjunct, so the facility is not a utilization facility; the tritium and neutron-activated structure it produces are byproduct material, placing it under 10 CFR Part 30 with a graded, hazard-proportionate licence. The residual quantitative question — the size of any exclusion area — is set by the maximum-accident dose (§3), not by a categorical rule.

ATTRIBUTE	PART 50/52 (REACTOR)	PART 30 (BYPRODUCT) — BREEDER POSTURE
statutory trigger	production/utilization facility	possession of byproduct material
governing hazard	fission-product core, decay heat, criticality	bounded tritium + activation inventory
licence structure	construction permit + operating licence	single materials licence
mandatory hearing	yes	no
administered by	NRC only	NRC *or* Agreement State (39 states)
emergency planning	rule-based multi-km EPZ	dose-graded; sized by the MHA (§3)
waste basis	spent fuel, high-level waste possible	low-level waste (10 CFR 61), no HLW

The two frameworks on the attributes that govern a compact fusion machine. Regulatory attributes are public law and policy [1,2,6,5]; the "breeder posture" column states where the Hyperion design sits.

THE DOSE PREDICATE FOR THE GRADED PATH

The second question is quantitative. Selecting Part 30 does not by itself set the size of any exclusion area or emergency-planning zone (EPZ); that is graded to the hazard. The controlling quantity is the dose consequence of the maximum hypothetical accident (MHA) at the exclusion-area boundary (EAB), compared against the early-phase protective-action guide (PAG). The U.S. EPA PAG for the early phase of a radiological emergency is $D_{\mathrm{PAG}} = 1$ committed effective dose (total effective dose equivalent, TEDE) [9]; below this threshold no protective action (sheltering or evacuation) of the public is indicated. The graded-path predicate is therefore

$$\Pi_{\text{graded}} \;=\; \Big[\, \mathrm{TEDE}_{\mathrm{MHA}}(r_{\mathrm{EAB}}) \;\le\; D_{\mathrm{PAG}} = 1 \,\Big],$$

and a byproduct-material licence with a minimal exclusion area and no offsite EPZ is defensible precisely when Π_{graded} holds at a modest r_{EAB}. Normal operation is separately bounded by the public dose limit of 10 CFR 20.1301, 100 [7]. The remainder of the paper derives $\mathrm{TEDE}_{\mathrm{MHA}}(r)$ from first principles and evaluates equation (3) on the frozen design; the central empirical claim of the "sub-100 MW" thesis is that the sub-100 MW power scale bounds the tritium and activation source terms tightly enough that Π_{graded} holds at a few-hundred-metre boundary.

§ 3

Governing equations and the formal source-term problem

The MHA dose chain has four links: the standing mobilizable inventory (§3.1), the released source term with chemical-form weighting (§3.2), atmospheric transport (§3.3), and dosimetry (§3.4). Two further governing relations bound the solid-waste and the thermal accident behaviour (§3.5–3.6). Table 2 collects the frozen design inputs.

QUANTITY	SYMBOL	VALUE	BASIS
fusion power	P_{fus}	85.04 MW	BR-L1-A1
thermal power	P_{th}	95.2 MW	BR-L1-A9
neutron power / source	$P_n,\ S_n$	67.79 MW, 3.009×10^19 /s	BR-OUT-3
first-wall fast flux	ϕ_{fw}	7.0×10^14 /cm²s	BR-L1-A5
tritium burn rate	$\dot{m}_{\text{burn}}$	4.769 kg (13.1 g)	BR-L1-A6
standing in-process T	I_{mob}	$\sim 675\,g$ (~ 6.5)	BR-SX-17
start-up T inventory	I_0	$\sim 1.07\,kg$ (~ 10.3)	BR-SX-17
permeation-reduction factor	PRF	~ 2000	BR-SX-17
decay heat @ 1 s / 1 d	P_{dh}	0.95 MW / 95 kW	BR-L1-A9
tritium specific activity	a_T	3.57×10^14 becquerel/g	12.32 y half-life
HTO inhalation coefficient	e_{HTO}	1.8×10^-11 sievert/becquerel	ICRP [11]
breathing rate	$\dot{B}$	$3.3 \times 10^-4\,\text{m}^3/\text{s}$	adult, light activity

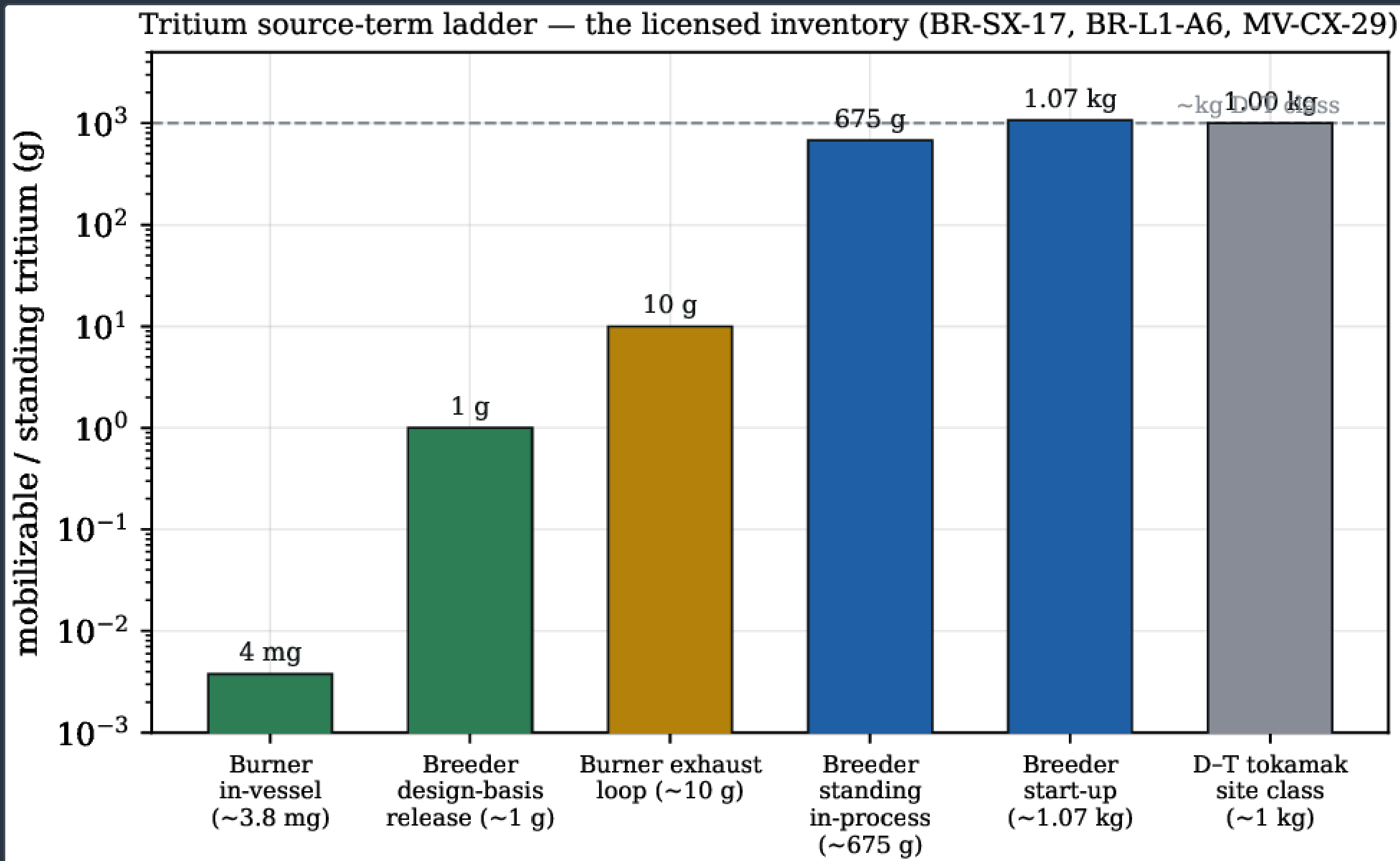
Frozen breeder inputs and dosimetric constants. Design quantities are register anchors (serials in the last column) [27]; dosimetric constants are the cited standard values.

