# Radiological Characterization and Management Priority Assessment of Radiation-Use Facilities Based on Weekly Monitoring Data

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## 1. Introduction

Routine radiation safety monitoring generates dose rate and contamination data to support radiation protection and regulatory compliance [2,3]; however, accumulated monitoring records are not routinely integrated for facility-level prioritization. This study proposes a Facility Management Index (FMI) integrating dose rate (D), surface contamination (S), airborne radioactivity (A), temporal variability (V), and repeated elevated detections (R) to prioritize HP inspections.

## 2. Methods

### *2.1 Monitoring Spaces and Instrumentation*

Ten spaces with complete Q2 2026 (13-week) weekly data were selected across three buildings: App. 217, 512, 513, and 515 (Radiation Application Research Building); 6th 006, 111, 112, and 113 (6th Research Building); and NF 1F and NF 110 (Nuclear Fuel Materials Research Building). Surface contamination was measured by smear (100 cm², 1-min counting time; MDA: α $9.37\times10^{-3}$, β $6.55\times10^{-3}$ Bq/cm²). Airborne radioactivity was sampled over 7.2 m³ for 10 min, and the filters were counted after a 72-h decay period (MDA: α $4.06\times10^{-3}$, β $1.64\times10^{-2}$ Bq/m³). Dose rate was measured weekly with a survey meter (lower limit 0.20 μSv/h) [1].

### *2.2 Data Analysis*

Data spanned 13 weeks (1 April–26 June 2026). Median, maximum, and CV (σ/μ × 100%) were calculated per measurement type; values reported as below the MDA were set to zero for statistical calculations, which may inflate CV in spaces with few or no detections above MDA. Statistical outlier candidates were identified by the Grubbs test (α = 0.05) applied separately to each measurement series (smear α, smear β, airborne α, airborne β); all flagged values were retained as valid measurements, and their influence on FMI classification was subsequently examined via sensitivity analysis.

### *2.3 Facility Management Index (FMI)*

$$FMI = D + S + A + V + R$$

Each component was scored from 0 to 2 (Table I) using exploratory thresholds derived from the empirical Q2 distribution, not from regulatory limits. Thresholds were selected to distinguish relatively elevated levels within the dataset and rounded to physically interpretable values; the distributional reference varied by component to reflect differences in detection frequency and radiological significance. For the D-score, values below 1.0 μSv/h scored 0 and values ≥3.0 μSv/h scored 2. For the S-score, the asymmetric α/β multipliers (α ≥ MDA×5, β ≥ MDA×10) reflect the higher radiological significance of alpha-emitting contamination. The V-score used the maximum CV among surface and airborne α/β measurements; the R-score counted dates with at least one measurement ≥MDA×5. Spent-filter air samples (Quantity = 0.0 m³) were excluded from A- and R-score calculations. The Group I threshold (FMI ≥ 6) was selected to identify spaces showing elevated scores across multiple monitoring components rather than those dominated by a single monitoring characteristic; because thresholds are dataset-relative, recalibration is needed for facility populations with materially different measurement ranges. Sensitivity analyses tested alternative Group I cutoffs (FMI ≥ 5 and ≥ 7), V-score thresholds (60/120% and 100/200%), and R-score criteria (MDA×3 and MDA×8).

Table I. FMI scoring criteria (0–2 points per component, maximum score 10)

| Component | 2 pts | 1 pt | 0 pts |
|---|---|---|---|
| **D (Dose rate)** | Max ≥ 3.0 μSv/h | 1.0 ≤ Max < 3.0 μSv/h | Max < 1.0 μSv/h |
| **S (Surface)** | β ≥ MDA×10 or α ≥ MDA×5 | Max ≥ MDA but below the 2-point crite-rion | All < MDA |
| **A (Airborne)** | α ≥ MDA×20 or β ≥ MDA×10 | Max ≥ MDA×5 but below the 2-point criterion | All < MDA×5 |
| **V (Variability)** | CV ≥ 150% | 80% ≤ CV < 150% | CV < 80% |

| | | | |
|---|---|---|---|
| **R (Repeated Elevated Detection)** | ≥ 2 dates | 1 date | None detected |

*V-score: maximum CV among surface α/β and airborne α/β. Classification: FMI ≥ 6 → Group I (intensive), 3–5 → Group II (precautionary), ≤ 2 → Group III (routine).*

*R-score: number of dates with any surface or airborne α/β ≥ MDA×5; spent-filter measurements (Quantity = 0.0 m³) excluded.*

