Lessons Learned from 10 Years' Experience of the Centralized Calibration Laboratory for the Management of Portable Radiation Instrument

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1. Introduction

There are many kinds of radiation instruments used in nuclear power plants for the purpose of protecting workers from radiation, performing radioactivity analysis of "radwaste", and monitoring environmental radiation. In 2017, there were a total of 4,310 radiation instruments, consisting of 1,619 in 4 categories, 1,979 radioactivity instruments in 9 categories, and 712 neutron instruments in 2 categories respectively. These radiation instruments are calibrated every six months in accordance with KOLAS(Korea Laboratory Accreditation Scheme) accreditation requirements.

The types of radiation instruments vary with manufacturer, manufacture year, and purchase region. This leads to difficulties in calibrating instruments as well as maintaining spare part supplies. In order to address these difficulties, KHNP-CRI created a centralized calibration laboratory in 2008 to handle procurement, maintenance, and management of all KHNP portable radiation instruments.

The calibration process for portable radiation instruments is accredited by KOLAS, which is itself authorized by ILAC. There are a total of 13 accredited items comprising 6 regarding radiation, 6 items for radioactivity, and 1 item for neutrons. The CRI possesses the most up-to-date gamma, neutron, beta irradiators, and X-ray generators. Recently the CRI has developed OCR calibration kits which enable more convenient and reliable calibration. Fig. 1 shows these kits. [1]

This paper analyzes the types of maintenance work carried out on portable radiation instruments for nuclear power plants, as well as the inadequacies experienced in KHNP-CRI since 2010 when the CRI began its integrated calibration.

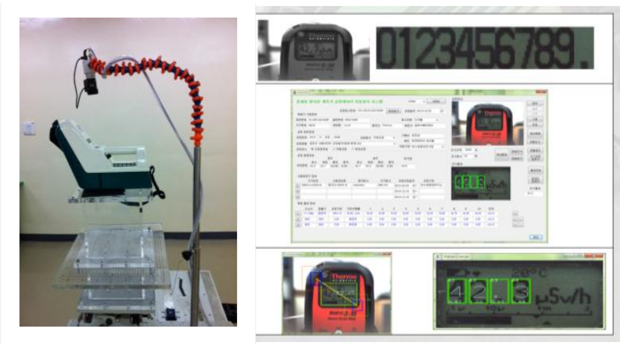

Fig. 1. CRI's OCR Calibration Kit

2. Methods and Results

KOLAS is a governmental body that works to establish a national standards system and handles the process of international cooperation necessary for industrial standardization. A globally-agreed Mutual Recognition Agreement (MRA) ensures that every country recognizes each other's certification report, in order to keep adequacy evaluation procedures from being used as a non-tariff technical barrier to trade. Thus, KOLAS set in place a system for international mutual recognition by signing the MRA for calibration in 2001.[2] KOLAS calibrating facilities undergo thorough follow-up management according to the Ministry of Trade, Industry, & Energy announcement 2016-398 and ISO 17025. Renewal evaluation or follow-up management evaluation takes place every two years, and calibration and measurement capability (CMC) is checked annually via internal review, with a proficiency or measurement test every three years.

Each month, the Central Research Institute, Korea Hydro & Nuclear Power Co., Ltd. compiles calibration data plus any issues recorded with equipment, and this data is subsequently reflected in efforts to address user complaints in the field, plan future calibration procedure and management, and purchase new equipment.

2.1 Analyzing Radioscope Equipment Challenges

Due to increasing numbers of nuclear power plants in operation, and follow-up measures following the Fukushima disaster, the CRI Calibration Office has overseen a steady increase in radioscope calibration. In particular, radioscope calibration for nuclear power plants in the UAE has become a significant field in which the KOLAS-MRA is put to use. The total number of calibrations carried out in 2010 was 3,600, and this figure increased to 8,200 in 2017.

Table I: Year-by-year calibration and repair (2010-2017)

	2010	2011	2012	2013	2014	2015	2016	2017	Total
Calibration (A)	3654	4523	5194	4625	7650	7518	7461	8224	48849
Repair(B)	369	434	405	408	437	438	506	530	3527
B/A (%)	10.10	9.60	7.80	8.82	5.71	5.83	6.78	6.44	7.22

In contrast, the number of maintenance operations was 369 in 2010 and increased to 530 in 2017. Here, we see that the ratio of maintenance work to calibration work decreased from 10% to 6.4% over the same period (see Table I).

For purposes of analyzing the challenges experienced with radioscope equipment since 2010, the 3,527 relevant repair-related operations can be divided into the categories of detector failure (with the highest number of instances at 25%) bad contacts (which account for 14%), circuit board defects (14%), defects with electronic components (13%), and defects with coverings (13%). (See Fig. 2). Causes of these different issues variously included aging of device parts, gradual short circuit from external shock, and parts damaged due to user negligence. Additionally, on rare occasions errors occurred in programs used by digital equipment. These errors are generally caused by damaged or discharged batteries and can be solved by initializing the programs, which is uneconomical to acquire exclusive equipment.

The gradually decreasing instance of repair operations since the early days of the lab operation, as depicted in Fig. 3, appears to be attributable to replacement of old equipment, training for radioscope users, and organized maintenance.

