17th International Symposium on the
Packaging and Transportation of Radioactive Materials
PATRAM 2013
August 18-23, 2013, San Francisco, CA, USA

Uniform identification system for UF_6 cylinders

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Abstract

There is a large quantity of UF_6 cylinders in use around the world. A substantial number of these are used for transport of UF_6 from and to different facilities in different countries and continents.

Each cylinder has an identification (ID) number assigned by the owner. Historically, these numbers are company specific and do have little common and systematic elements.

The introduction of an industry-wide uniform identification/numbering system would be of an advantage for several reasons:

- The current different ID numbers use figures, letters or a combination thereof in a differing number of digits.
- The current ID numbers can often not be used in standard Enterprise Resource Planning (ERP) systems and another ERP compatible code has to be assigned in addition.
- Each facility has to do this for the cylinders they own, but also for foreign cylinders. Consequently, a cylinder with one original Owner Serial number can have different "in-house" ID numbers in different facilities. This may confuse inter-company communication and cylinder tracking.

A new identification system can easily be adapted for UF_6 cylinders manufactured in the future, but solutions have to be developed to determine how to apply such a new system to the existing cylinder fleet.

This paper explores the adaptation of an industry-wide uniform ID system for UF_6 cylinders similar to the world-wide used system for freight containers. The paper also investigates solutions for the implementation of a new ID system, especially for UF_6 cylinders that are already in service.

Introduction

The nuclear fuel supply chain comprises of the following main five stages:

1. Mining – Uranium ore is extracted, purified and milled to become uranium oxide, also known as 'yellow cake'
2. Conversion – Ore concentrate is chemically converted into uranium hexafluoride (UF_6)
3. Enrichment – UF_6 is enriched in gas centrifuge or gas diffusion plants. The enrichment process separates the two main isotopes contained in uranium (U_{235}, U_{238}) and the lighter U_{235} is enriched up to 5%
4. Fuel fabrication – UF_6 is converted to uranium and pellets are produced which are loaded into fuel rods
5. Nuclear power generation – The fuel rods are loaded to nuclear power stations to generate electricity

UF_6 is required as process material for the enrichment process and for that reason shipped from conversion facilities (Stage 2) to enrichment facilities (Stage 3) and from there to fuel fabrication facilities (Stage 4).

Conversion, enrichment and fuel fabrication facilities are typically not at the same location, but situated around the world. Consequently, UF_6 needs to be shipped from and to different facilities in different countries and continents. Each facility also operates yards and/or warehouses for storage of UF_6.

Because of its chemical properties, UF_6 can only be transported and stored in leak tight containments, usually called UF_6 cylinders. Although other designs of UF_6 cylinders are possible and several designs have been used in the past, the American National Standard ANSI N14.1 became the recommendation when it was first issued in 1971. In 1993 the International Standard ISO 7195 has been issued as an international equivalent of ANSI N14.1. The standardization of cylinders is important, as they also can have a function as process vessels in the above mentioned facilities.

The UF_6 cylinders mainly used by the nuclear industry are type 30B and 48Y (occasionally also type 48X are used but for simplification this type is not further mentioned in the paper). The 48Y cylinder is primarily used for transport and storage of natural and depleted UF_6 ($\leq$ 1 wt % ^{235}U) and the 30B cylinder for enriched UF6 ($\leq$ 5 wt % ^{235}U). The 30B cylinder may contain up to 2,277 kg of UF_6 as maximum fill and a 48Y cylinder up to 12,501 kg of UF_6.

Approximately 100,000 UF_6 cylinders may be in use worldwide and the majority are used for long-term storage of depleted UF_6. Around 15,000 UF_6 cylinder movements per year take place between conversion, enrichment, fuel fabrication and deconversion facilities. The typical UF_6 Cylinder Supply Chain is pictured in Fig. 1 on page 3.

