IDENTIFICATION AND ASSESSMENT OF THE HAZARDS IN A NUCLEAR FUEL FABRICATION FACILITY

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In uranium fuel fabrication facilities, large amounts of radioactive material are present in a dispersible form. This is particularly so in the early stages of the fuel fabrication process. In addition, the radioactive material encountered exists in diverse chemical and physical forms and is used in conjunction with flammable or chemically reactive substances as part of the process. Thus, in these facilities, the main hazards are potential criticality and releases of uranium hexafluoride (UF_6) and (U_3O_8), from which workers, public and the environment should be protected. In nuclear fuel fabrication facility, the process for the obtainment of U3O8 for fuel elements fabrication for research reactors starting from UF_6 comprises two well defined stages characterized by the risks involved in the raw materials and intermediate products. The first stage is the wet process (conversion process) includes the hydrolysis of UF_6 to UO_2F_2 and posterior precipitation to ammonium diuranate (ADU); the second stage is dry process to obtain the U_3O_8 powder from ADU at high temperature. This work presents the analysis of the events in nuclear fuel fabrication facilities that have as a consequence the stated risks, their detection and prevention to protect the workers, public and environment.
This work will be show the analysis of the events in nuclear fuel fabrication facility that have as a consequence the stated risks, their detection and prevention to protect the workers, public and environment from the hazards of radiological and chemical (toxicity material) hazards.

1- INTRODUCTION AND BACKGROUND

Radiation and radioactive substances have many beneficial applications, begging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled. In nuclear fuel fabrication plant, nuclear material (uranium enriched 20%) are used, stored and disposed of, in quantities or concentrations that pose potential hazards to workers, the public and the environment. The physical and chemical forms of the uranium compounds may also vary within a nuclear fuel fabrication plant. Some of the processes use large quantities of hazards chemical substances and gases, which may be toxic, corrosive (UF_6), combustible, or explosive, and consequently may give rise to the need for specific safety requirements in addition to requirements for nuclear safety. For this reasons, the radiation protection programme was implemented in nuclear fuel fabrication plant to prevent or mitigate any risk will be take place during normal and abnormal conditions. In uranium fuel fabrication plant, the main hazards are potential criticality and releases of uranium hexafluoride (UF_6) and UO_2, from which workers, the public and the environment must be protected by means of adequate design and construction, by safe operation and physical protection system. The chemical toxicity of uranium in a soluble form such as UF6 is more significant than its radiotoxicity [1]. In uranium fuel fabrication facilities, only low enriched uranium (LEU) is processed. The radiotoxicity of LEU is low, and thus any potential off-site radiological consequences following an accident would be expected to be limited. However, the radiological consequences of an accidental release of reprocessed uranium would be likely to be greater. Along with UF6, large quantities of hazardous chemicals such as hydrogen fluoride (HF) are also present. In addition, when UF6 is released it reacts with the moisture in the air to produce HF and soluble uranyl fluoride (UO_2F_2), which present additional safety hazards [1]. Therefore, safety analyses for uranium fuel fabrication facility should also address the potential hazard resulting from these chemicals. In this paper we study the identification and assessment of the hazards in a nuclear fuel fabrication plant uses the low enriched uranium (LEU) 20% to be ensure that in all operational states, exposures to radiation are kept below prescribed limits and as low as reasonable corresponding (ALARA) principle and to ensure mitigation of the radiological consequences of accidents. [2,3].

2. GENERAL DESCRIPTION OF NUCLEAR FUEL FABRICATION FACILITY NFFF

The Nuclear Fuel Fabrication Facility (NFFF) is a Material Testing Reactor type (MTR) fuel element facility, for producing the specified fuel elements required for Research Reactor. The plant uses uranium hexaflouride (UF_6, 20% U^{235} by wt.) as a raw material which is processed through a series of the manufacturing, inspection and test plan to produce the final specified fuel elements. Each fuel element is comprised of 19 plates containing about 2 kg of uranium. Radiological safety aspects during design, construction, operation, and all reasonably accepted steps should be taken to prevent or reduce the chance of accidents occurrence [2].

In nuclear fuel fabrication plant, enriched uranium hexafluoride UF_6 is converted into fuel elements for nuclear research reactors. In the wet process or ammonium diuranate (ADU) process, the UF6 with enriched Uranium is 20% is vaporized by heating and transferred to reaction vessel, hydrolyzed with water, and neutralized with NH_4OH to form a slurry of ADU in an aqueous solution of ammonium fluoride and ammonium hydroxide. The ADU is recovered by centrifuging and then is clarified, dried, and calcined to form UO_2 or U_3O_8 powder at 800ºC [2].

The following tasks, necessary to conduct the process, administrative activities, and support, take place in the NFFF [2]:

- UF_6 reception and storage
- Non-nuclear materials reception and storage
- Conversion from UF6 to U_3O_8
- U_3O_8 - Al powders compacting
- Fuel plates manufacturing
- Al structural components manufacturing
- Al components surface treatment
- Fuel element assembly
- Consumables, components, and final product quality control
- Intermediate nuclear materials and fuel element storage
- Administrative services
- Production support services
- Operation auxiliary services
- Radiological waste treatment
- Chemical waste treatment
- Security services

2.1 Wet Process (UF_6-ADU Conversion Process)

In the wet process or ammonium diuranate (ADU) process, the UF_6 with enriched Uranium is 20% is vaporized and transferred to reaction vessel, hydrolyzed with water, and neutralized with NH_4OH to form a slurry of ADU in an aqueous solution of ammonium fluoride and ammonium hydroxide. The ADU is recovered by centrifuging and then is clarified, dried, and calcined to form UO_2 or U_3O_8 powder. Figure1 are a flow diagram and sheet for the conversion process to convert UF_6 to ADU [3].