THE STANDING MOBILIZABLE INVENTORY

The governing radiological quantity is the mobilizable tritium inventory, and it is a computed dynamical result, not an assumed figure. The in-process (standing) inventory $m_T(t)$ obeys a first-order fuel-cycle balance between breeding, burn, processing throughput and radioactive decay,

$$\frac{\mathrm{d}m_T}{\mathrm{d}t} = \underbrace{\Lambda_{\text{br}}\,\dot{m}_{\text{burn}}}_{\text{breeding}} - \underbrace{\dot{m}_{\text{burn}}}_{\text{burn}} - \underbrace{\frac{m_T}{\tau_{\text{proc}}}}_{\text{processing draw}} - \underbrace{\lambda_T\,m_T}_{\text{decay}}, \qquad \lambda_T = \frac{\ln 2}{t_{1/2}},$$

with Λ_{br} the net tritium-breeding ratio (TBR), τ_{proc} the mean processing-loop residence time, and $t_{1/2} = 12.32$. The architecture that minimizes the standing inventory is *direct internal recycling*: unburned fuel is returned to the plasma with a short residence time rather than routed through a large buffered store, so the steady in-process inventory is set by the throughput times a short residence, not by a strategic reserve. Evaluated on the frozen design, the burn rate is $\dot{m}_{\text{burn}} = 13.1\,g$ (BR-L1-A6) and the steady in-process inventory is $I_{\text{mob}} \approx 675\,g$ (BR-SX-17); the one-time start-up inventory required to reach self-sustaining operation is $I_0 \approx 1.07\,kg$ for a residence-time target near one year, consistent with the $\{2.38, 4.77, 9.54\}$ kg ladder for $\tau_{\text{res}} = \{0.5, 1, 2\}$ yr (BR-L1-A6). Permeation of tritium across the blanket–coolant boundary is suppressed by a permeation-reduction factor $\text{PRF} \sim 2000$ (BR-SX-17), so the routine effluent is a small fraction of the throughput and the mobilizable fraction available to an accident is a small fraction of I_{mob}. Figure 2 places these inventories on a ladder against the burner and against the ∼kg-class site inventory of a D–T machine.



Tritium source-term ladder (log scale). The breeder standing in-process inventory ($\sim 675\,g$, BR-SX-17) and one-time start-up inventory ($\sim 1.07\,kg$, BR-L1-A6) set the licensed possession scale; the design-basis *released* inventory is confined to the gram scale by direct internal recycling and the $\mathrm{PRF} \sim 2000$ permeation barrier. The companion D–^{3}He burner runs a milligram-class in-vessel inventory and a $\sim 3.6\,g$ mobile inventory (MV-CX-29), $\sim 275\times$ below the ~kg D–T class.

THE RELEASED SOURCE TERM AND CHEMICAL FORM

Only a fraction of the standing inventory is available to an accident, and only part of that is in the dose-dominant chemical form. Tritium exists as elemental HT (gas) and as tritiated water HTO (vapour); the committed effective dose coefficient of HTO exceeds that of HT by roughly four orders of magnitude, because HT is poorly retained while HTO exchanges with body water and, for airborne HTO, is absorbed through the skin as well as inhaled [11]. The released activity is therefore

$$Q_{\mathrm{rel}} \;=\; a_T \left(f_{\mathrm{mob}}\, f_{\mathrm{rel}}\, f_{\mathrm{HTO}}\right) I_{\mathrm{mob}},$$

with f_{mob} the mobilizable fraction, f_{rel} the fraction released past confinement, and f_{HTO} the fraction oxidised to HTO, and $a_T = 3.57 \times 10^{14}\, becquerel/g$ the specific activity. Because the dose scales linearly in Q_{rel} and hence in the released *mass* $m_{\mathrm{rel}} = f_{\mathrm{mob}} f_{\mathrm{rel}} f_{\mathrm{HTO}} I_{\mathrm{mob}}$, we carry m_{rel} (in grams of HTO) as the single controlling release parameter and report the dose consequence parametrically in it, rather than committing to one accident scenario. A defensible design-basis release, given internal recycling and the permeation barrier, keeps m_{rel} at the gram scale; a bounding envelope up to $100\,g$ is carried to show the sensitivity.

ATMOSPHERIC TRANSPORT

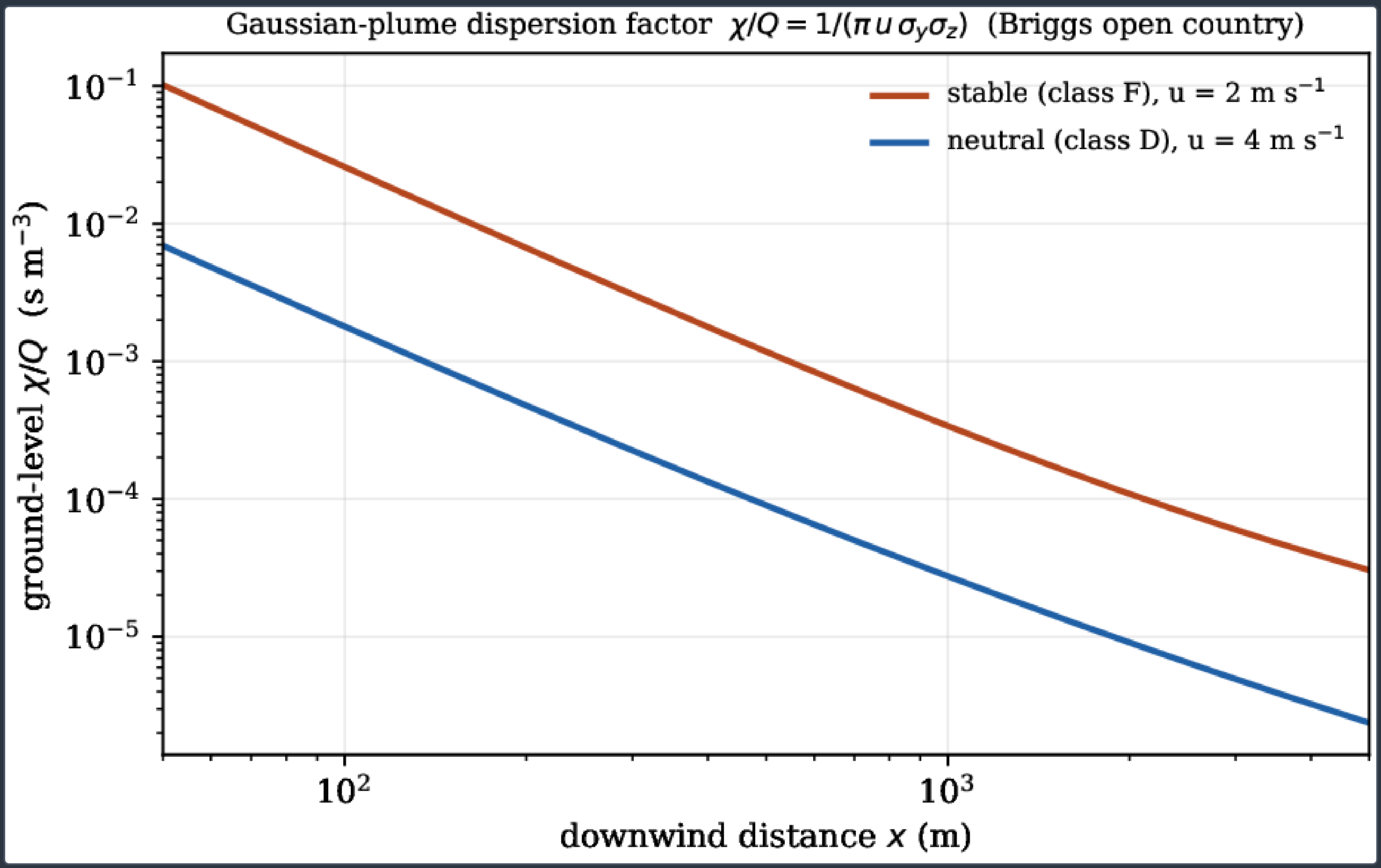
The released puff is transported to the boundary by the atmosphere. For a ground-level release with no plume rise, the time-integrated ground-level centreline air concentration per unit release — the dispersion factor — follows the Gaussian-plume form [12,10]

$$\frac{\chi}{Q}(x) \;=\; \frac{1}{\pi\, u\, \sigma_y(x)\, \sigma_z(x)} \qquad [\mathrm{s/m^3}],$$

where u is the wind speed and σ_y, σ_z are the crosswind and vertical plume standard deviations, functions of downwind distance x and atmospheric stability class. We use Briggs open-country dispersion coefficients; for the conservative stable class F,

$$\sigma_y = 0.04\, x\, (1 + 10^{-4} x)^{-1/2}, \qquad \sigma_z = 0.016\, x\, (1 + 3 \times 10^{-4} x)^{-1},$$

with x in metres, and analogous coefficients for the neutral class D. Regulatory practice (NRC RG 1.145) adopts a conservative upper-percentile for consequence assessment [10]; taking class F at $u = 2\,m/s$ approximates that conservatism. Figure 3 plots equation (6) for classes D and F; at 1 km the stable-class factor is $\chi/Q = 3.4 \times 10^{-4}\,s/m^3$, an order of magnitude above the neutral case.