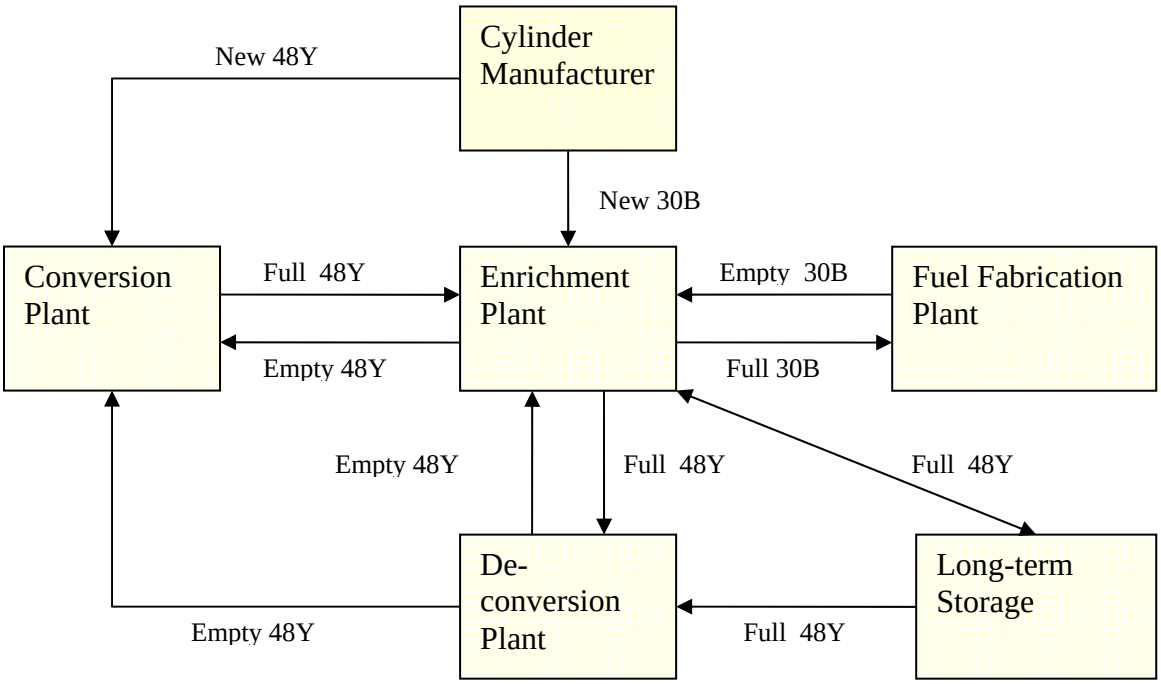

Fig. 1 UF_6 Cylinder Supply Chain

This paper is focusing on improvements of the UF_6 cylinder identification for the logistics of UF_6 cylinders within the supply chain and the use of identification numbers in standard Enterprise Resource Planning (ERP) systems.

Cylinder Identification Background

All UF_6 cylinders have a nameplate attached in accordance with ANSI N14.1 and/or ISO 7195. The nameplate contains several information, e.g. Manufacturer Serial number, Owner Serial number, National Board number and Owner name and therewith a clear identification of the cylinder is guaranteed. An example of a nameplate is shown in Fig. 2 on page 4.

UF_6 cylinders are manufactured as pressure vessels and require a pressure vessel code stamp and number. The code number is assigned by the code organisation and is stamped / engraved on the nameplate. On the nameplate is also a Manufacturer Serial number engraved which is intended for tracing and filing the fabrication history of the UF_6 cylinder. The Owner Serial number is intended to be the identifier for the UF_6 cylinder and every UF_6 cylinder owner has implemented a specific numbering system.

Several papers (see Ref. 1, 2) have addressed the presence of these multiple numbers and different owner numbering systems to be confusing and proposed a unique numbering system. At the same time, they mentioned that in practice no serious issues of misidentification have been encountered.

The fact however that each UF_6 cylinder owner has been using their own system for UF_6 cylinder identification has shown difficulties with recording material batches in the uranium accounts at facilities. For that reason facility operators have started to assign new material batch numbers to incoming UF_6 cylinders to process material batch data in computer systems (see Ref. 3). A temporary label of the assigned material batch number is at some facilities attached to the cylinder but is not engraved on the nameplate. The assignment of an internal material batch number to an Owner Serial number is unique and fixed. In addition a translation listing is available every time.

