

IAEA EXPERIENCE WITH AUTHENTICATION OF IN-PLANT NDA INSTRUMENTATION

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Abstract

IAEA EXPERIENCE WITH AUTHENTICATION OF IN-PLANT NDA INSTRUMENTATION.

The paper discusses IAEA experience with permanently installed measuring equipment, i.e. in-plant NDA instrumentation, which often has advantages over portable equipment, such as improved accuracy, automated sample handling and data collection, and capacity for higher throughput. In some cases, in-plant equipment is the only means of making a field measurement. However, the use of in-plant equipment requires an additional set of inspector procedures to ensure that the instrument is working correctly and has not been tampered with. This process of verifying instrument performance is called authentication. General guidelines for approaches to authentication have been studied and formulated by an IAEA Advisory Group Meeting held in November 1981. Procedures for specific instruments have been developed in some cases with the help of national support programmes. The field application of authentication is accomplished by incorporating specific actions into inspection procedures. Results are written down as part of the working papers and included in the final inspection report. For quantitative checks such as measurement of a working standard the results are sent along with the inspection measurements to the Agency for inclusion in the safeguards data base. The in-plant equipment may be owned by the facility, a State, a safeguards organization or the Agency. In each case, the use of the in-plant equipment will necessitate additional interactions between facility operator and inspector, in order to judge the impact on plant operation, and understand what is being measured and what can go wrong. The inspector must have sufficient training to make decisions based on authentication results in the field as to whether the instrument can be used to make safeguards measurements. The paper discusses the IAEA's experience gained in the field application of authentication procedures for instrument systems such as weighing and volume measuring devices, rod scanners, neutron activation systems and K-edge densitometers.

INTRODUCTION

The International Atomic Energy Agency uses in-plant NDA instruments to collect part of the inspection data used to verify nuclear material inventories. This in-plant instrumentation can be owned by either the facility operator, a national control authority, or the Agency. In each case, the Agency inspector must ensure that the instrument is giving valid results at the time the inspection data is collected. This process is called authentication of the instrument. The guidelines and underlying principles for authentication were developed by various individual researchers and collectively by an advisory group convened by the Agency in November 1981 [1,2,3]. Two general methods have emerged which can be applied to reach the required degree of authentication. This paper focuses on Agency experience to date using these methods.

TAMPERING MODES

There are three modes of possible tampering with an inplant measurement system: tampering with (1) the material introduced for measurement; (2) the instrument itself (including the detection assembly and the components for converting the signal into its final form as a measured value); (3) those parts of the equipment for storing and retrieving the measurement data. While these three tampering possibilities are interrelated, most of the effort to date has concentrated on instrument tampering.

AUTHENTICATION

The two general techniques used to confirm the validity of the measurement results are called external and internal authentication [4]. In applying the external approach, the key principle is to remeasure some of the samples by a technique completely under Agency control. The internal technique focuses on the instrument, using Agency-protected standards plus checks to detect sophisticated tampering. These checks include the use of:

- Protected standards
- Blind samples
- Blind standards
- Response checks by standard addition
- Parallel instruments
- Software authentication
- Replacement of key components
- Visual inspection
- Containment and surveillance.

In practice, the Agency may use both techniques for a given in-plant instrument.

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IN-PLANT INSTRUMENTATION

Examples of in-plant instrumentation to which the Agency now applies or will in the near future apply authentication methods are described in the next four sub-sections.

i) UF₆ Cylinder Scales

Product UF₆ from an enrichment facility is typically stored and shipped in cylinders weighing 2.4 tonnes. The ²³⁵U content is measured by weighing the cylinders and determining the ²³⁵U enrichment. During an inventory, the inspector will observe the cylinder weighing performed using the operator's scales. To authenticate the in-plant scales, a portable load cell based weighing system (LCBS) has been developed and put into operation. This is an example of external authentication. A certain number of cylinders are selected after having been weighed on the plant scales and reweighed using the LCBS [4,5]. The LCBS, which is under the inspector's control and independently calibrated, is capable of weighing 2.4 tonnes with a precision of ± 1 kg.

