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GNS

PV 360/82

Test specification

Cask structural component –
Leak-tightness test
Helium leak-tightness test procedure

- CASTOR® THTR/AVR -

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Author	[redacted]		
Approval mark of spec. dept.			
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Level II Acceptance

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Revision status

Revision	Data	Author Explanation of the change with page number if necessary
0	21.12.2018	[redacted] *First issue.*
1	14.02.2019	[redacted] *Completely reworked.*
2	23.06.2020	[redacted] *Verification of the helium partial pressure in the cover added.*
3	24.06.2020	[redacted] *Note in chapter 11 reworked and steps added.*

The changes from the Rev. 1 of this report are marked by a vertical black line at the left text margin.

Inhaltsverzeichnis

1 Purpose, scope and introduction

The tests are intended to demonstrate compliance with the helium standard leak rate permissible for the entire containment system. By successfully passing the test, the functionality of the containment system in accordance with the specifications is proven.

CASTOR® THTR/AVR packages according to the German design approval certificate D/4214/B(U) F-96, Rev. 11 are to be transported on the territory of the United States of America. This transport requires a revision of the existing certificate USA/0808/B(U) F-96, Rev. 0 for the revalidation of the German Certificate of Competent Authority.

[redacted] to the leak test of the lids belonging to the containment system, which is mandatory prior to transport according to WKP 500.07-03 [1], [redacted] of the CASTOR® THTR/AVR design.

This test procedure shall be applied only after approval by an Level III certificate holder according to ASNT NDT [4]. The leak tests are to be carried out analogous to [2] as a helium leak test.

The following original components of an [redacted] are to be leak-tested:

- [redacted]
- Secondary lid, item 55,
- Blind flange, item 89,
- Protection cap, item 61.

The helium standard leak rate of each of the single components as well as the sum of all standard leak rates must be determined. The metal O-rings (item 70, item 71 and/or item 73 acc. to [3]) must be installed additionally in order to form a helium or test volume. The determined leak rates must be assigned to the single test objectives item 2, item 55, item 61, and item 89.

In case a component [redacted] is leak-tested in [redacted] all single leak rates must be summed up. In case multiple components are leak-tested together (e.g. [redacted] and secondary lid) the measured total leak rate must be assumed for each of the components involved into the integral test. The primary lid, item 20 acc. to [3] must not be installed during the test.

2 Abbreviations and formula symbols used

$AG^{1)}$	: % of the DLV	: display accuracy of the helium leak detector
E_2	: -	: Sensitivity of the background determination
E_3	: -	: Sensitivity of the leak rate determination
p_{He}	: hPa	: Helium partial pressure in the helium chamber
p_1	: hPa	: Pressure in the helium chamber after evacuation
p_2	: hPa	: Pressure in the helium chamber after filling
Q_{ANZ}	: $Pa \cdot m^3 \cdot s^{-1}$	: Helium leak rate display
Q_{He}	: $Pa \cdot m^3 \cdot s^{-1}$	: Average helium leak rate
Q_{HeK}	: $Pa \cdot m^3 \cdot s^{-1}$	: Corrected helium leak rate
Q_{He1}	: $Pa \cdot m^3 \cdot s^{-1}$	: First helium leak rate
Q_{He2}	: $Pa \cdot m^3 \cdot s^{-1}$	: Second helium leak rate
Q_L	: $Pa \cdot m^3 \cdot s^{-1}$	: Leak rate after deducting the background
Q_S	: $Pa \cdot m^3 \cdot s^{-1}$	: Target leak rate of the test leak
Q_{SK}	: $Pa \cdot m^3 \cdot s^{-1}$	: Corrected target leak rate oft the test leak
Q_{ST}	: $Pa \cdot m^3 \cdot s^{-1}$	: Standard helium leak rate
Q_{TL1}	: $Pa \cdot m^3 \cdot s^{-1}$	: Test leak rate during commissioning
Q_{TL2}	: $Pa \cdot m^3 \cdot s^{-1}$	: Test leak rate during background determination
Q_{TL3}	: $Pa \cdot m^3 \cdot s^{-1}$	: Test leak rate during leak rate determination
Q_U	: $Pa \cdot m^3 \cdot s^{-1}$	: Background leak rate
Q_{UG}	: $Pa \cdot m^3 \cdot s^{-1}$	: Background leak rate during commissioning
Q_{UK}	: $Pa \cdot m^3 \cdot s^{-1}$	: Corrected background leak rate
Q_{ZUL}	: $Pa \cdot m^3 \cdot s^{-1}$	: Permissible total standard helium leak rate
T_{ACT}	: °C	: Temperature of the test leak
T_{REF}	: °C	: Calibration temperature of the test leak
ΔQ_U	: $Pa \cdot m^3 \cdot s^{-1}$	: Background leak rate difference between two measured values Q_U
ΔQ_1	: %/°C	: Temperature dependency of the test leak
ΔQ_2	: %/a	: Time dependency of the test leak
Δt	: a	: Time difference
ΔT	: °C	: Temperature difference
ΣQ_{ST}	: $Pa \cdot m^3 \cdot s^{-1}$	: Total standard helium leak rate