## 3. Results and Discussion

### *3.1 Radiological Characteristics by Space*

App. 217 exhibited a median dose rate of 1.31 μSv/h (max 6.74 μSv/h) and FMI = 10. Statistical outlier candidates identified on 8 April (Grubbs test; G = 2.47, 2.74 > Gcrit = 2.13, 2.29) were retained as valid measurements; their exclusion did not alter the Group I classification. Room 6th 113 showed a maximum dose rate of 3.12 μSv/h, β-surface contamination of $2.28\times10^{-1}$ Bq/cm² (MDA×35), CV = 185%, and repeated ≥MDA×5 detections, yielding FMI = 8. Across the remaining spaces, FMI ranged from 1 to 9, indicating substantial differences in the combined magnitude, variability, and recurrence of monitoring results.

### 3.2 FMI-Based Management Prioritization

FMI results are summarized in Table II. Five spaces were classified as Group I, two as Group II, and three as Group III. At 6th 113, the co-occurrence of elevated dose rate, high surface contamination, high variability, and repeated detections demonstrated a multi-component pattern not captured by single-point maximum comparisons. CV may be disproportionately high near the MDA when sub-MDA values are set to zero; App. 512 (CV = 332%, FMI = 3) illustrates this limitation, and V-scores should therefore be interpreted alongside contamination magnitude and recurrence. Notably, 6th 006 and NF 110 reached Group I through variability and repeated elevated detections rather than high single-point maxima, demonstrating the value of V- and R-scores. Increasing the Group I cutoff to FMI ≥ 7 reclassified only 6th 006 and NF 110 to Group II; V- and R-score variant tests left all other classifications unchanged. The relatively high Group I fraction (5 of 10) reflects the index's dataset-relative design: FMI ranks spaces within the monitored population rather than against an absolute radiological standard, thereby identifying spaces with relatively elevated monitoring characteristics within the study population. These findings suggest that the FMI can complement conventional compliance-based monitoring as a data-driven prioritization framework for HP decision-making.

Table II. FMI scores and management group classification

| Space | D | S | A | V | R | FMI | Group |
|---|---|---|---|---|---|---|---|
| App. 217 | 2 | 2 | 2 | 2 | 2 | 10 | I |
| App. 512 | 0 | 1 | 0 | 2 | 0 | 3 | II |
| App. 513 | 0 | 0 | 0 | 1 | 0 | 1 | III |
| App. 515 | 0 | 0 | 0 | 1 | 0 | 1 | III |
| 6th 006 | 0 | 1 | 1 | 2 | 2 | 6 | I |
| 6th 111 | 0 | 0 | 0 | 1 | 0 | 1 | III |
| 6th 112 | 0 | 1 | 0 | 2 | 1 | 4 | II |
| 6th 113 | 2 | 2 | 0 | 2 | 2 | 8 | I |
| NF 1F | 2 | 1 | 2 | 2 | 2 | 9 | I |
| NF 110 | 0 | 1 | 1 | 2 | 2 | 6 | I |

*Classification: FMI ≥ 6 → Group I, 3–5 → Group II, ≤ 2 → Group III. Spent-filter samples (Quantity = 0.0 m³) excluded from A- and R-scores. * App. 217: 8 Apr statistical outlier candidates retained; FMI = 10 (Group I) unchanged if excluded.*

## 4. Conclusion

The FMI integrated weekly dose rate, contamination magnitude, temporal variability, and repeated elevated detections to prioritize HP inspections. By incorporating variability and recurrence in addition to measurement magnitude, the FMI provides complementary information that is not captured by conventional single-point assessment alone. Among 10 spaces, five were classified as Group I, two as Group II, and three as Group III. Group I spaces may be considered for priority HP inspection, Group II spaces require trend monitoring, and Group III spaces remain under routine monitoring. Although the current thresholds are calibrated to the Q2 2026 distribution of a single research institute, potential applicability to other facility populations should be evaluated through recalibration and external validation. Future studies will assess inter-facility generalizability and incorporate persistent low-level detections, nuclide type, and work frequency.

## REFERENCES

[1] NSSC, Technical Standards for Radiation Safety, NSSC Notice 2025-3, 2025.

[2] IAEA, Occupational Radiation Protection, GSG-7, Vienna, 2018.

[3] IAEA, International Basic Safety Standards, GSR Part 3, Vienna, 2014.