Design Information Analysis of TRU Fuel Manufacturing Facility

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1. Introduction

According to the decision of the Atomic Energy Commission of Korea government, Transuranic (TRU) fuel manufacturing facility (TFMF) capable of 1.8 t-HM/yr will be constructed by 2025 together with technology development of nuclear fuel using TRU material recovered from pyro-processing of spent fuel [1]. However, the IAEA safeguards approach for fuel fabrication facility using TRU material is not developed yet. In this paper, to facilitate the development of safeguards approach for TFMF, safeguards design information of TFMF is analyzed and material balance area (MBA) and key measurement points (KMP) are suggested.

2. Safeguards Design Information of TFMF

2.1 General information

TFMF is 1.8 t-HM/yr scale fuel fabrication facility to supply TRU (U-TRU-RE-Zr) metallic fuel to Prototype Generation IV Sodium-cooled Fast Reactor (PGSFR) of 150MWe. Fabrication processes are composed of mainly fuel slug, fuel rod, fuel assembly and scrap recycle process. A simplified flow diagram of TFMF is shown in Figure 1[2].

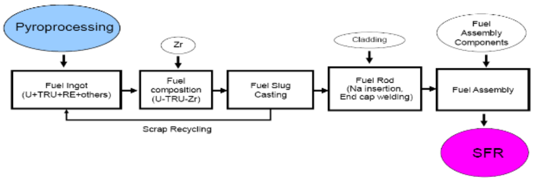

Fig. 1. Flow diagram of TRU fuel manufacturing facility.

2.2 Process descriptions

Fuel slug fabrication consists of induction melting, injection casting, demolding and shearing of fuel slug. Injection casting method is adopted to fabricate TRU metallic fuel slug of PGSFR. Injection casting is known to be the most cost efficient, capable of mass production and suitable for remote control [3].

Fuel rod fabrication process is composed of hardware production and fuel slug loading part. The fuel rod is fabricated with an upper end cap, a cladding, a lower end cap, and wire [3]. Design parameters of fuel rod are shown in Table 1 [4].

Table 1. Fuel rod design parameters

Fuel rod	Design Para.
OD/thickness of cladding	7.4 mm / 0.5 mm
Wire diameter	0.95 mm
Fuel rod length	2,240 mm
Fuel active length	900 mm
Composition	U-TRU-RE-Zr
Fuel slug diameter	5.54 mm

In fuel rod fabrication process, sodium which has high thermal conductivity is inserted into the jacket and placed between fuel and cladding. Sodium reduces central temperature of fuel rod. Then, fuel rods are moved into the fuel assembly process and assembled with the other fuel components such as duct, nose piece, fuel handling socket, reflector. Fuel assembly consists of 217 fuel rods and weighs 290 kg. the schematic diagram of the fuel rod and assembly is shown in figure 2 [5].

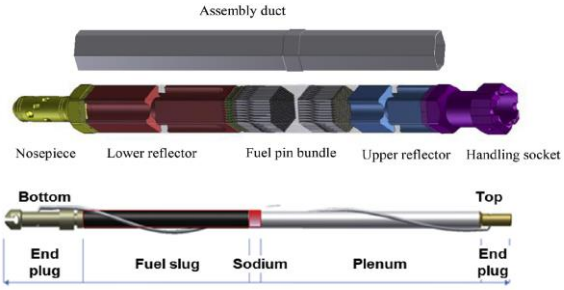

Fig. 2. Schematic of fuel rod and fuel subassembly.

Scrap is generated mostly from fuel slug fabrication process because injection casting method has a drawback of low yield of up to 55% [6]. Therefore, scrap recovery process is essential to TFMF.

2.3 Material descriptions

Nuclear materials which TFMF mainly handles are U and U/TRU metal ingot as feed, fuel slug and rod as intermediate product, and fuel assembly as final product. Recycled U-TRU-Zr can be used as feed material. U oxide material to dilute TRU is not considered and only U an TRU metal ingot recovered from pyro-processing facility is used. TRU material is handled in a shielded hot cell remotely because it contains chemically active lanthanide impurities [3]. Nuclear materials of fuel casing and part of fuel rod process are handled in Ar hot cell. Once welding of fuel rod which prevent leakage of TRU and sodium, is completed then material is moved to air hot cell. Feed and product material are stored in air hot-cell.

Low hold up is expected because nuclear material is not disclosed to outside other than fuel slug process and shearing cutting technique that prevent disperse of dust is used during ingot and fuel slug cutting. However, large amount of waste including nuclear material is expected because 700 quartz molds and 10 crucibles per 1 assembly are used.

3. MBA and KMPs

Determination of MBA and KMPs is next step for development of safeguards approach TFMF. In this section, MBA and KMPs of TFMF are suggested based on the design information.

3.1 Material balance area

Main point for MBA determination is whether more than one MBA is necessary. Process of TFMF is relatively simple compare to oxide fuel fabrication facility. And shipper/receiver difference (SRD) can be provided by identifying a SRD KMP within a MBA. So, single MBA is suggested for TFMF as shown in figure 3. This MBA suggestion is based on the assumption that TFMF and other related facilities such as pyro-process facility and PGSFR are distributed. If TFMF is grouped with other facilities, then separating storage area from single MBA can be considered.

3.2 Key measurement points

KMPs refer to a location where nuclear material appears in such a form that it may be measured to determine material flow or inventory. 8 inventory KMPs and 5 flow KMPs are suggested as shown in figure 3.

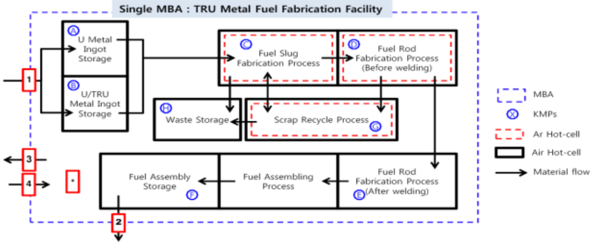

Fig. 3. Suggested MBA and KMPs for TFMF.

4. Conclusion

As construction of TRU fuel manufacturing facilities is planned, safeguards design information of TFMF is analyzed. MBA and KMPs are also suggested based on the design information. Although TFMF is still preliminary conceptual design stage, there is need to identify technical challenges and develop safeguards measures to safeguards TFMF.

Acknowledgement

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