Note on the leak rate unit: $1\ Pa \cdot m^3 \cdot s^{-1} = 10\ hPa \cdot l \cdot s^{-1}$

1): Decade limit value

3 Carrying out leak-tightness tests

This chapter contains the details specified for the equipment, the measuring times and the generally applicable procedure.

3.1 Requirements on the test equipment and the test gas

3.1.1 Helium leak detector

The helium leak-tightness test can be carried out with a commercially-available helium leak detector provided it has a detection limit sufficient for the standard leak rate to be verified.
The helium leak detector must have a linear output for connecting to the recorder.

3.1.2 Test leak

The leak rate of the test leak should be of the same order of magnitude as the helium leak rate to be verified.
The sensitivity of the measurement setup should be > 50% during all measurements, independent of the leak rate of the test leak.
There must be a valid calibration certificate for the test leak used. The test leak must be marked with the expiry date of the calibration.

3.1.3 Pressure measuring device

Measurement range [1)]	: 1 - 2000 hPa
Maximum deviation [2)]	: $\pm$ 10 hPa
Display resolution [2)]	: $\leq$ 1 hPa
Recording connection	: Adapted to the recorder

[1)] The smallest, required measurement range is specified.

[2)] The stated values must be maintained in the 1 – 2000 hPa range.

The pressure measurement should be independent of the type of gas. There must be a valid calibration certificate for the pressure measuring device used. The pressure measuring device must be marked with the expiry date of the calibration.

3.1.4 Temperature measuring device

Measurement range [1)]	: 0 - 100 °C
Maximum deviation [2)]	: $\pm$ 1.0 K
Display resolution [2)]	: $\leq$ 0.1 K

[1)] The smallest, required measurement range is specified.

[2)] The stated values must be maintained in the 0 - 100 °C range.

There must be a valid calibration certificate for the temperature measuring device used. The temperature measuring device must be marked with the expiry date of the calibration.

3.1.5 Recorder

Input channels	: min. 2
Feed rate [3)]	: 5 to 30 mm/min
Recorder width in y-direction	: min. 100 mm

[3)] The smallest, required setting range is specified. If a recorder with a larger setting range is used, the feed rate should be set in the above mentioned range.

Electronic recording devices that meet the standards of the FDA guideline 21 CFR may also be used.

3.1.6 Vacuum pump for evacuating the helium chamber

The vacuum pump to be used must be selected according to the respective inspection task.

3.1.7 Helium

Purity	: min. 3.0 (99,9 %)

3.2 Measurement times

Before reading the display on the helium leak detector for Q_{He1}, Q_{TL3} and Q_{He2}, wait for a stationary or falling display. The measurement time in this condition is at least five minutes.

Comment:
This condition is also satisfied if the display fluctuates around a stationary or falling average value.

If $Q_{He} >> Q_{zul}$ and it is not foreseeable that Q_{ST} will become $< Q_{zul}$, waiting for a constant display is not required.

3.3 Procedure for the helium background determination and determining the standard helium leakage rate

[redacted]

[redacted]

3.4 Filling the helium chamber for test objects without filling connection

The helium space is optionally filled according to the following methods:

- The helium space is at first flushed with nitrogen and subsequently helium is sprayed in by means of a spray gun.

The helium partial pressure p_{He} in the helium space is not known exactly and is conservatively estimated to be [redacted]

3.5 General test preparations

The general test preparations for carrying out helium leak-tightness tests are described in the following.

3.5.1 Commissioning of the devices

As part of the preparatory work, all devices are placed in operation, the device data are recorded, and the recorder paper labeled. The labeling of the recorder paper ensures a unique assignment to the protocols to be filled out.

3.5.2 Determining the corrected target leak rate of the test leak

After logging the data of the test leak, a temperature measurement is carried out on the metallic surface of the test leak and the corrected target leak rate of the test leak Q_{SK} determined. If the ambient temperatures are not stable, the corrected target leak rate of the test leak must be determined immediately before the test.