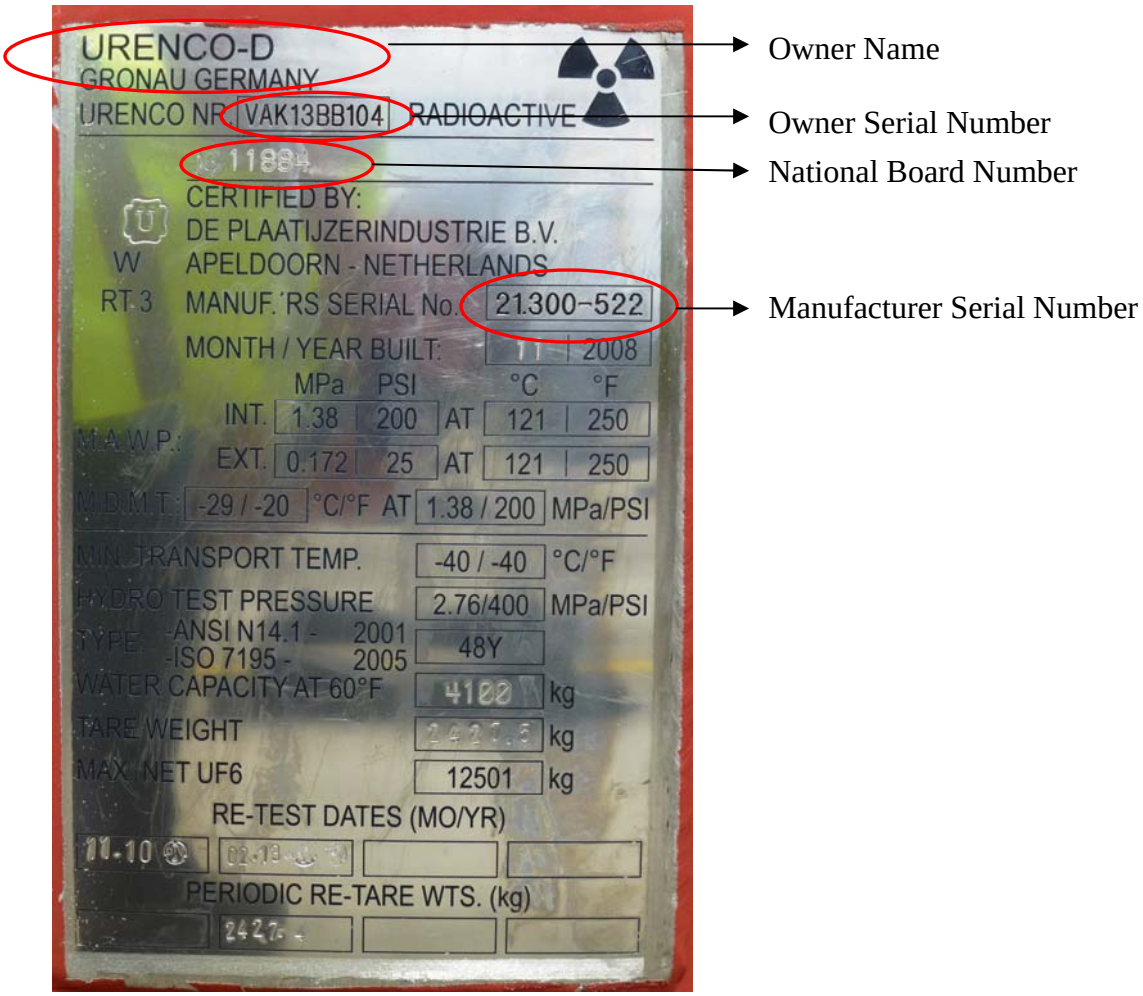

Fig. 2 Example of a 48Y cylinder nameplate

ISO 6346 and BIC

The International Organization for Standardization (ISO) provides a standard for the identification and presentation of information for freight containers (see Ref. 4 - ISO 6346). The identification system described in this standard is intended for general application (e.g. documentation, control and communication) and for display on the container. Since ISO 6346 can be also used for containers other than freight containers, this standard can be used for UF_6

cylinder identification. The standard has been already successfully adopted by one UF_6 cylinder owner.

In accordance with ISO 6346, the Bureau International des Containers (BIC) is appointed to be the international body for the registration of container owners. ISO 6346 enforces the requirement for registration and due to the registration at BIC the container owner avoids duplication of codes, issues during operation and issues with customs authorities.

It consists of:
- Three capital letters registered with BIC as Owner Code,
- An equipment category identifier which consist of one capital letter as follows:
    - U for all freight containers,
    - J for detachable freight container-related equipment,
    - Z for trailers and chassis,
- A 6 digit serial number of owners choice,
- A check digit.

For example, a freight container operated by WNTI with a serial number of 123456 would have the following layout:

WNT	**U**	**123456**	**5**
Owner prefix registered with BIC	Equipment identifier	Serial number	Check digit

The 6 digit serial number could be used as follows by the owner of UF_6 cylinders:
- First two digits of the serial number to identify the UF_6 cylinder type or other cylinder related equipment as follows:
    - 10 – 19 for 30B cylinders
    - 20 – 29 for 48Y cylinders
    - 30 – 99 for other cylinder types, sample ampoules/bottles or cylinder related equipment
- Last 4 digits of the serial number as sequential number

Proposed Concept for implementation

UF_6 cylinders manufactured after introduction of the new system could have this ID number marked on the nameplate as Owner Serial number and/or Manufacturer Serial number. The new ID number is compatible for ERP systems and also intended to be used for material accountancy purposes.

Since UF_6 cylinders have a very long operating life time a full replacement of the existing fleet of UF_6 cylinders would take decades. For that reason a successful implementation of a new identification system for all UF_6 cylinders can be only be achieved if a solution is found for all existing UF_6 cylinders.

Changes on the nameplate and the engraved data of existing UF_6 cylinders are not allowed and there is normally no available space for additional information. Furthermore, changing existing data on the nameplate (such as Manufacturer Serial number, Owner Serial number etc) could potentially lead to issues regarding tracking and traceability of the UF_6 cylinder. For that reason attaching an additional plate with the new ID number (BIC) is the recommended solution. Although additional information is added, the sole identifier to be used for logistics purposes is the new assigned ID number engraved on the number plate.