ii) Accountability Tank Electromanometer

The accountability for reprocessing plant solutions is typically done by measuring the solution volume and concentration. The volume measurements usually rely on operator's installed instrumentation. In most cases, manometer level readings are visually made by inspector and plant personnel. There are some facilities where this process is automated using electromanometers coupled to computer systems [6]. While this simplifies data collection, it presents the inspector with an authentication problem. Focusing just on the electromanometer (Fig. 1) and computer portions of the system (Fig. 2), the Agency at present employs the following authentication procedures:



FIG.1. Electromanometer electronics. The instrument rack, from top to bottom, comprises common carrier interface, digital voltmeter, electronic scanner, Ruska electromanometer, pneumatic scanner, and Scanivalve assembly.

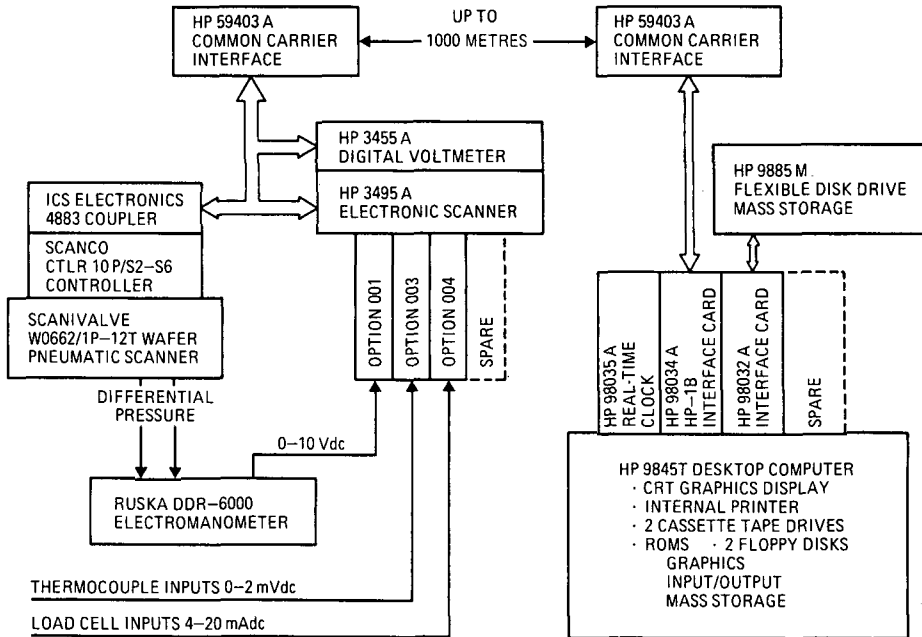


FIG.2. Block diagram of the automated electromanometer system.

External methods: A set of parallel water manometers is periodically read and the volume determinations compared to the electromanometer volume.¹

Internal methods: Visual inspection is made of the pneumatic connections, air flow rate, and electronic component functions.

Software authentication is accomplished by replacing the plant program disk with an Agency-controlled disk. Data is collected with the Agency software and compared to plant values, using independently determined Agency calibration constraints. The agreement should be within 0.4%.

The internal system checks are exercised to detect certain instrument faults, e.g. pressure or temperature out of range conditions.

¹ This procedure constitutes an external authentication if the water manometers are under Agency control. If not, this check is considered a parallel unauthenticated measurement [3].

