## INDONESIAN ACHIEVEMENT

Since 1996 Indonesia has produced $^{99}$Mo from HEU fission product mainly for domestic consumption. Due to limited and restricted raw material of HEU, Indonesia has a conversion program from HEU to LEU for producing $^{99}$Mo from LEU foil target. The substitution of low enriched uranium (LEU) metal foils for the HEU $UO_2$ used in current target designs will be applied for production of $^{99}$Mo commercially. Batan has had a joint research project with ANL to develop LEU-metal-foil target fabrication since 1992. Many achievements have resulted from the experiments. Design target has undergone several changes in design, materials and wrapping of LEU foil targets [1]. ANL has developed several of LEU target design and fabrication, and has demonstrated Radio Metallurgy Installation hot cell in Batan for disassembly process to take out LEU foil from the target after being irradiated in the RSG-GAS BATAN reactor. Installed power of RSG-GAS is 30 MW but operational power is 15 MW. LEU foil targets were irradiated in CIP of RSG-GAS with thermal neutron flux $2.4x10^{14}$n $cm^{-2}s^{-1}$. Chemical processing was conducted in Isotope Production Centre hot cell for producing $^{99}$Mo which will be used to produce $^{99m}$Tc generator. Batan has a license to use the process from US DOE. The experiment was terminated temporarily in 2001 due to September eleven accident. In 2004, cooperation between the ANL and BATAN was continued. In November 2005, ANL provided training on LEU target assembly to BATAN by simulation of Cu-foil as LEU foil. Then BATAN personnel demonstrated reassembly of 2 ANL LEU targets to replace Zn and Al foil barrier with Ni foil barrier in January 2006. In 2006, Indonesia began to manufacture foil targets using depleted uranium following the procedures established by ANL [2].

In 2006 BATAN has been studying the stages of manufacture of foil targets including the manufacture of uranium foil, aluminium pipe targets preparation, assembly, welding, and leak testing.

The parameters that have been learned are uranium foil manufacturing parameters to obtain the same foil thickness, foil uranium quenching parameter to get the level of homogeneity
β-phase and fine grain diameter, assembly parameters for foil targets rigid, and weld parameters to obtain the target foil that is not leaking.

Foil targets resulting from the rolling has good characteristics. The surface of the foil is very smooth, and the grain has random orientation after heat treatment and quenching. Foil targets are fabricated from Ni foil-wrapped-U foil inserted in between two concentric aluminium tubes, and the ends of the tubes are welded. Testing is conducted to assure that there is no leakage in the welded tubes.

In March 2006, Indonesia served as host of LEU FOIL TARGET workshop in cooperation with IAEA and ANL. Participant countries come from KAERI-Korea, ANL-USA, REWDRC-Libya, IAEA, PINSTECH Islamabad-Pakistan and CCHEN-Chile.

In March 2008, 2 participants from Libya, 1 participant from Chile and 1 participant from MURR together with ANL experts visited BATAN to learn about LEU foil fabrication and its chemical processing.

There have been many LEU foil targets made and irradiated and also chemically processed in BATAN.

In 2009, irradiation of LEU foil targets was successfully performed four times, and the results were analysed and evaluated, and the conclusion was that the results meet the requirements set by Medy Physic as shown in Table 1.

TABLE 1. Product analysis of $^{99}$Mo from LEU foil target

| ANALYSIS | RESULT | | | |
|---|---|---|---|---|
| Weight $^{235}$U, (g) | 1,5 (April 2009) | 3,0 (June 2009) | 3,0 (August 2009) | 3,0 (Oct. 2009) |
| Specific activity, (Ci/g Mo) | $1.02 \times 10^4$ | $2.24 \times 10^4$ | $2.03 \times 10^4$ | $1.56 \times 10^4$ |
| Radioactivity concent., (mCi/ml) | 528 | 1396 | 1600 | 1097 |
| Radionuclide purity, (µ/Ci/mCi $^{99}$Mo) | $^{131}$I : 0.039<br>$^{103}$Ru : nd<br>$^{89}$Sr : nd<br>$^{90}$Sr : nd<br>γ -impurities: 0.013 | $^{131}$I : 0.033<br>$^{103}$Ru : nd<br>$^{89}$Sr : nd<br>$^{90}$Sr : nd<br>γ-impurities: 0.07 | $^{131}$I : 0.075<br>$^{103}$Ru : 0.01<br>$^{89}$Sr : nd<br>$^{90}$Sr : nd<br>γ-impurities: 0.07 | $^{131}$I : 0.015<br>$^{103}$Ru : 0.015<br>$^{89}$Sr : nd<br>$^{90}$Sr : nd<br>γ -impurities: 0.004 |
| α-contamination*, (µ/Ci/mCi $^{99}$Mo) | $1.2 \times 10^{-7}$ | $1.7 \times 10^{-7}$ | $1.7 \times 10^{-7}$ | $4.8 \times 10^{-8}$ |

* (Detektor ZNS, counter)

We can conclude that LEU foil target fabrication technology is ready for commercial production. And all of these activities are for preparing Indonesia to change the production of $^{99}$Mo from HEU fission product to LEU fission product.

So, foil target fabrication using Ni foil-wrapped-LEU foil inserted in between two concentric aluminium tubes will be used as a method for the commercially used LEU foil target fabrication to produce $^{99}$Mo. The process used to extract $^{99}$Mo from irradiated LEU foil is by dissolution process using nitric acid solution, and extracted $^{99}$Mo will be precipitated and treated using the same method as used in HEU $UO_2$ foil processing, as well as for the production process of $^{99m}$Tc generator.

However, PT BATAN Teknologi as of this writing still does not use that method, although they now have to convert the use of uranium from HEU to LEU.

[1] Cooperation Programme documents BATAN-ANL, 2001
[2] Draft Document for Assembling 8 g or 16 g Ni Foil Wrapped LEU Metal Foil Annular Targets, ANL, January 2006.