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Comparison of Nuclear Material Accounting Report Formats and Operator-Side Considerations in Format Transition

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1. Introduction

Since concluding a Comprehensive Safeguards Agreement (CSA) with the IAEA in 1975, the Republic of Korea has performed nuclear material accounting reporting based on the IAEA Fixed Format. Nuclear operators also submit monthly and annual Nuclear material accounting reports to the State in Fixed Format.

The Fixed Format is intuitive for operators because field lengths and column positions are predefined; however, it imposes constraints on several fields—such as batch name and nuclear material weight—and its extensibility is limited. Originating from the punched-card environment of the early 1970s, this rigid structure struggles to accommodate new data types and is poorly compatible with modern database technologies.

Because of these constraints, the IAEA developed the Labelled Format and in the 2000s the schema-based XML Format an internationally standardized format offering cross-system compatibility and automated validation already adopted by countries such as the Euratom and UK.

Accordingly, Korea Nuclear Safety and Security Commission (NSSC) and the Korea Institute of Nuclear Nonproliferation and Control (KINAC) are examining a transition from the Fixed Format to the XML Format, with a view to improving the accumulation and utilization of accounting data and aligning with international practice.

Motivated by this discussion, the present study compares the structural characteristics of the three formats and summarizes the considerations that arise on the operator side during a format transition.

2. Comparison of Accounting Report Formats

Table 1 summarizes the structural characteristics of the Code 10 formats according to two common criteria: data structure and representative field-length constraints (batch name, report number, and free-text capacity). These criteria were selected because they most directly determine the workload burden placed on operators, rather than the underlying accounting logic itself—indeed, the Inventory Change Code (IC Code) and Material Description Code (MD Code) remain the same across all three formats [1,2,4], so this logic is unchanged by the XML transition, and only the structure of the container carrying it differs.

Table 1. Comparison of Code 10 Formats

Item	Fixed	Labelled	XML
Structure (Data Identification)	Fixed column position base (80 columns)	Label base (000:....#)	Schema (XSD) tags base (< > … </ >)
Field-length constraints (examples)	Batch name: 8 chars; Report no.: up to 9999 (4 digits); Free text: up to 68 chars/entry separate attachment (Concise Note)	Batch name: 16 chars; Report no.: constraint relaxed; Free text: up to 2,000 chars (Label 391 or Textual Report)	Batch name: 100 chars; Report no.: no limit; Free text: up to 4,000 chars (<Comment> or Textual Report)
Advantages	Simple and intuitive; Long operational track record	More flexible field order and length; no C code procedure needed	Most flexible; self-describing; strong schema validation
Disadvantages	Rigid field lengths, Requires C code procedure	Requires label reference, Low human readability; Requires system redesign	Increased data burden, Low human readability; Requires system redesign
Country	Korea, Japan	Canada	Euratom, UK

The Fixed Format assigns an 80-character line to each entry of the ICR, PIL, and MBR, with every data element occupying a predefined column position [1,3]. This structure originates from the punched-card environment of the early 1970s: numeric fields are limited to eight digits and batch names to eight characters, so that a single accounting item exceeding one line's capacity, or a batch containing more than one element, must be split across multiple lines using the continuation code (C) and summed to the final reported quantity [1,3]. This continuation-line procedure is the format's defining source of complexity. Reflecting its long operational track record, the Fixed Format remains in use by Korea and Japan.

Labelled Format assigns an explicit label in front of each data element instead of a column position (e.g., Label 407 for the KMP code, Label 446 for the batch name), so that fields may appear in any order and only

the labels actually required for a given entry need to be transmitted [2]. Because label-based items are not bound to a fixed line length, the continuation-code mechanism required in the Fixed Format does not apply, and a single label such as Label 391 (Concise Note text) can accommodate up to 2,000 characters within one entry [2]. In other words, while somewhat more flexible than the Fixed Format, the Labelled Format requires the reader to know the meaning of each tag, which makes it comparatively less readable. Canada is a representative example of a State currently operating on this format.

The XML Format is defined by an XML Schema Definition (XSD) in which a single root element (IAEANMAReports) contains report header elements (InventoryChangeReport, PhysicalInventoryListing, MaterialBalanceReport, TextualReport), each in turn composed of entry elements such as ICREntry, PILEntry, and MBREntry [4]. Each data element is enclosed within an opening and closing tag (e.g., <Burnup>...</Burnup>), with the tag name itself indicating the meaning of the enclosed value. Its greatest strength lies in extensibility: field-length constraints are relaxed substantially—batch names up to 100 characters and report numbers with no digit limit—and data that once required continuation lines or a separate Concise Note, such as burnup or free-text comments, can simply be expressed as elements of the entry, without a separate record type [4]. Unlike the Fixed Format's rigid, hard-coded column structure, the schema can also be revised to add new fields as reporting needs evolve, without requiring a fundamental redesign of the entire format. The result is a self-describing, highly extensible structure with virtually no character-length restrictions, though one that trades the Fixed Format's plain-text simplicity for schema-level complexity. Euratom operates on this format, and the UK, which previously had no independent national accounting system and reported under the Euratom safeguards framework, has since developed its own national system to convert and submit reports in IAEA XML format, following its withdrawal from Euratom after Brexit in 2020 [5].