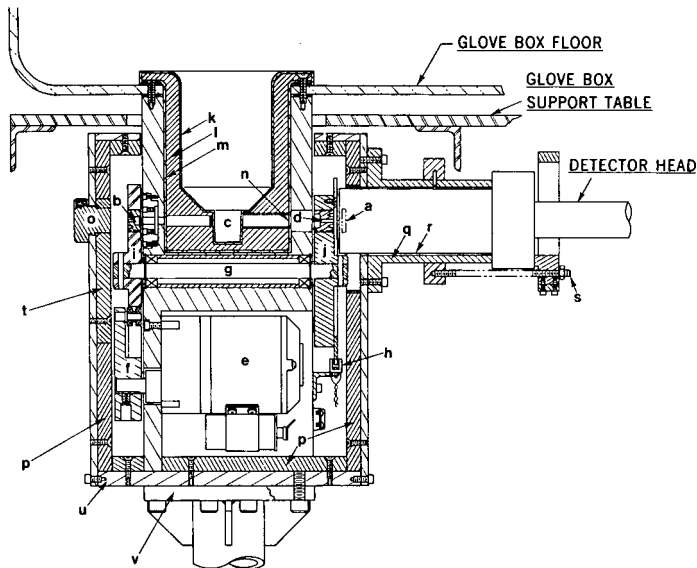


FIG.3. Schematic of the K-edge densitometer: (a) Ge crystal; (b) tungsten transmission source holder; (c) sample position; (d) tungsten collimator holder; (e) drive motor for Geneva mechanism; (f) Geneva mechanism; (g) common axle for source and collimator wheels; (h) position-sensing mechanism; (i) stainless-steel source wheel; (j) tungsten collimator wheel; (k) polyurethane liner for measurement well; (l) tungsten shield; (m) stainless-steel containment can; (n) 10-mil stainless-steel window; (o) removable tungsten plug for changing sources; (p) lead shielding; (q) tungsten detector shield; (r) polyethylene electrical shield; (s) detector clamping device; (t) tungsten shielding; (u) aluminium anchor plate; (v) aluminium support base.

iii) Fuel Rod Scanners

Fuel pin scanners are instruments used to scan the active length of fuel pins for uniformity and total fissile content determination. They are used on the fuel fabrication production line primarily for quality control. For low enriched fuel fabrication plants, the LEU fuel rod scanner is an interrogation device containing a neutron source such as ^{252}Cf ; neutrons or delayed gammas from the fissions produced are measured with a neutron or gamma detector. Fuel rod scanners are very large devices; their control and counting electronics, which are fairly complex, are computer-based and normally owned and operated by the plant operator. IAEA has used such devices in several facilities for the verification of the declared enrichment or in some cases of the total

^{235}U content of the selected rods, using plant-specific reference rods for standardization.²

To authenticate the in-plant rod scanner, IAEA plant specific reference rods, blank rods and the selected rods to be verified are mixed and randomly ordered in an unreconciled sequence and inserted into the rod scanner. The sequential results obtained are reconciled with the identification of each rod after the measurement. This can provide a degree of authentication. However, to detect falsifications by means of the eddy-current technique, a randomly selected sub-set of the selected rods needs to be verified by an attribute measurement using NDA techniques (e.g. enrichment measurement).

iv) K-Edge Densitometer (KED)

As stated earlier, reprocessing plant solution accountability requires both volume and concentration measurements. A K-edge densitometer can be used to measure the plutonium concentration in samples of product nitrate solution [7]. Figure 3 shows one such instrument system installed in a facility glovebox. A variety of authentication procedures have been developed and applied to this particular system.

External Authentication: Plutonium nitrate samples are drawn from the same batch and shipped to the Safeguards Analytical Laboratory (SAL) for an independent measurement under Agency control. Figure 4 shows data comparisons which are representative of the charts plotted for authentication purposes. These chemical results were obtained not at SAL but by a plant operator [8]; nevertheless they illustrate the concept. By using this external authentication approach, the Agency has a high level of confidence in the plant measurements. However, the sample treatment is also usually not fully under the control of the IAEA, and since there is a relatively long time delay before the SAL results can be available the Agency also uses internal authentication procedures to assure timely detection.³

² These plant-specific reference rods are independently verified by the Agency.

³ A portable version of the KED currently under development might be used to apply a more timely external authentication check.