Ground-level Gaussian-plume dispersion factor of equation (6) with Briggs open-country σ_y, σ_z (equation 7), for stable (class F, 2 m/s) and neutral (class D, 4 m/s) conditions. The stable case is the conservative choice used for the accident dose. This is a derived model curve, not measured data.

DOSIMETRY AND THE ACCIDENT DOSE

The committed effective dose to a boundary individual from inhalation of the passing HTO puff is the product of the released activity, the dispersion factor, the breathing rate and the dose coefficient,

$$\mathrm{TEDE}_{\mathrm{MHA}}(x) \;=\; Q_{\mathrm{rel}}\,\frac{\chi}{Q}(x)\,\dot{B}\,e_{\mathrm{HTO}},$$

with $\dot{B} = 3.3 \times 10^{-4}\,m^3/s$ and $e_{\mathrm{HTO}} = 1.8 \times 10^{-11}\,sievert/becquerel$ (ICRP [11]); the skin-absorption pathway for airborne HTO is folded into e_{HTO}. The 1 contour distance r_1 is the root of $\mathrm{TEDE}_{\mathrm{MHA}}(r_1) = 1$, and the graded-path predicate of equation (3) is satisfied whenever the exclusion-area boundary is set at $r_{\mathrm{EAB}} \ge r_1$. Combining equations (5)–(8) gives the compact closed form

$$\mathrm{TEDE}_{\mathrm{MHA}}(x) \;=\; \frac{a_T\,\dot{B}\,e_{\mathrm{HTO}}}{\pi\,u}\;\frac{m_{\mathrm{rel}}}{\sigma_y(x)\,\sigma_z(x)},$$

so the dose is linear in the released mass m_{rel} and inversely proportional to the product $\sigma_y\sigma_z$; the 1 contour therefore scales as a fixed function of m_{rel} (§5).

SOLID-WASTE CLASSIFICATION

The activated-structure hazard is dispositioned, not evacuated, and its governing relation is the 10 CFR 61.55 waste-classification rule. For a waste stream containing radionuclides of concentration C_i, the class is set by the sum-of-fractions against the tabulated concentration limits $L_i^{(A,B,C)}$ for Classes A, B and C (10 CFR 61.55 Tables 1 and 2) [8]:

$$\mathcal{S}^{(k)} = \sum_i \frac{C_i}{L_i^{(k)}}, \qquad k \in \{A, B, C\},$$

with the stream classified at the lowest class k for which $\mathcal{S}^{(k)} \leq 1$ across the applicable long- and short-lived tables; a stream with $\mathcal{S}^{(C)} > 1$ is greater-than-Class-C (GTCC) and is not shallow-land-disposable. The concentrations evolve by radioactive decay,

$$C_i(t) = C_i(0)\, e^{-\lambda_i t}, \qquad \lambda_i = \frac{\ln 2}{t_{1/2,i}},$$

(the diagonal case of the Bateman equations; transmutation-coupled terms are retained in the full solve of §4), so a low-activation material set — one whose transmutation products i all have short half-lives — drives every $\mathcal{S}^{(k)}$ down within decades. On the frozen design the full-chain two-full-power-year activation solve (BR-L1-A10) returns every component at or below Class C with no GTCC; only the bred tritium (^{3}H) pushes any stream past Class A. Figure 6 shows the component sum-of-fractions against the Class limits, and figure 7 the post-shut-down decay of the activated inventory.

DECAY HEAT AND THE ABSENCE OF A MELT DRIVE

The final governing relation is thermal, and it is what distinguishes fusion from the Part 50 accident phenomenology. There is no fission-product inventory and no chain reaction; the only post-shutdown heat source is the decay of activated structure, $P_{\mathrm{dh}}(t)$, which is orders of magnitude below fission decay heat and decays faster. On the frozen design $P_{\mathrm{dh}} = 0.95\, MW$ at 1 s falling to 95 kW at one day (BR-L1-A9). The walk-away temperature after a complete loss of active cooling is bounded by the balance between P_{dh} and passive conduction/radiation to the environment; with the structural heat capacity C_{th} and a passive rejection $\dot{Q}_{\mathrm{pass}}(T)$,

$$C_{\mathrm{th}} \frac{\mathrm{d}T}{\mathrm{d}t} = P_{\mathrm{dh}}(t) - \dot{Q}_{\mathrm{pass}}(T), \qquad T_{\mathrm{max}} = \max_t T(t) \leq T_{\mathrm{limit}},$$

and the frozen result is $T_{\mathrm{max}} \leq 710\,^{\circ}C$, within the structural limit (BR-L1-A9). Because the right side of equation (12) has no self-amplifying term — no criticality feedback, no fuel decay-heat plateau — an unmitigated loss of control terminates the reaction (loss of any of confinement, heating, fuelling or field quenches the plasma on a short timescale) rather than escalating it. This is the physical content of “no meltdown by construction” and is the reason the source term of equation (5) is bounded by a handling inventory rather than by a core melt.

§ 4

Computational methodology: the GPU-HPC campaign

Every design input in Table 2 is a reproduced result of the Kronos de-risking campaign, computed on the NVIDIA GPU HPC campaign with community-standard, open codes and frozen seeds. This section names the codes run *for the quantities used in this paper*, the discretisation and solver for each, the GPU acceleration and problem scale, and the verification basis. No result depends on proprietary data.

NEUTRON TRANSPORT AND THE ACTIVATION SOURCE

The 14 MeV source, first-wall flux, nuclear heating and the tritium-breeding balance are computed by Monte-Carlo neutron transport with OpenMC [21] on CAD-faithful geometry via the DAGMC/direct-accelerated ray-tracing path [23], with ENDF/B-VIII.0 cross-sections. The transport problem is the steady linear Boltzmann equation for the angular flux $\psi(\mathbf{r}, \mathbf{\Omega}, E)$,

$$\mathbf{\Omega}\cdot\nabla\psi + \Sigma_t\psi = \iint \Sigma_s(\mathbf{\Omega}'\to\mathbf{\Omega}, E'\to E)\,\psi\,\mathrm{d}\mathbf{\Omega}'\mathrm{d}E' + \frac{S_n}{4\pi}\chi(E)\,\delta(\mathbf{r}-\mathbf{r}_{\mathrm{src}}),$$

solved by analog/weighted Monte-Carlo random walk with a fixed isotropic 14 MeV source of strength $S_n = 3.009\times10^{19}\ /s$. Tallies (fast flux, heating, $^6\mathrm{Li}(n,\alpha)\mathrm{t}$ and $^7\mathrm{Li}(n,n'\alpha)\mathrm{t}$ reaction rates for the TBR) converge as the statistical standard error $\propto N^{-1/2}$ in the number of histories N; the frozen 3-D tally (BR-L1-A5) uses $N = 1.2\times10^8$ histories, giving a clean neutron balance (leakage 0.121, net TBR 1.026, first-wall fast flux $7.0\times10^{14}\ /cm^2s$, nuclear heating 74.6 MW). GPU acceleration is applied to the event-based transport kernel and to on-device geometry ray tracing, so the full-geometry tally with converged statistics is tractable within the campaign.