The 4 steps of process are:

1- Vaporization process – conversion of a UF_6 solid into a gaseous state by adding heat for UF_6 Cylinder.

2- Hydrolysis process – a chemical process by which the oxygen or hydrogen in water combines with an element, or some element of a compound, to form a new compound.

3- Precipitation – formation of finely divided solids in a chemical reaction.

4- Separation – remove or separate solid particles ADU from the liquid effluent.

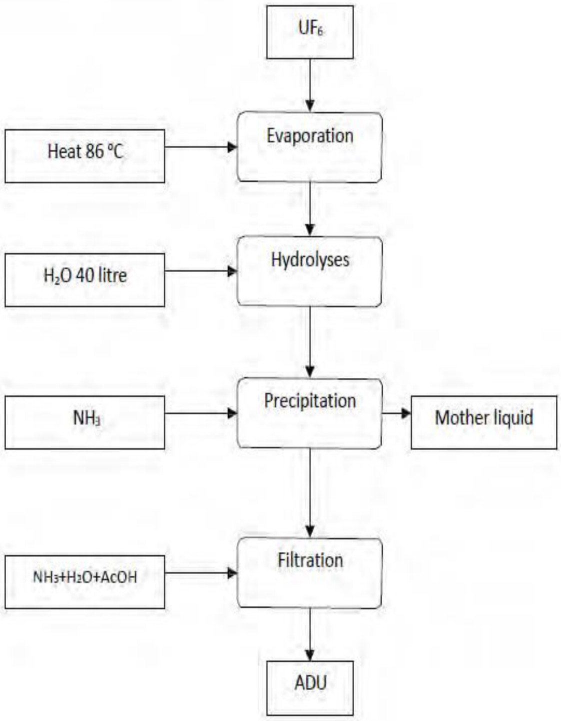

FIG. 1. *Flow diagram of UF_6 – ADU conversion process*

2.2 Dry Process (ADU-U_3O_8 powder production)

The ADU obtained is calcinated at 800°C to U_3O_8 in an oxidant atmosphere. The product is then milled: the bigger particles broken and the smaller agglomerated. Afterwards it is sized between 44 and 150 microns. A treatment at 1400°C is made to obtain the high density U_3O_8 required. Subsequently the material is treated in a mortar, milled and sieved keeping the particles between 44 and 88 microns obtaining the desired product.

3. RISK ANALYSIS IN NFFF

A major concern in nuclear fuel fabrication facility NFFF is the potential for accidental release of uranium hexafluoride. The UF_6 is a reactive substance which reacts with water forming HF and UO_2F_2. The HF is a highly corrosive substance and the UO_2F_2 is very toxic. A sudden release of UF_6 inside a building or to the atmosphere could conceivably cause undesirable health effects to workers and the public in general.

Risk is the possibility of a hazard having adverse consequences under a defined set of conditions. Safety, the inverse of risk, is the probability that harm will not occur under specified conditions. Substances that are extremely toxic can be used safely if the environment is controlled to prevent the absorption of the toxic substance [3].

Any accidental or malicious act by an employee can potentially lead to catastrophic incidents that threaten the environment and the reputation of facility. For this reasons, we should to be study the hazards during the operation of NFFF.

4. TYPES OF HAZARDS IN NFFF

Hazard refers to the potential that a chemical or physical characteristic of a material, system, process, or plant will cause harm or produce adverse consequences. Hazards from nuclear fuel fabrication facility can be dominated by the toxic rather than by the direct radiological effects of the nuclear material.

Increasing in UF_6 mass transferred into hydrolyser without control. It is assumed that the whole contents of UF_6 cylinder ~ 25 kg of UF_6 are transferred into the hydrolyser tank due to operators.

1- Heating at temperature higher than 120 ^{o}C would lead to hydraulic rupture of a full UF6 cylinder. To prevent this event, the redundant, independent controls of temperature linked to automatic stopping of heating for above setting temperature.

3- Contact of UF6 with hydrocarbons generates explosive mixture. To prevent this forbidden use any hydrocarbons in the plant.

4- Blocking in the piping or valves are events produce to pressure increase in the gas transfer system. To prevent the explosion transfer the UF6 gas to expansion tank system.

5- Criticality accident may be take place during the process especially in the wet conversion area such as, Tokaimura nuclear accident in Japan 1999 [4].
Factors that must be controlled to prevent criticality include the following: mass and volume, enrichment, geometry, interaction and separation, moderation, reflection, concentration and density, neutron absorber or poisons, and heterogeneity.
The prevention of criticality is given operatively by the mass control of fissile material at the wet process. And the mass and moderator control at the dry process. Always units of less than 2.4 kg of uranium (20% U^{235}) are handled.

6- Fire

7- Theft of nuclear material or unauthorized of removal of fissile material. To prevent this hazard should be use the NMAC program.

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