3. Operator-Side Considerations in Format Transition

3.1 Increased Data Management Burden

While the XML Format relaxes field-length constraints, it also requires several items absent from the Fixed Format—shipper-assigned batch name and container ID, recipient information, burnup—to be entered as formal fields, and which of these become an operator's official reporting obligation needs joint review by the State and operators. A further decision is whether to adopt XML as an entirely new syntax or to build the system around compatibility with, and field mapping to, the existing Fixed Format, given the readability and retraining costs of raw XML. Either way, the transition is expected to increase the data-management burden on facility personnel compared with the Fixed Format's operator-intuitive design.

3.2 Transition of Long-Established Operating Practices

The concern most keenly felt in practice is less about individual technical differences than about changing operating habits accumulated over decades. Korea's system has run on the Fixed Format for nearly 40 years, during which format-specific practices—continuation-code handling, the 8-character batch-name limit, KMP code mapping—have become deeply embedded tacit knowledge; this proficiency does not readily carry over once the continuation-code concept disappears under XML. This shared understanding also extends to IAEA and KINAC inspectors, who have long used the Fixed Format report itself as a medium for on-site review (connecting to the readability discussion in Section 3.4), so a format change requires both operators and inspectors to rebuild common ground. It further creates a workforce issue, as experienced Fixed-Format staff and newly trained XML personnel coexist for some time, raising the risk of transitional errors—particularly concerning given that reporting errors can trigger IAEA or regulatory findings. The transition should therefore be treated as much an organizational and human-resource challenge as a technical one.

3.3 Validation Function

The automatic schema (XSD)-based validation often cited as an XML advantage needs to be weighed against existing domestic practice: SDP already performs pre-submission checks for missing fields, duplicate batch names, code validity, and format errors, and most operators maintain their own facility-level QC procedures. XSD validation is also inherently limited to syntactic checks—field presence, data type, length, enumeration—and cannot catch semantic errors such as a correctly formatted but nonexistent or mismapped MDC or KMP code. The concrete scope of validation XML adds beyond what K-SDP already provides therefore needs to be clearly identified.

3.4 Report Readability and Ease of Verification

A less-discussed trade-off is between automated validation and human readability. The Fixed Format's plain-text, fixed-column structure lets personnel and inspectors visually review reports without any tool, whereas XML's nested tags are optimized for machine processing but far harder to read directly—likely requiring a human-readable viewer or export function once adopted, without which qualitative review capacity could actually deteriorate. This weakened visual review also raises the stakes on schema completeness: an XSD that does not fully capture real-world exceptions and inter-field constraints could let an inaccurate but schema-valid report pass unnoticed, making rigorous schema design and testing essential. Given that K-SDP and operator QC already cover much of the syntactic-validation ground, these readability and schema-design costs leave a real question of practical benefit—one that is arguably more a change-management issue than a

technical one.

3.5 Mapping of Historical Data

Operators with decades of accumulated reporting history face an additional burden concerning the treatment of past records once a new format is adopted. The UK's experience in developing its national accountancy system is illustrative: because corrections to reports submitted under the prior regime were not permitted after the new reporting system's effective date, the UK Office for Nuclear Regulation had to negotiate a dedicated technical solution with the IAEA to ensure traceability between historical and newly formatted reports [5]. A similar challenge would apply to Korea's transition, where facilities such as KAERI hold decades of Fixed Format reporting history; establishing a clear mapping and correction mechanism between historical Fixed Format records and future XML Format submissions therefore constitutes a substantial and easily overlooked component of the transition burden.

3.6 Development of New Nuclear material Accounting Systems

Operators running their own nuclear material accounting systems (e.g., KAERI, KEPCO NF) cannot simply adapt their existing Fixed Format–based systems to XML; because the underlying data structure itself changes fundamentally, an entirely new system would need to be developed in its place, along with coordinated changes to KINAC's LOF system. This development would need to extend well beyond building a system with XML-compliant fields, encompassing the new data elements discussed in Section 3.1, schema-level validation functionality to address the semantic-error gap noted in Section 3.3, and a human-readable report viewer to compensate for the readability loss discussed in Section 3.4. Given this scope, the effort is expected to require substantial time and budget, with close collaboration between internal IT staff and external developers. Before full deployment, the new system's XML output would also need to pass staged testing—first in-house, then in coordination with other operators, and finally through parallel submission to the IAEA to confirm the reports meet its requirements.

4. Conclusion

The transition from the Fixed Format to the XML Format offers the benefit of relaxed field constraints, but entails a considerable burden on the operator side, including an increased data-entry workload, the transition of long-established operating practices, a trade-off between validation and readability, and information-system integration costs. In particular, it should be noted that this burden goes beyond a simple technical mapping problem and constitutes an organizational and administrative issue encompassing decades of accumulated organizational tacit knowledge and inspection/verification practices, as well as how strongly the practical benefit of the transition is felt on the ground. Before adopting the XML Format, nuclear facility operators should undergo a process of becoming sufficiently familiar with the new format, followed by an extended trial-operation period, during which ensuring schema completeness and providing a human-readable supplementary viewing function should be reviewed together. Careful consideration must also be given to matters such as the mapping of existing data.

References

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