Integrity Examination of Depleted UF_6 Cylinder

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1. Introduction

Depleted UF_6 cylinders should be periodically inspected every five years to safely store nuclear material and to verify its integrity in a variety of work situations, such as transportation, filling, and so on.

All UF_6 cylinders shall be routinely examined as received and prior to sampling, withdrawal, filling, or shipping to ensure that they remain in a safe, usable condition. Leakage, cracks, excessive distortion, bent or broken valves or plugs, broken or torn stiffening rings or skirts, or other conditions that may affect the safe use of the cylinder shall warrant appropriate precautions, including removing the cylinder from service until the defective condition is satisfactorily corrected. [1].

Since the 1980s, KAERI has stored and managed about 186 tons of depleted uranium hexafluoride in sixteen 48Y containers. Depleted UF_6 is an unstable material. Therefore, it should be converted to stable compounds such as U_3O_8. Prior to conversion, the integrity of the cylinders was checked to improve the reliability of the safe storage and transportation.

2. Integrity Examination of Cylinders

On March 2017, AREVA NC performed following services on 17 cylinders (16ea 48Y type and a 30–inch type). The checking was started to measure the thickness of each body. And, the overall contamination and irradiation level was measured on those 17 cylinders. And then the general evaluation was performed for the cylinder body and plug reporting any impact, distortion or any damage that may affect the integrity of the cylinders. Finally the valve integrity was checked.

2.1. Measurement of cylinder thickness

Thickness of 17 cylinders was measured by ultrasonic means device at some specific points on each cylinder. The measuring method is same as the one used on Tricastin site.

2.2. Radiological safety checkup

Radiological safety checkup measurement for overall contamination and radiation dose rate was performed on 17 cylinders.

2.3. General inspection of cylinder body and plug

Body and plug of the 17 cylinders were inspected to check any impact, distortion, or any damage that may affect the integrity of the cylinders.

2.4. Integrity examination of cylinder valve

The purpose of the leak test on the cylinder's valve is to check the conformity of the state of the valve by itself with the absence of leak defects.

2.4.1. Principles

The leak test of the valve is performed in 2 steps.

- Leak test of the flexible connection and of the feedthrough of the valve.
- Leak test of the valve seat (the valve is in closed position)

The Fig. 1 illustrates the checking point. The final leak rate of the valve will be the sum of the two measured leak rate.

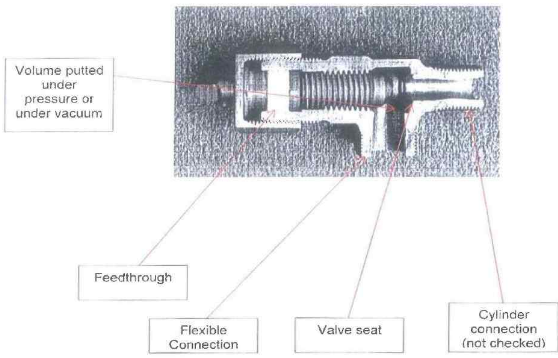

Fig. 1. The valve of checked cylinder

2.4.2. Test condition

As the UF_6 under the storage conditions is at crystalline state, this crystalline UF_6 around the valve might block a leak. So during all the process of the tests, the valve was heated around 346K in order to sublime the UF_6 around the valve. Since the UF_6 reacts with air, the drop test of the valve seat was performed with nitrogen.

2.4.3. Test equipment

The leak tests were performed with the "Hot Valve Tester" (hereafter called HVT) provided by AREVA NC from Pierrelatte plant. The HVT has the functions to automatically carry the operations of heating, vacuuming, pressurizing and monitoring the pressure during the test. The HVT is composed of a vacuum pump, a computerized system and a vacuuming-pressurizing system. The good setting condition of the HVT are checked before the performing the leak test by the use of a known calibrated leak. This calibrated leak simulates a real leak. In this mode the HVT will perform the safer than the flexible valve connection. This test will be successful and identical of the calibrated leak +/- 10%, if the leak rate was measured and calculated by the HVT.