3.5.3 Adjusting the leak detector

The leak detector is adjusted before the first test. The proof of proper functioning must be provided at least once a day with a calibrated test leak.

To achieve better sensitivity when measuring Q_{TL1}, the leak rate display should be set so that the following applies: $Q_{ANZ} - Q_{UG} \geq Q_{SK}$.

4 Target values for the helium leakage rate

The permissible **standard helium leak rate Q_{ST}** and **total standard helium leak rate Q_{ZUL}** for the sealing barrier secondary lid (including body of the cask) are shown in the following table:

Component	Standard-helium leak rate Q_{ST}
[redacted] ([redacted] in cover filled with helium, [redacted] filled with helium, see Fig. 2)	[redacted]
Please Note: To ensure that [redacted] with helium during the tests, the adhesive tape must be applied overlapping the previous test.	
[redacted] ([redacted], until [redacted] filled with helium, see Fig. 3)	[redacted]
Blind flange (Item 89)	[redacted]
Protection cap (Item 61)	[redacted]
Secondary lid (Item 55)	[redacted]
	Total standard-helium leak rate Q_{ZUL}
[redacted] Item 89 Item 61 Item 55	[redacted]

5 Timing of the tests

The following table shows the cask components which have to be tested with the belonging test timings.

Cask structural components [1)]	Test-Nr.:
[redacted]	1
[redacted]	2
Blind flange - Item 89	4
Protection cap – Item 61	3
Secondary lid - Item 55	5

1) According Part List-Nr. 500.07/1 [3]

6 Condition of the components to be tested

The components which have to be tested, have to be dry and free of oil, dust and soiling's as far as they could influence the quality of the test results.

7 Recording

The measured values and measurement results must be recorded during the test. This PV 360/82 contains sheets for the records (PV 360/82 F01 – PV 360/82 F04) that can be used for logging.
The use of other templates is permissible if the following minimum details are included:

- Test location, test date
- Protocol number
- Current page and number of pages
- Test specification with revision level
- ID number of the test object
- Drawing number with revision level
- Condition of components
- Test pressure (He partial pressure)
- Test procedure
- Permissible individual and total leak rates (if required)
- All measured values required for calculation the leak rate (see measurement protocol)
- Type and serial number of test devices
  - Leak detector
  - Test leak
  - Pressure measuring device
  - Temperature measuring device
- Information about the test leak
  - Target leak rate (from the protocol of the valid calibration)
  - Dependency on temperature and time
- Fulfilled or not fulfilled
- Name and qualification of the inspector
- Inspection supervisor or works expert

Recordings must be created for all inspections in addition to the measurement and test records. The following minimum information is required on the recordings:

- Date
- Feed rate
- Measuring ranges of the recorder
- Position and ID number of the components
- Assignment: Measured value / channel / colour
- Assignment to the protocols
- Measured values to be logged

The data/time of the measured values must be marked on the corresponding recording curve during the recording.

8 Cited documents

[1]: WKP-Nr.: 500.07-03, Index: 12
Periodic inspection plan on a loaded cask for transport and storage
CASTOR® THTR/AVR

[2]: PV 360/17, Rev. 2
Test specification, Leak-tightness, Helium leak-tightness test procedure
CASTOR® THTR/AVR, Beladung

[3]: Part List, 500.07, Rev. 13
Cask for transport und storage, CASTOR® THTR/AVR

[4]: ASNT Standard Topical Outlines for Qualification of Nondestructive
Testing Personnel, (ANSI/ASNT CP-105-2016)

9 Calculation and evaluation

Temperature difference of the test leak:

$$\Delta T = T_{ACT} - T_{REF}$$

Corrected target leak rate of the test leak:

$$Q_{SK} = Q_S \cdot (1 + 0.01 \cdot \Delta Q_1)^{\Delta T}$$

Sensitivity of the background determination:

$$E_2 = (Q_{TL2} - Q_U) / Q_{SK}$$

Corrected background leak rate:

$$Q_{UK} = Q_U / E_2$$

Helium partial pressure in the helium chamber:

$$p_{He} = p_2 - p_1$$

Average helium leak rate:

$$Q_{He} = (Q_{He1} + Q_{He2}) / 2$$

Sensitivity of the leak rate determination:

$$E_3 = (Q_{TL3} - Q_{He}) / Q_{SK}$$

Corrected helium leak rate:

$$Q_{HeK} = Q_{He} / E_3$$

Leak rate after deducting the helium background

$$\mathbf{Q_L} = Q_{HeK} - Q_{UK}$$

If $Q_L \leq 0$, the following applies: $Q_L \leq$ (decade limit value relative to Q_{He2}) · AG

