Consideration of Hold-up for Material Accountancy in Pyroprocessing Plant

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1. Introduction

A safeguards material accountancy usually relies on the accounting analysis of physical inventories at the time of annual physical inventory taking. During that period, the operation process is stopped and cleaned-out to minimize the amount of materials impossible to measure, so called residual hold-up. The way to clean-out the process as well as the material hold-up amount have not yet been investigated in detail, mostly due to the lack of integrated operation schemes and dedicated experimental data. Therefore, the clean-out and hold-up issue tends to be regarded one of the major challenges in safeguarding a pyro-processing plant. The purpose of this study is to analyze the material hold-up effect on material accountancy and suggest possible clean-out approaches for safeguarding a pyro-process.

2. Hold-up in Material Accountancy

Hold-up in the field of safeguards defined as nuclear material deposits remaining after shutdown of a plant in and about process equipment, interconnecting piping, filters and adjacent work area [1]. For plants in operation, the hold-up is the amount of nuclear material contained in the process. It is also referred to as in-process inventory. Because the hold-up is un-measureable inventory, it is usually treated as hidden inventories, which means a part of materials unaccounted for (MUF) in materials accounting terminology.

In general, hold-up amount does saturate in steady-state conditions after a certain period of initial operation. The data set from the calciner of the ammonium diuranate (ADU) experiment is a good example of the steady-state behavior of hold-up with time [2].

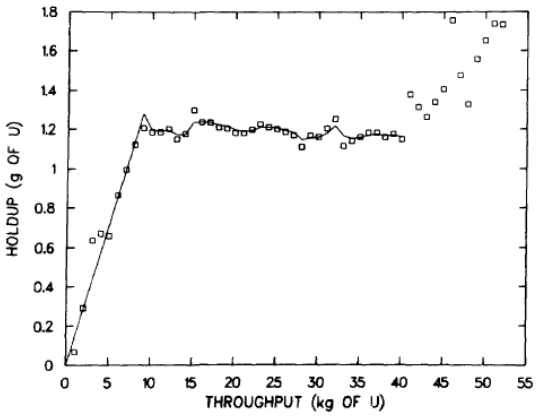

Fig. 1. Uranium holdup data and model for the calciner (from Ref [2]).

Hold-up data from mixed oxide fuel (MOX) fabrication plant shows 0.1 ~ 0.4% of batch size in the 200 kg-batch capacity blender [3]. Another example of powder material hold-up in MOX plant shows 5 g/meter of ceramic power hold-up observed in the transfer pipes [4]. With the assumption of 20 cm of pipe diameter, it refers to 5 g/m^2 hold-up on a surface

3. Hold-up in Pyroprocessing

The major anticipated mechanisms of material accumulation in pyroprocess are (1) the accumulation

of fine particles of spent fuel on the surfaces or in the gaps of process equipment in a region of head-end process, and (2) the condensation of salt phase process materials on the surface of process equipment in the main pyroprocessing area.

The hold-up amount of powder mixing equipment for head-end pyroprocess was estimated by the weight difference between before and after the 50 kg-batch mixing experiments. Measured hold-up was about 30 g, which is equivalent to 0.06% of batch size.

In case of detection of an abrupt diversion under a near real-time accountancy, the hold-up of about 1.8 kg of plutonium-equivalent materials over the entire processes can falls in the acceptable range.

There can be several ways to minimize or recover hold-up materials in a design concept or fabrication technique, such as special surface treatment, knocker or scrapper with recovery mechanism, or encapsulation to minimize powder scattering or salt evaporation area, etc [6].

4. Conclusion

The amount of material hold-up in the process directly affects the requirements of accounting measurement uncertainties to satisfy allowed MUF evaluation. The hold-up does not continuously increase but fluctuation under steady-state operation conditions. Experiences from other similar facilities and our own experimental results with estimated accounting uncertainty estimation seems like the practically achievable range of hold-up and MUF evaluation results. It should be, however, noticed that the margin of accounting measurement uncertainty does not always allow as much residual material. In case of protracted diversion cases, however, the effect by hold-up material worsens the accountancy performance. Therefore, process equipment design and operation scheme should carefully take into account the way how to minimize hold-up materials.

REFERENCES

[1] IAEA, “IAEA Safeguards Glossary 2001 Edition”, International Nuclear Verification Series NO.3, 2001.

[2] K. Pillay and R. Picard, “Fundamentals of Materials Accounting for Nuclear Safeguards”, Ch.6, p.152, LA-11569-1, LANL, 1989.

[3] ESARDA MOX Working Group, “Control of nuclear material hold-up: the key factors for design and operation of MOX fuel fabrication plants in Europe”, IAEA-SM-367/8/04, 2004

[4] E. Haas, “Description and Safeguards Concept for the former Siemens MOX Fuel Fabrication Plant (MOX II) Siemens Brennelementewerk Hanau, Germany”, and personal communications.

[5] T. Iwamoto, “Hold-up Measurement in a Reprocessing Facility”, JNFL.