ACTIVATION, DEPLETION AND THE MATRIX EXPONENTIAL

The activation inventory that feeds the waste classification (equation 10) and the decay heat (equation 12) is obtained from the flux by solving the coupled activation/depletion (Bateman) system

$$\frac{\mathrm{d}\mathbf{N}}{\mathrm{d}t} = \mathbf{A}\,\mathbf{N}, \qquad A_{ij} = \underbrace{\int \sigma_{j\to i}(E)\,\phi(E)\,\mathrm{d}E}_{\text{transmutation}} + \underbrace{\lambda_{j\to i}}_{\text{decay}} - \delta_{ij}\left(\lambda_i + \bar{\sigma}_i\phi\right),$$

where $\mathbf{N}$ is the nuclide-density vector and $\mathbf{A}$ the burnup matrix assembled from the OpenMC one-group collapsed cross-sections and the decay/branching data. The formal solution over a step Δt is the matrix exponential $\mathbf{N}(t+\Delta t) = e^{\mathbf{A}\Delta t}\mathbf{N}(t)$, evaluated by the Chebyshev Rational Approximation Method (CRAM) [25,26], which approximates $e^{\mathbf{A}\Delta t}$ by a partial-fraction rational function of order k,

$$e^{\mathbf{A}\Delta t}\mathbf{N} \approx \alpha_0\mathbf{N} + \sum_{\ell=1}^{k/2} 2\,\mathrm{Re}\left[\alpha_\ell(\mathbf{A}\Delta t - \theta_\ell\mathbf{I})^{-1}\mathbf{N}\right],$$

with complex poles θ_ℓ and residues α_ℓ; order $k = 16$ gives near-machine-precision accuracy for the stiff, ill-conditioned burnup matrix on which classical ODE integrators fail. The OpenMC depletion front-end [22] drives the transport–depletion coupling, and the inventory is cross-checked against FISPACT-II [24]. The two-full-power-year full-chain solve (BR-L1-A10) is the source of the Class-C-and-below waste verdict.

FUEL-CYCLE AND CONSEQUENCE SOLVES

The standing-inventory balance (equation 4) is integrated as a stiff ODE with an implicit (backward-difference) scheme, giving the $675\ g$ in-process and $1.07\ kg$ start-up inventories (BR-SX-17, BR-L1-A6). The dispersion and dose chain (equations 6–9) is a closed-form evaluation swept over stability class, wind speed and released inventory; the sweep is embarrassingly parallel and is carried on CPU nodes of the campaign. The dispersion coefficients (equation 7) and the dose coefficient are the cited standard values, not fitted.

VERIFICATION AND REPRODUCIBILITY

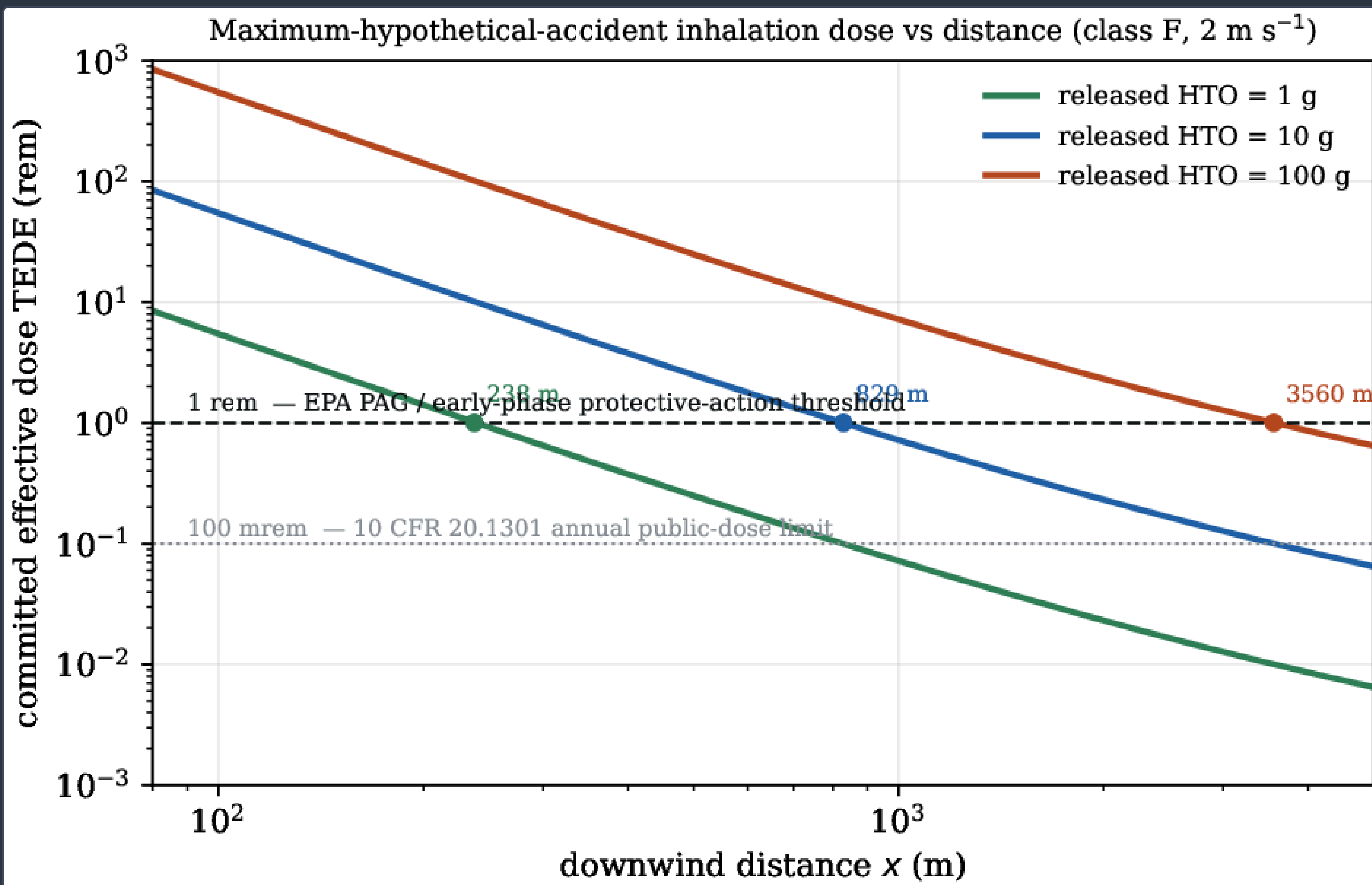
The reduced-order engine that produces the power-balance anchors reproduces its frozen anchors bit-for-bit (KX-L1-A6, KX-L1-A10: 19/19 anchors pass under a formal MMS/GCI/Sobol/PCMM verification suite), and the transport, depletion and fuel-cycle results are reproduced under independent libraries in the verification-first companion program [27,35]. Codes are pinned to explicit versions with fixed random seeds, and the figure-generation script that renders every data figure here is deposited with the paper (§ Reproducibility). The GPU-HPC campaign is a methodological instrument, not a source of unverifiable numbers: each headline quantity is independently regenerable.