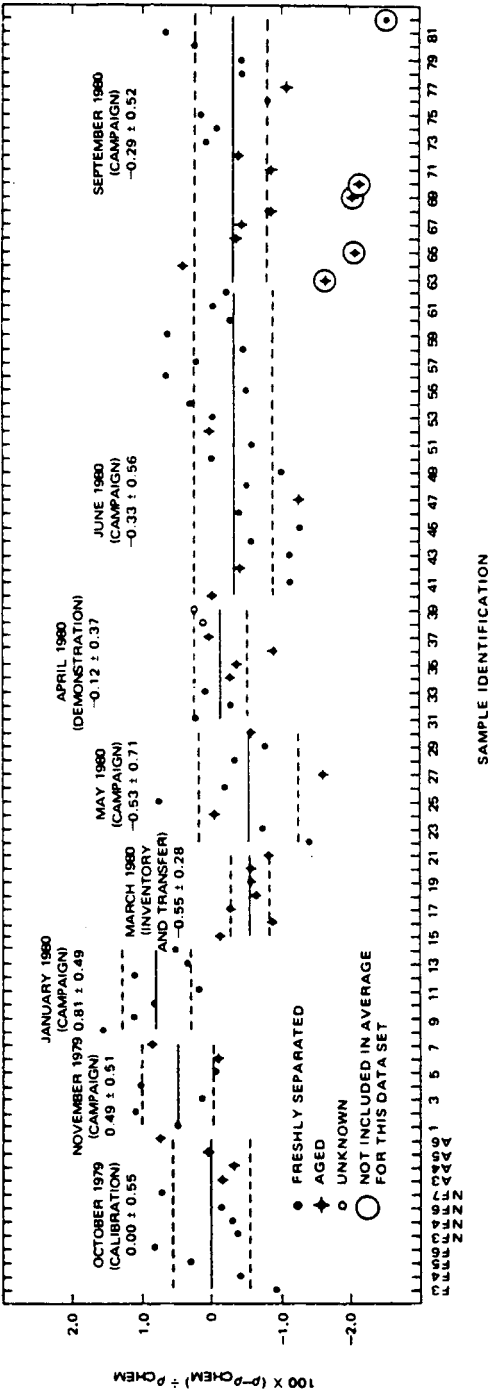


FIG. 4. Percentage deviation between results for Pu concentration determined at Tokai by the K-edge technique and by destructive analytical chemistry.

Internal Authentication: A set of protected working standards consisting of tantalum foils is used by the inspector to check the instrument calibration and precision. These foils can be inserted from outside the glovebox and do not enter the contaminated region. However, they are only a partial check as they do not verify the transmission path length.

A visual inspection is made of the entire system and the switch positions on key electronic modules are compared with the standard settings. The inspector has examples of standard gamma-ray spectra which he can compare with the spectra collected during the inspection measurements.

The inspector can request the use of an Agency-owned program disk to ensure that the correct data acquisition and analysis procedures are being followed. The raw data can be written on disk and sent to Headquarters for re-analysis.

In addition to these already implemented procedures, suggestions have been made to seal certain key components, e.g. the source wheel housing, and to authenticate the electronics, computer and MCA by temporary replacement with a portable intelligent MCA [9].

GENERAL OBSERVATIONS

The use of the in-plant equipment will necessitate additional interactions between facility operator and inspector. Both parties will require enough design information to judge the impact on processing, and understand what is being measured and what can go wrong. The inspector must have sufficient training to make decisions, based on authentication results in the field, as to whether the instrument can be used to make safeguards measurements. Thus the effort required to authenticate the instrument must be included in the effort benefit analysis.

Internal authentication procedures require more technical knowledge and detailed training on the inspector's part than does the external approach, but the external approach may not always give timely results.

More development needs to be done on authentication procedures for the materials and data tampering cases. Also,

procedures and techniques should be developed for the collection of authenticated data during times when the equipment operates unattended and an inspector is not present.

SUMMARY

The Agency currently uses in-plant instruments to collect inspection data. Authentication procedures are being applied to validate the instruments making the measurements. The Agency is gaining field experience in the use of the authentication techniques. With this experience, the balance between minimizing the intrusiveness of the authentication methods and maintaining high credibility of results can be optimized.

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