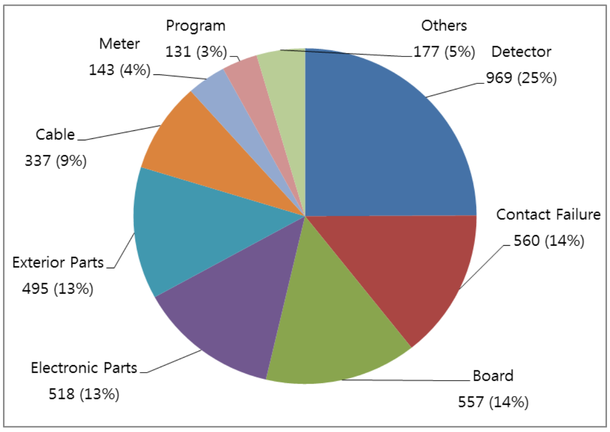

Fig. 2. Repairs classified by defective parts (1010-2017)

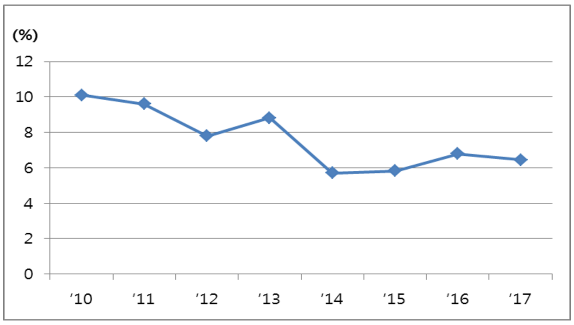

Fig. 3. Year-by-year maintenance

2.2 Analysis of Calibration Inadequacies Identified in KOLAS Evaluation

Since 2010, the CRI Calibration Office has been evaluated by KOLAS for it renewal of its calibration certification twice and follow-up management or scope of accreditation expansion review four times in total, in the process a total of 35 instances. Of these, the 26 most significant instances were related to quality management and 9 instances were related to technology, which in turn could be subcategorized into 4 instances related to radiation, 2 instances to radioactivity, and 3 instances to neutron technology. As regards quality management, most of the issues involving expression errors with procedures and reports, available education and training for calibration staff, or correction of simple typos occurred in the early days of operation after accreditation of CRI Calibration Office, or concerning revision of related technical standards, which suggests that processes of trial and error during initial periods of operation were responsible for these problems. Technology-related inadequacies were mostly associated with uncertainties regarding evaluation method or factors related to CMC(Calibration and Measurement Capability). The majority of these, which were also concentrated in the early days after accreditation or at the time of the scope of accreditation, involved either factors related to weight of uncertainty perceived differently according to the different perspectives of experts engaged in accreditation, or the failure to reflect revisions in the measurement uncertainty expression standard guidelines. Fig. 4 illustrates uncertainty factors at CRI for the neutron dosimeter, and suggests that they are values decided by calculating the agency-specific contribution to Relative Standard Uncertainty, Probability Distribution for different factors.

Factor	Type	Estimated value	R.S (%)	Prob. Dist.	Sens. Coeff.	Con.(%)	Degree of Freedom
h^*_Φ	B	385 pSv·cm^2	1.0	Normal	1.0	1.0	∞
B_0	B	3.14 × 10^8 s^{-1}	1.6	Normal	1.0	1.6	∞
F	B	1.015	0.58	Normal	1.0	0.58	∞
r	B	1 200 mm	0.02	Rectangle	2.013	0.04	∞
λ_{air}	B	1.055×10^{-4} cm^{-1}	1.5	Normal	0.013	0.020	∞
ΔT	B	720 day	0.08	Rectangle	0.516	0.041	∞
$T_{1/2}$	B	966.79 day	0.1	Rectangle	0.516	0.052	∞
M_T	A	2.08 mSv.h	0.29	Rectangle	1	0.29	∞
M_B	A	447 μSv/h	0.41	Rectangle	1	0.41	∞
K_B	B	1	5.0	Rectangle	1.0	5.0	∞
Relative Standard Uncertainty						5.4	∞

Fig. 4. Uncertainty with the CRI's neutron dosimeter (an illustration)

3. Conclusions

With a view to improving the reliability of the nuclear power plant radioscope calibration and increasing work efficiency, CRI has centralized to one calibration room previously scattered across nuclear power site. Thus, CRI has achieved its goals as a KOLAS calibration agency: to ensure consistency in calibration and reduce maintenance and repair costs, among others.

Since the exportation of nuclear power plants to the UAE, the possibilities for exporting nuclear power plants are now greater than ever, and to overcome technical barriers to trade, mutual recognition agreements (MRA) regarding partner states' certified reports on device performance are gaining in importance. Necessary preparation tasks should include training and maintaining technical professionals in calibration, calibration technology development, and development of such technology as decommissioning-focused measurement equipment.

REFERENCES

[1] Korea Laboratory Accreditation Scheme (KOLAS), the Korean Association of Standards and Testing Organizations (KASTO), KOLAS Guide to Accreditation of International Certified Calibrating Agencies, May 2017.

[2] Moonhyung Cho, Kidoo Kang, & Yuho Weon, "Development of Automated Calibration Data Acquisition System for Radiation Monitoring Instruments", Korean Association for Radiation Protection (KARP) Fall Conference, November 2014.