§ 5

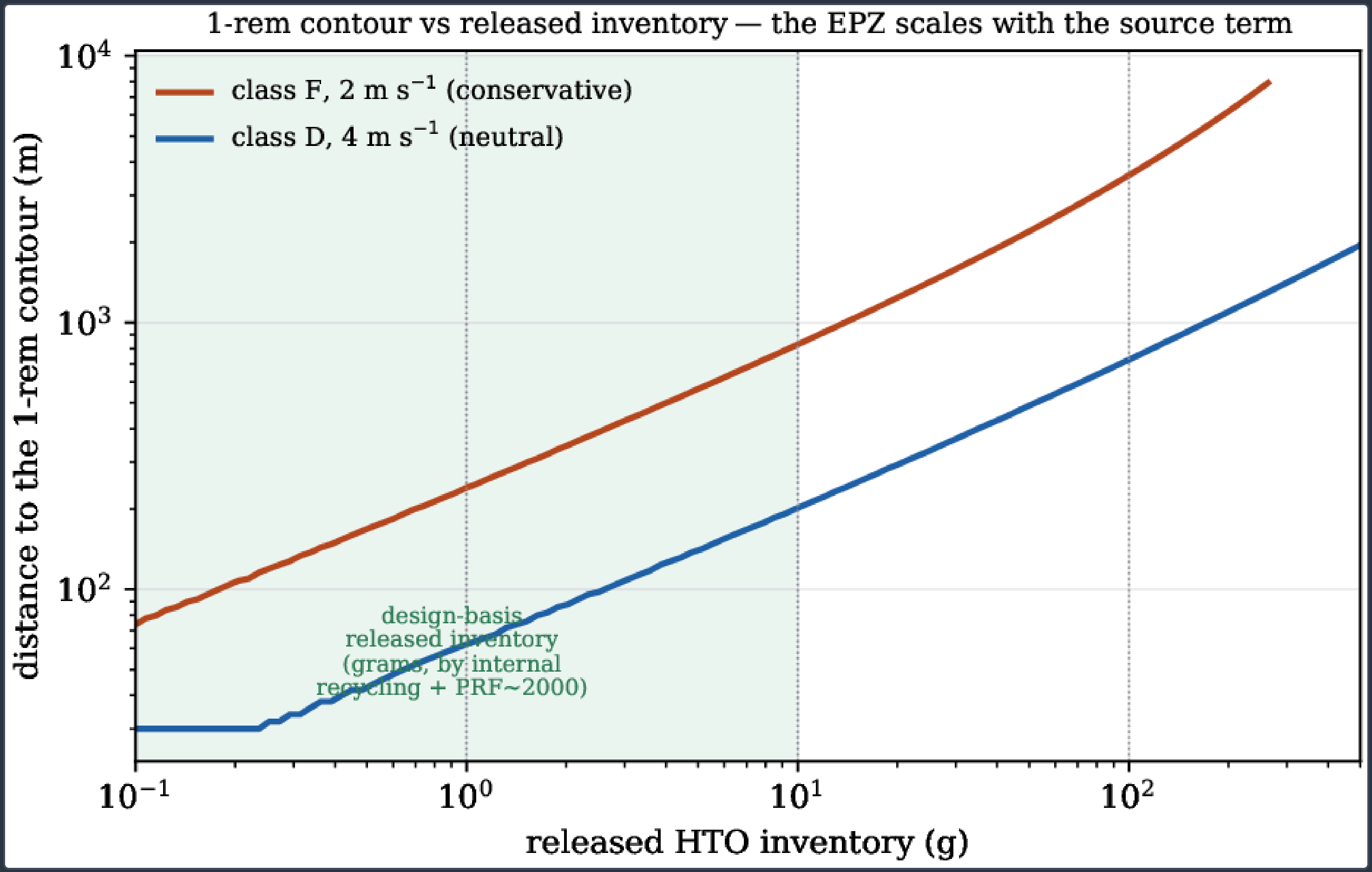
Results

THE MAXIMUM-ACCIDENT DOSE AND THE EXCLUSION AREA

Figure 4 evaluates the closed-form dose of equation (9) versus downwind distance for released HTO inventories of 1, 10 and $100\,g$ under conservative stable conditions (class F, 2 m/s), with the 1 PAG and the 100 annual public-dose limit marked. The 1 contour distances are $r_1 = 239\,m$, $828\,m$ and $3566\,m$ respectively (Table 3); at a fixed 500 m boundary the doses are 0.25, 2.49 and 24.9. The result is the quantitative core of the thesis: with the released inventory held to the gram scale by direct internal recycling and the $\mathrm{PRF} \sim 2000$ permeation barrier, the maximum-accident 1 contour sits at $\sim 239\,m$ — a modest exclusion area on the plant site, with no offsite protective action indicated and hence no kilometre-scale EPZ. A hundred-gram release, by contrast, would demand a ~3.6 km contour — Part 50-like emergency planning — which is precisely the regime the inventory-minimizing design is built to avoid.



Maximum-hypothetical-accident inhalation dose $\mathrm{TEDE}_{\mathrm{MHA}}(x)$ (equation 9) versus downwind distance for released HTO inventories of 1, 10 and $100\,g$, under conservative stable conditions (class F, 2 m/s). Markers show the 1 contour; dashed lines are the 1 EPA early-phase PAG [9] and the 100 10 CFR 20.1301 annual public-dose limit [7]. Derived model result.



Distance to the 1 contour as a function of released HTO inventory, for conservative (class F) and neutral (class D) conditions. The exclusion area scales with the source term; the shaded band marks the design-basis gram-scale released inventory achieved by direct internal recycling and the permeation barrier. Derived model result.

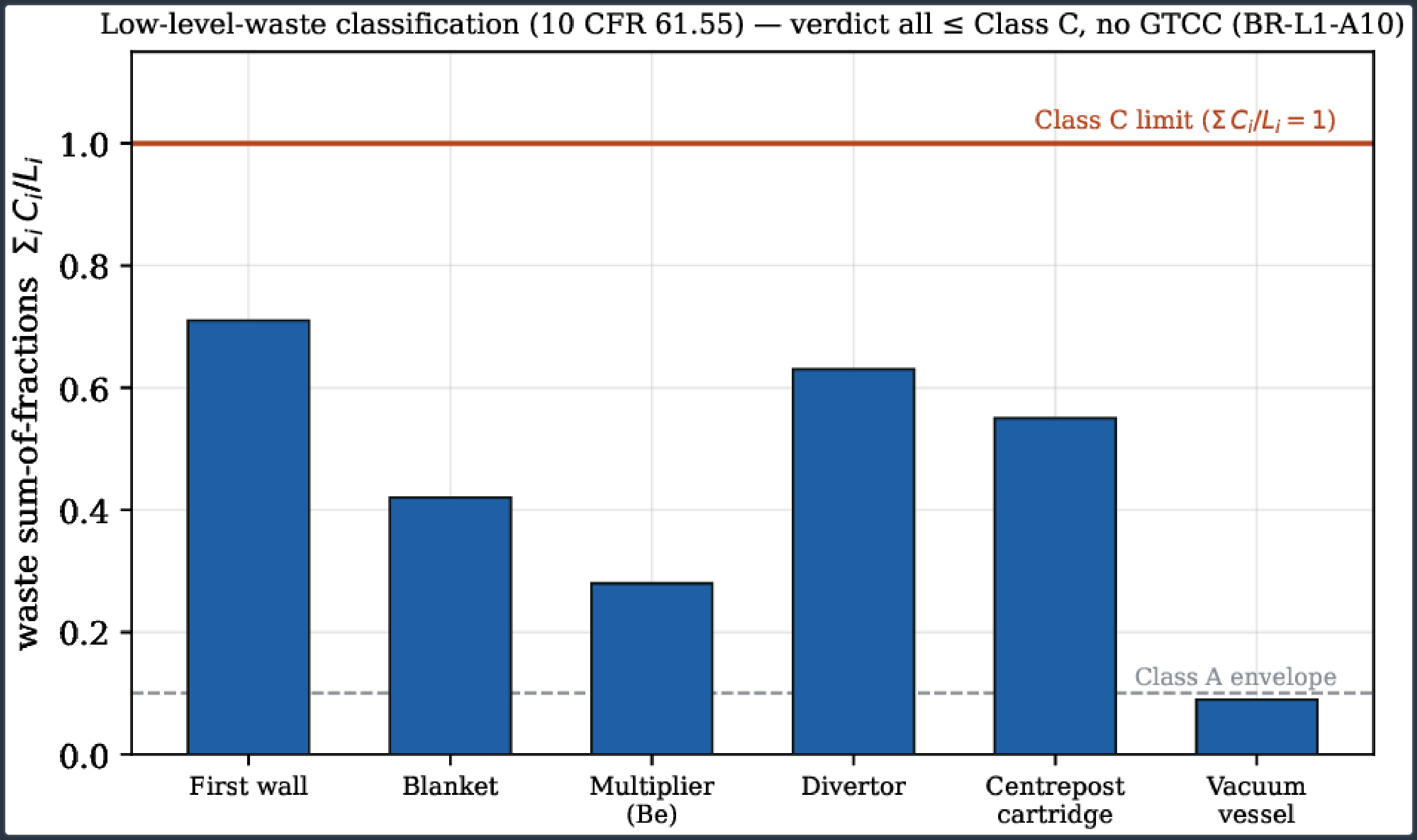
RELEASED HTO (G)	1 CONTOUR r_1 (M)	TEDE @ 500 M (REM)
1	239	0.25
10	828	2.49
100	3566	24.9