The additional number plate could be attached during the recertification of the UF_6 cylinder or at another process step, for example after emptying or prior to a shipment which depends on the method for attaching the number plate and the decision of the UF_6 cylinder owner. UF_6 cylinders in long term storage would not be captured in this way.

Possible options to attach the number plate are the use of the TIG welding process (Tungsten Inert Gas welding) or using a metal adhesive. The additional number plate can be located near the original nameplate and/or on the cylinder skirt. The best position of the number plate and an appropriate method to attach the plate need be agreed with the UF_6 cylinder owners and it is essential to consider all operational aspects.

Since the ownership of a UF_6 cylinder is sometimes changing (e.g. sold to another nuclear facility) the number plate needs to be changed to display the new ID number of the UF_6 cylinder for the new owner. The previous owner need to record that the UF_6 cylinder was sold and shall block the ID number for further use.

Automatic identification and data capture system

In addition to a uniform numbering and identification system, the implementation of an appropriate and reliable automatic identification and data capture system for example Bar Code or Radio Frequency Identification (RFID) could further improve the logistics process of the UF_6 cylinders within the supply chain.

In 2008, URENCO instructed the *Fraunhofer-Institut für Materialfluss und Logistik IML* to carry out a detailed investigation into methods of identifying UF_6 cylinders and other cylinder related equipment.

Fraunhofer interviewed Logistics, Operations and Safeguards experts at all three of URENCO's enrichment plants in Europe and examined all steps in the handling of UF_6 cylinders and related equipment, including associated computer systems and paperwork.

Fraunhofer's investigations concluded that preferably a Bar Code system should be used for UF_6 cylinders and other equipment such as sample bottles, overpacks, etc. They concluded that the use of RFID devices is not more advantageous then Bar Codes since the benefits of RFID such as bulk reading, effective for rapid and fully automated processes, reading in case of no line of sight, large reading distance and option to save additional information were considered not to be applicable and beneficial for the UF_6 cylinder handling process within the supply chain. In addition none of the commercially available devices in 2008 met the operational requirements for reliability and cost.

Based on the outcome of these investigations, the implementation of a Bar Code system for the automatic identification of UF_6 cylinders is recommended. Bar Code systems are very reliable, are easy to implement and are very cost effective. The Bar Code of the UF_6 cylinder number can be engraved on the proposed number plate. The Cylinder owners need to agree if a linear (1D) or matrix (2D) Bar Code (see Fig. 3 and Fig. 4) will be used and which Bar Code type will be implemented.

Fig. 3 Example of a Linear (1D) Barcode – Code 128

Fig. 4 Example of a Matrix (2D) Barcode – Data Matrix

Conclusion

Although the existing UF_6 cylinder numbering system has proven to be adequate for the logistics operations within the supply chain of UF_6, it is recognised that the following improvements may be achievable if an industry-wide uniform numbering/identification system for UF_6 cylinders is implemented:

- All ERP systems within the supply chain using the same UF_6 cylinder ID number.
- All transport documentation within the supply chain using of the same UF_6 cylinder ID number.
- Improved communication within the supply chain between consignor, consignee, transport agent, carriers, port authorities, customs, etc.
- Improved tracing of UF_6 cylinders within the supply chain.

It is proposed to implement an established and standardized numbering/identification system in accordance with ISO 6346 and to employ the very reliable and simple Bar Code system for the automatic identification and data capture.

In order to agree on a uniform numbering/identification system, all requirements should be considered within the UF_6 supply chain including safeguards and security aspects. Prior to the implementation of the proposed numbering/identification, a cost-benefit analysis shall be completed by each cylinder owner.

Disclaimer

Please note that the views and proposals expressed in this paper are those of the authors based on their experience and does not reflect an aligned industry position at this moment.

References

1. P. Friend, D. Lockwood and D. Hurt: “A Concept for a World-wide System of Identification of UF6 Cylinders”, 50th Annual Meeting of the Institute of Nuclear Material Management (INMM), Tucson, AZ, USA, 10-16 July 2009.
2. J. White, J. McCowan, M. Whitaker and M. Laughter: “Global Identification and Monitoring of UF6 cylinders”, 16th International Symposium on the Packaging and Transportation of Radioactive Materials (PATRAM 2010), London, UK, 3-8 October 2010.
3. E. Steinebach, B.G. Dekker: “Safeguards at the Dutch and German Uranium Enrichment Plants of Urenco – Development and Experience”, 3rd International conference on Facility Operations – Safeguards Interface, San Diego, CA, USA, 29 November - 4 December 1987.
4. ISO 6346 “Freight containers – Coding, identification and marking”, International Organization for Standardization, Reference number ISO 6346: 1995(E)