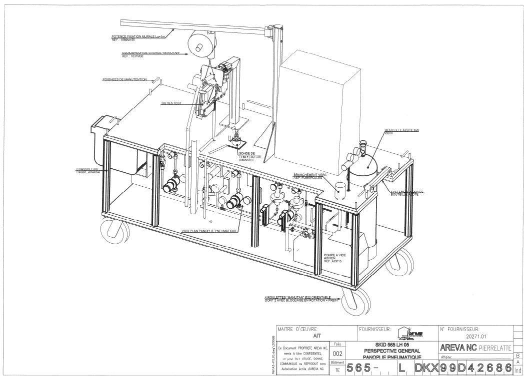

Fig. 2. Hot Valve Tester

3. Results

The test results of external surface, plugs and radiological characteristics were fine. The leak tests were performed by the pressure change test method: the volume surrounding the checking area was put either under vacuum or under pressure. During the entire test, the pressure was monitored, in case of a leak the pressure inside the volume may raise or drop during a measured period. As the checked volume is known, a leak rate can be expressed in $Pa{\cdot}m3{\cdot}s^{-1}$, the leak rate can be finally expressed in $Pa{\cdot}.m3{\cdot}.s^{-1}$ SLR to be in compliance with the ISO 12807 standard. As the leak test conditions were different from the conditions given in the ISO 12807, the leak measured lake can be converted to the following conditions:

- Temperature :298K
- Gas: dry air
- Difference of pressure $1.013{\cdot}10^5$ Pa

The results of the leak tests are following Table 1.

Table 1. The leak tests results of the cylinders

Cylinder Reference	Type	Valve Connection Leak test rate ($Pa.m^3.s^{-1}$ SLR)	Valve seat Leak test rate ($Pa.m^3.s^{-1}$ SLR)	Total Leak rate ($Pa.m^3.s^{-1}$ SLR)	Leak Rate Conformity < 1.10^{-4} $Pa.m^3.s^{-1}$ SLR
16-5131	48Y	2,74E-05	1,30E-05	4,04E-05	OK
9-5399	48Y	4,29E-05	2,00E-05	6,29E-05	OK
8-5396	48Y	2,65E-05	1,30E-05	3,95E-05	OK
10-5404	48Y	2,30E-05	1,30E-05	3,60E-05	OK
11-5405	48Y	3,44E-05	1,30E-05	4,74E-05	OK
12-5398	48Y	2,67E-05	1,30E-05	3,97E-05	OK
13-5401	48Y	4,26E-05	1,30E-05	5,56E-05	OK
14-5406	48Y	2,08E-05	1,30E-05	3,38E-05	OK
15-5394	48Y	4,13E-05	2,40E-05	6,53E-05	OK
17	30B	3,65E-05	1,30E-05	4,95E-05	OK
6-5393	48Y	3,17E-05	1,30E-05	4,47E-05	OK
3-5397	48Y	1,54E-05	1,30E-05	2,84E-05	OK
4-5403	48Y	1,09E-05	2,00E-05	3,09E-05	OK
7-5407	48Y	4,74E-05	1,30E-05	6,04E-05	OK
2-5402	48Y	3,85E-05	1,30E-05	5,15E-05	OK
1-5395	48Y	2,04E-05	1,30E-05	3,34E-05	OK
5-5400	48Y	4,76E-05	1,30E-05	6,06E-05	OK

For leak test of the flexible connection and the feedthrough were performed at first in the same time by the pressure rise test method, the internal volume of the valve was put under vacuum at a pressure around $200{\cdot}10^4$ Pa_{ab}. If a leak the external air get inside the volume and the pressure will rise.

And for leak test of valve seat was performed by pressure drop test. The test was performed after the flexible connection and the feedthrough leak test. The internal volume was put under pressure around $1200{\cdot}10^3$ Pa_{ab} with nitrogen. In case of a leak on the valve seat the nitrogen will pass to the cylinder volume and the pressure will decrease.

The results show that there are no leakage for all valves and plugs of cylinders

4. Conclusions

The integrity checking on 17 cylinders for safe storage and management of depleted UF_6 was performed with AREVA NC, France, in compliance with ANSI 14.1. Especially, body and valve of cylinder were inspected for physical safety and leakage according to the procedures of AREVA NC. The AREVA NC made the HVT equipment which was used during the valve leakage test, and leakage rate was met for AREVA NC and the international requirements.

From this work, the integrity of UF_6 cylinders was proved safe. Therefore, we are about to proceed the following process, the sampling of UF_6 prior to conversion to more stable form such as U_3O_8 or UO_2.

REFERENCES

[1] Institute for Nuclear materials management, American National Standard for Nuclear Materials Uranium Hexafluoride-Packagings for Transport, American National Standards Institute, Inc., pp.11-12, 2012.