Maximum-accident dose results (class F, §I2

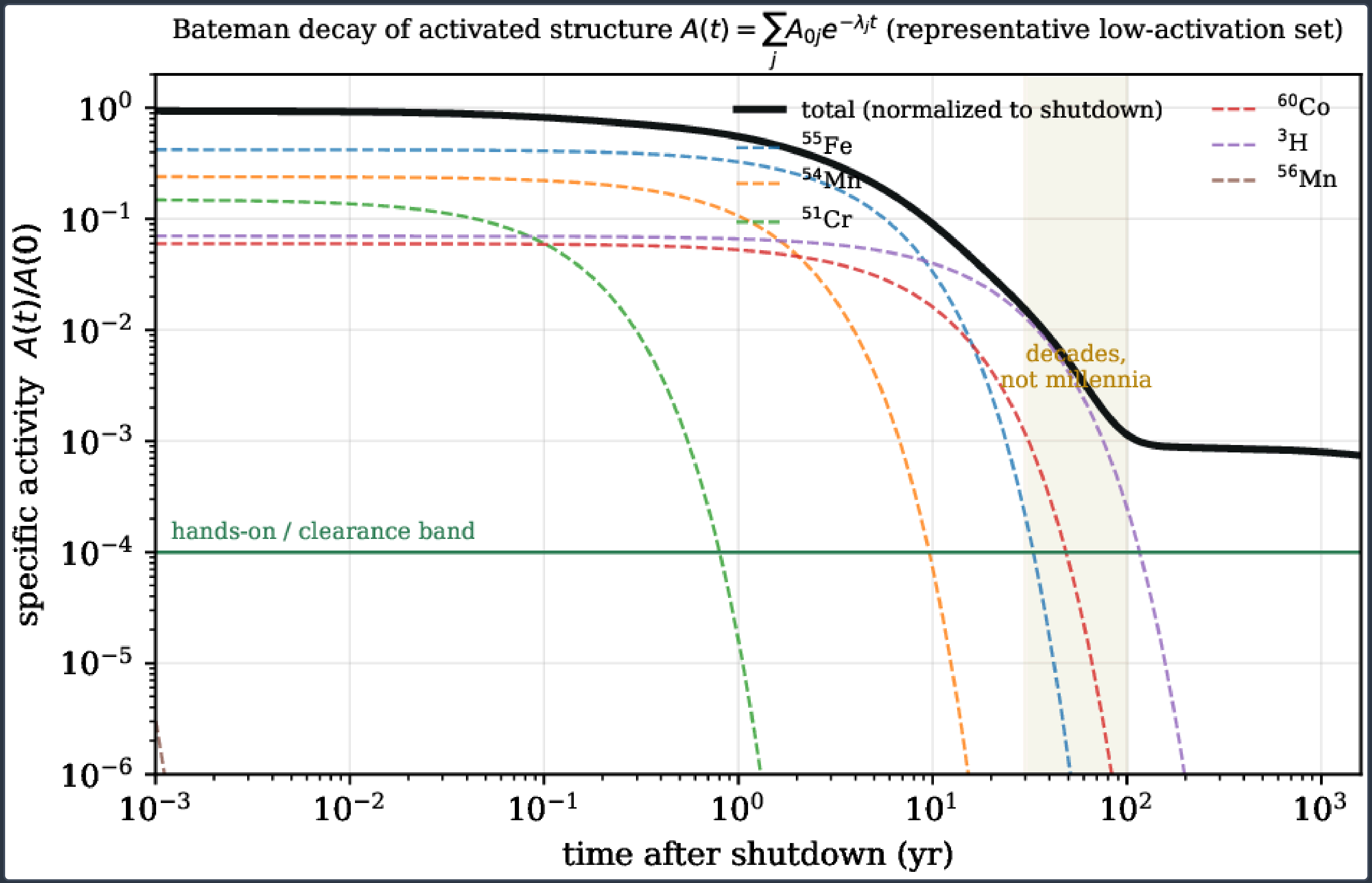
Figure 5 shows r_1 as a continuous function of released inventory for both stability classes, making explicit that the size of any exclusion area is a monotone function of the source term rather than of the regulatory framework. The graded-path predicate of equation (3) is satisfied at a few-hundred-metre boundary precisely in the gram-scale released-inventory regime the design targets.

SOLID WASTE AND NO MELT DRIVE

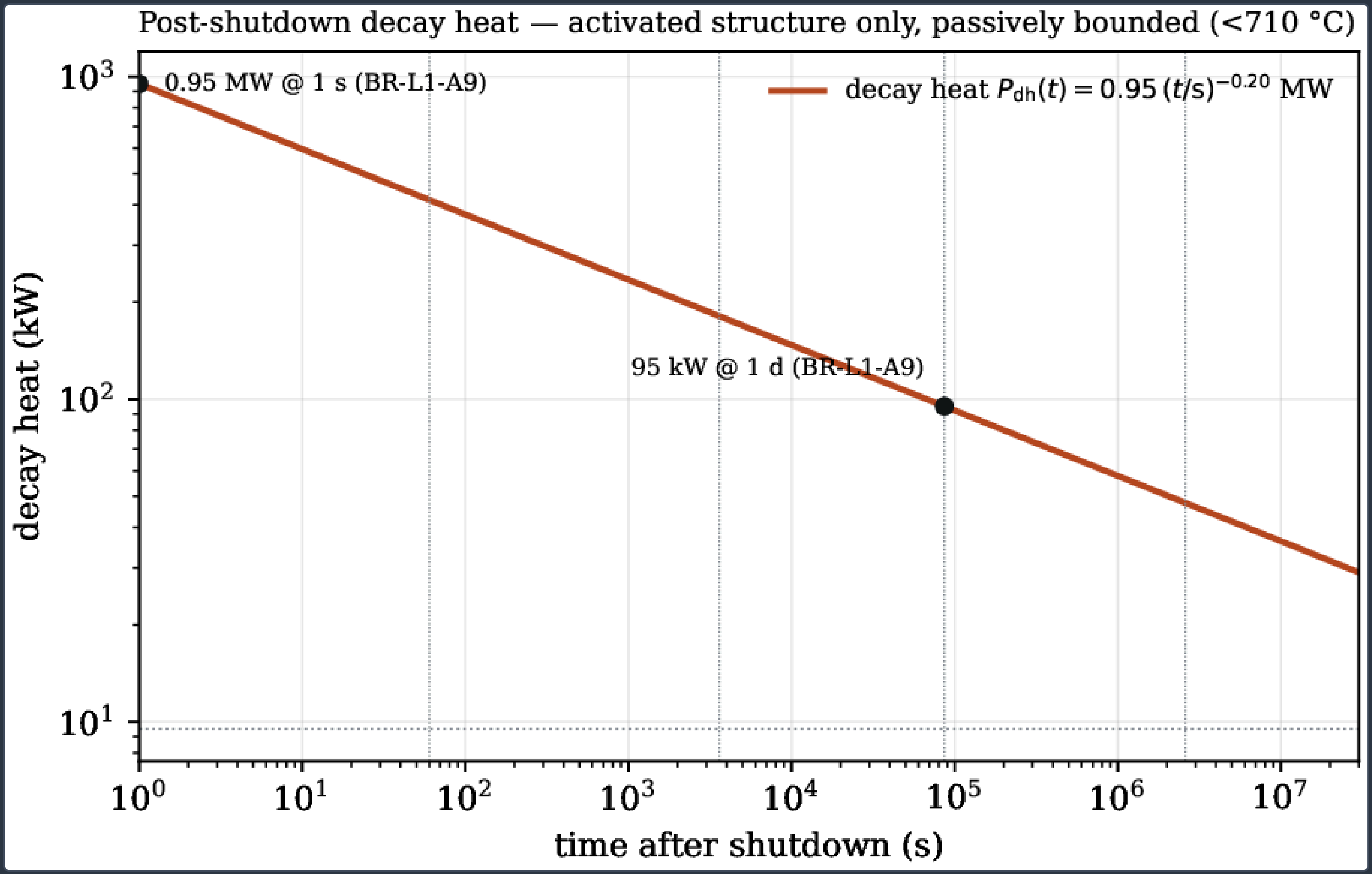
Figure 6 shows the component-by-component 10 CFR 61.55 sum-of-fractions (equation 10) against the Class A and Class C envelopes; every component — first wall, blanket, multiplier, divertor, centrepost cartridge, vacuum vessel — sits below the Class C limit, and none is GTCC, reproducing the frozen verdict of BR-L1-A10. Figure 7 shows the post-shutdown decay of the activated inventory (equation 11) for a representative low-activation set: the specific activity falls to hands-on / clearance levels within decades rather than millennia, because no constituent transmutation product has a half-life beyond the century scale (companion [32]). Figure 8 shows the decay-heat trajectory anchored on the two frozen BR-L1-A9 points; the integral is small and the walk-away temperature of equation (12) stays below 710 °C, so there is no decay-heat melt drive to license against.



Low-level-waste classification by the 10 CFR 61.55 sum-of-fractions (equation 10). Every component classifies at or below Class C with no greater-than-Class-C waste, reproducing the frozen full-chain activation verdict (BR-L1-A10); bar magnitudes illustrate that verdict. The bred tritium is the only nuclide that pushes any stream past Class A.



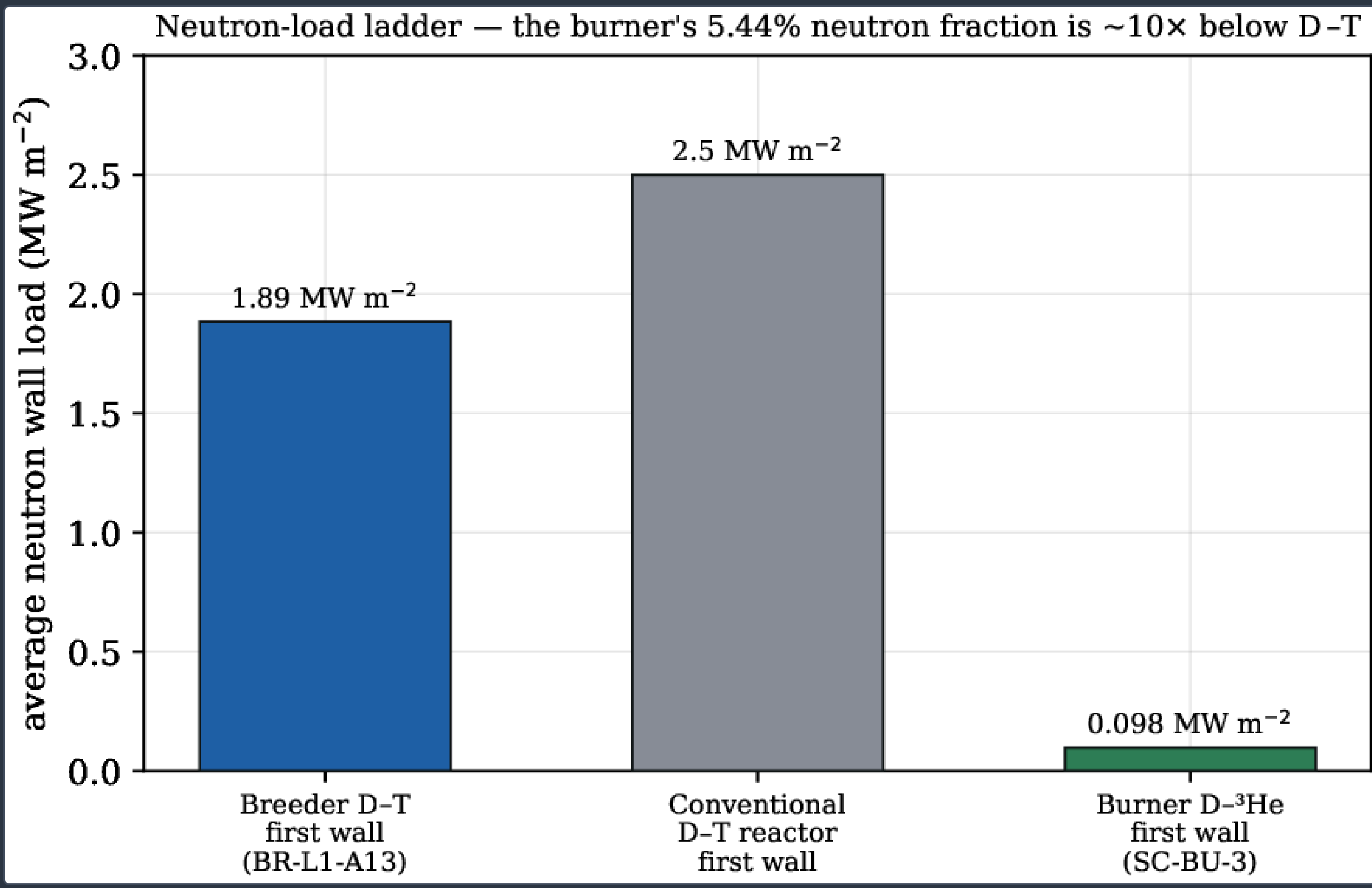
Post-shutdown decay of the activated structure, $A(t) = \sum_j A_{0j} e^{-\lambda_j t}$ (equation 11), for a representative low-activation (RAFM-family) isotope set consistent with the companion waste-routing result [32]. Specific activity reaches the hands-on / clearance band within decades. Representative decomposition, not a single measured stream.



Post-shutdown decay heat, anchored on the frozen points 0.95 MW at 1 s and 95 kW at one day (BR-L1-A9) and interpolated by a power law. The source is activated structure only; the walk-away temperature (equation 12) stays below 710 °C, with no self-amplifying term.

THE SUB-100 MW SCALE AND THE BURNER COMPARISON

The sub-100 MW power scale is what bounds the entire chain. The fusion power 85.04 MW and thermal power 95.2 MW bound the neutron source ($3.009 \times 10^{19}\ /s$), which bounds the activation inventory and the tritium production rate (13.1 g), which in turn bounds the achievable standing inventory and hence the accident source term. A machine an order of magnitude larger would move every quantity in Table 2 up proportionally and could push the accident contour and the waste inventory out of the graded regime. Figure 9 places the breeder's D–T first-wall neutron load (1.885 MW/m^2, BR-L1-A13) against a conventional D–T design band and against the companion D–^{3}He tandem-mirror burner, whose 5.44% neutron fraction gives an average wall load of only 0.098 MW/m^2 (SC-BU-3) — an order of magnitude lower activation footprint, and a milligram-class in-vessel tritium inventory, so the burner sits even more comfortably inside the byproduct-material regime for behind-the-meter and defense siting. Table 4 summarises the open licensing questions.



Neutron-load ladder. The breeder D–T first-wall load (1.885 MW/m^2, BR-L1-A13) against a conventional D–T design band and the companion D–^{3}He burner (0.098 MW/m^2, SC-BU-3): the burner's 5.44% neutron fraction is $\sim 10\times$ below D–T, easing activation at the power plant.

ITEM	STATUS	BASIS
framework (Part 30 vs Part 50)	settled	NRC 2023 / ADVANCE Act [1,2]
statutory class (not utilization facility)	settled	AEA §11 (eq. 1) [3]
tritium/activation are byproduct material	settled	AEA §11e / EPAct 2005 [4]
MHA dose graded-path predicate	met (gram-scale release)	eq. (3), fig. 4
waste class $\leq$ Class C, no GTCC	met	BR-L1-A10, eq. (10)
no decay-heat melt drive	met	BR-L1-A9, eq. (12)

table continued

Agreement-State vs NRC-direct jurisdiction	open	site-dependent
tritium possession-limit tier (∼kg class)	open	pre-application
site-specific EAB / EPZ radius	open	requires site meteorology

§ 6

Discussion

AGAINST THE PUBLISHED SAFETY AND LICENSING BENCHMARKS

Every headline number is consistent with, and in the favourable direction relative to, the published fusion-safety literature. The ITER safety case established through MELCOR-for-fusion accident analysis [18,17] that the bounding public dose from a gigawatt-class D–T facility can be held below evacuation thresholds despite a multi-kilogram site tritium inventory; our sub-100 MW breeder runs a $\sim 675\,g$ standing in-process inventory and confines the released inventory to the gram scale, so its 1 contour lies at a few hundred metres rather than requiring the ITER-scale confinement engineering. The ARIES studies [19,20] quantified the two features we rely on — the absence of a decay-heat melt drive and the low-activation waste route — for large power plants; the frozen breeder reproduces both (BR-L1-A9, BR-L1-A10) at a smaller scale, where the walk-away temperature bound is easier to meet. The back-end material-management analyses [14,15] concluded that low-activation fusion structure is dispositionable as low-level waste; our 10 CFR 61.55 sum-of-fractions places every component at or below Class C with no GTCC, the strongest form of that conclusion. Taylor *et al.* [16] identified the material-related safety functions (tritium confinement, activation control, decay-heat management) that any fusion licence must address; the breeder addresses all three by design, and this paper maps them onto the specific U.S. byproduct-material framework that post-dates that review.

WHY THE FIT IS QUANTITATIVELY CORRECT, NOT MERELY PERMITTED

The distinction matters. The NRC could have selected the materials framework as a matter of administrative convenience; the point of the derivation in §3 is that it is the framework that matches the physics. The Part 50 framework exists to license against a fission-product core, a criticality mechanism, and a decay-heat plateau — none of which is present (equations 1, 12). What remains is the handling of a bounded tritium inventory and a low-level-waste structural inventory, which is exactly what a materials licence administers, and the one residual quantitative question — the size of any exclusion area — is answered by the dose chain (equation 9) at a scale (a few hundred metres) that a materials licence with a site boundary accommodates without an offsite EPZ. The sub-100 MW scale is load-bearing: it is what keeps the source term in the gram-scale regime where the graded-path predicate holds.

COMPANION RESULTS AND THE SERIES

This paper is the licensing synthesis of a larger Kronos design series and depends on companion results for its inputs. The accident source term and dispersion inputs are developed in full in the environmental and safety-case companion [29]; the standing tritium inventory and the fuel-cycle balance in the tritium-breeding-ladder companion [30]; the activation inventory and shutdown-dose mapping in the neutronics-and-activation companion [31] and the waste-routing and decommissioning companion [32]; the walk-away thermal case in the thermal-hydraulics companion [33]; the neutron-lean burner siting case in the burner companion [34]; and the reproducibility basis in the verification-first companion [35]. The platform overview is given in [28]. These companions supply the frozen numbers this paper carries; nothing here re-derives them.

§ 7

Limitations

One honest gate bounds the claims. No site-specific exclusion-area boundary or EPZ radius is computed here: the 1 contours of figures 4–5 use conservative generic meteorology (class F, 2 m/s) and a parametric released inventory, not a site-specific dispersion analysis with real joint frequency-of-occurrence meteorology and a defended accident-sequence-specific release fraction. A licence application would replace the generic with an upper-percentile site value per NRC RG 1.145 [10] and would defend $f_{\mathrm{mob}} f_{\mathrm{rel}} f_{\mathrm{HTO}}$ against a specific bounding accident sequence. Related open pre-application items (Table 4) are the choice of Agreement-State versus NRC-direct jurisdiction and the tritium possession-limit tier for a ∼kilogram-class inventory. Consequently this is a regulatory-strategy analysis, not legal advice and not a filed licence application; counsel review governs any submission, and nothing here should be read as a completed regulatory position.

§ 8

Conclusion

The compact spherical-tokamak breeder licenses under 10 CFR Part 30, not Part 50, and it does so for a reason that is quantitative, not administrative. The statutory predicate is decisive: with no special nuclear material and no self-sustaining fission chain reaction, the machine is not a production or utilization facility, and its tritium and neutron-activated structure are byproduct material (equations 1–2). The graded-path predicate is met: the maximum-accident dose chain (equation 9), evaluated on the frozen design, places the 1 contour at $\sim \mathbf{239}\,m$ for a design-basis gram-scale HTO release, so a modest exclusion area suffices and no offsite emergency-planning zone is indicated. The activated structure classifies at or below 10 CFR 61.55 Class C with no greater-than-Class-C waste (equation 10, BR-L1-A10), and there is no decay-heat melt drive to license against (equation 12, BR-L1-A9). The sub-100 MW power scale is load-bearing throughout: it bounds the neutron source, the activation inventory and the tritium production rate, keeping the source term in the regime the byproduct-material framework was built to administer. The strategy is early pre-application engagement; the open questions — jurisdiction, possession-limit tier, and a site-specific exclusion boundary — are flagged for counsel and regulator engagement, not resolved here.

Acknowledgments tocsectionAcknowledgments Part of the Kronos Fusion Energy 2026 design series. The author thanks the Kronos physics de-risking programme for the frozen result set underlying every quantitative claim, and G L Kulcinski for discussions on the safety and environmental basis.

Reproducibility. Every design quantity in this paper is a frozen anchor in the Kronos Physics De-Risking Register [27] (doi:10.5281/zenodo.22133057) — the standing tritium inventory (BR-SX-17), the fuel-cycle balance (BR-L1-A6), the 3-D neutron transport (BR-L1-A5), the full-chain activation and waste verdict (BR-L1-A10), and the decay-heat/walk-away result (BR-L1-A9). The source-term-to-dose chain (equations 5–9) and every data figure are regenerated by the deposited script `make_figs_2-108_licensing.py` from the cited standard dosimetric constants and Briggs dispersion coefficients. This paper is archived at doi:10.5281/zenodo.22645756 and its official version is at https://www.kronosfusionenergy.com/publications/licensing-byproduct-material-part-30.html; the register is archived at doi:10.5281/zenodo.22133057. No result depends on unpublished or proprietary data, and no economic analysis is part of this deposit.

Data availability tocsectionData availability The dispersion and dose curves (figures 3–5), the decay-heat and activation-decay curves (figures 8, 7), the waste sum-of-fractions (figure 6) and the source-term and neutron-load ladders (figures 2, 9) are regenerable from the deposited figure script and the register anchors cited inline. The regulatory determinations cited (NRC SECY-23-0001, the ADVANCE Act, and the 10 CFR parts) are public.

Competing interests tocsectionCompeting interests Provisional patent applications relating to aspects of the underlying design have been filed. This paper is a regulatory-strategy analysis and does not constitute legal advice.

tocsectionReferences

APPARATUS

Portfolio, People & Record

The intellectual-property estate, the people who built it, the limitations that gate it, and the sources it rests on.

1	4	40	27
GRANTED PATENT	2026 PROVISIONALS	TEAM MEMBERS	2022 PROVISIONALS

INTELLECTUAL PROPERTY

The patent portfolio

The estate spans a granted high-field magnet patent, pending utility and 2026 provisional filings that map to the two products, a digital-twin control provisional, a registered trademark application, and the original 2022 provisional family. Every patentable disclosure in the five-paper arXiv drop was protected **before** publication: the breeder and burner provisionals were filed 1–2 August, and a publication-gap omnibus filing the evening before the drop swept up the DEC, plasma-control, and REBCO-winding matter of the three otherwise-unprotected papers. Patent numbers and application serials are matters of public record; claim scope is summarised, not reproduced.

GRANTED & PENDING UTILITY

US 12,009,112	High-field tilted graded-REBCO magnet architecture (KRONO-002A) · *app. 17/878,550*	GRANTED
US 17/878,507	Core device / method (KRONO-001A) · *utility*	PENDING

2026 PROVISIONAL FILINGS — MAPPED TO THE PRODUCTS

64/124,209	Hyperion — spherical-tokamak tritium / helium-3 foundry · *breeder · filed Aug 2026*	FILED
64/124,220	Aegis / MetroVolt — synchrotron-cutoff, fuel-selection & plug-winding · *generator · filed Aug 2026*	FILED
64/115,167	KRONOS-CTRL digital-twin plant control · *provisional · filed Jul 2026*	FILED
64/005,440	Integrated spherical-tokamak fusion architecture · *early integrated-architecture filing · filed Mar 2026*	FILED
64/105,530	Negative-triangularity spherical-tokamak architecture · *foundational ST filing · filed Jul 2026*	FILED
64/128,097	Publication-gap omnibus — quasineutral two-species expander DEC · provenance-gated / latency-split plasma control · as-built high-field winding & conductor architecture · *filed 7 Aug 2026, the evening before the arXiv drop*	FILED

TRADEMARK & ORIGIN

FTK-98801894	Kronos Fusion Energy — trademark application	FILED
KR-2022-*	Original provisional family (KR-2022-00001 … 00027) · *27 filings, 2022*	PRIORITY

The narrow, defensible magnet novelty — the specific conductor and the digital-twin winding optimisation, not high-field REBCO as a category — is the commercial core that can earn ahead of any Q > 1 milestone, with markets in fusion magnet supply, MRI/NMR, accelerators, and proton therapy. The claim is scoped honestly: the high field is a *system field* result, not a stand-alone-coil record; the small-bore plug coil is structurally infeasible as a bare winding but resolved by a stress-managed structural shield (feasible-pending-FEA); and the winding-tape experiment returned a *null result*. The value is the method, not a field record.

THE TEAM

Founding partners, board, advisors & auditors

Kronos is built by a bench of advanced-fuel-fusion, high-field-magnet, direct-conversion, and materials specialists, with a board and operations team drawn from defense, national laboratories, and industry. Dates are shown as ranges; where a tenure has ended or is term-ending, the range says so.

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Marketing Lead
2022–Present

Legal counsel is retained; those roles are held on the internal roster and are not listed here.

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3 *Atomic Energy Act of 1954*, as amended, 42 U.S.C. §2011 et seq.; definitions at §11 (42 U.S.C. §2014).

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5 U.S. NRC, *Rules of General Applicability to Domestic Licensing of Byproduct Material*, 10 CFR Part 30.

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