Standard helium leak rate:

$$\mathbf{Q_{ST}} = Q_L \cdot 1013\ hPa / p_{He}$$

If no background value is subtracted from the corrected helium leak rate Q_{HeK}, the following applies:

$$\mathbf{Q_{ST}} = Q_{HeK} \cdot 1013\ hPa / p_{He}$$

10 Preparation works

10.1 Test preparation

Leak detector, test leak, pressure measuring device, temperature measuring device, recorder and vacuum pump have to be prepared according to the given equipment instructions and have to be put into operation. Run warm the helium leak detector and the vacuum pump. Record the equipment data (manufacturer/type/number) as well as the accuracy of indication of the leak detector AG, the APZ-Number (see F04).

Assure the continuity of the test hole(s).

10.2 Determining the corrected target leak rate of the test leak

Record the data of the test leak in the measurement record (see F03):

Target leak rate of the test leak Q_S, calibration temperature of the test leak T_{REF}, dependency on temperature and time ΔQ_1, ΔQ_2 and the calibration date.

Carry out the measurement of temperature on the metallic surface of the test leak. Record the temperature of the test leak T_{ACT} in the measurement record (see F03). Determine and record the time difference Δt between the test leak calibration date and the date of the test.

Determine and record the temperature difference ΔT according to the specification of the measurement record (F03).

Determine and record the corrected target leak rate of the test leak Q_{SK} according to the specification of the measurement record (see F03).

10.3 Adjusting the leak detector

Open valve V_{TL} (see appendix 1, s. 1) and start the leak detector.
Close valve V_{TL} when reaching the leak detector measuring readiness.
Carry out the measurement of the background leakage rate of the leak detector. Read Q_{UG} and record it in the measurement record (F03).
Open valve V_{TL}.
If no automatic adjustment of the leak detector is carried out, set the leakage rate display.

Remark:
In order to get a better sensitivity, the leakage rate display is set as follows:

$$Q_{ANZ} - Q_{UG} \geq Q_{SK}$$

Carry out the measurement of the test leak leakage rate Q_{TL1} at the starting. Read Q_{TL1} and record it in the measurement record (see F03).

11 Performing of the test

11.1 Test procedure for the [redacted]

1. Test preparation (carry out according appendix 1 and section 10).
2. Determination of the corrected background leak rate is not necessary.

Determining the standard helium rate

3. Connect the test equipment with the test space by the test adapter.
4. Assemble a suitable calibrated device for measurement of the helium partial pressure to the cover.
5. Close all valves.
6. Start the helium leak detector. After reaching the measuring readiness of the helium leak detector: Start the recorder.
7. Open valve V_P and evacuate the space to $\leq$ 10 hPa.
8. Open valve V_{LD} and start the helium leak detector.
9. Close valve V_P.
10. Flush first the cover with nitrogen and fill the cover subsequently with helium.
11. All openings of the cover must be closed immediately after filling with aluminum adhesive tape.
12. The helium partial pressure p_{He} in the helium chamber is conservatively estimated to be 300 hPa and is used for the following calculation.

Note:
The minimum helium partial pressure of [redacted] must be verified by a suitable calibrated measuring device.

Is the helium partial pressure [redacted], start the test procedure again from step 9!

13. Carry out the measurement of the first helium leak rate Q_{He1}. Read Q_{He1} and record it in the F04.
14. Open valve V_{TL}.
15. Carry out the measurement of the test leak rate during leak rate determination Q_{TL3}. Read Q_{TL3} and record it in the F04.
16. Close valve V_{TL}.
17. Carry out the measurement of the second helium leak rate Q_{He2}. Read Q_{He2} and record it in the F04.
18. Close all valves.

Note:
The minimum helium partial pressure of [redacted] must be verified by a suitable calibrated measuring device.

Is the helium partial pressure [redacted] start the test procedure again from step 9!

19. Stop the recorder. Shut down the equipment according to the specifications of the test record. Dismantle the test equipment and the filling equipment incl. adapter.
20. Determine and record the average helium leak rate Q_{He} according to F04.
21. Determine and record the sensitivity of the leak rate E_3 according to F04.
22. Determine and record the corrected helium leak rate Q_{HeK} according to F04.
23. Determine and record the standard helium leak rate Q_{ST} according to F03 and F04.

11.2 Test procedure for [redacted]

1. Test preparation (carry out according appendix 1 and section 10).
2. Determination of the corrected background leak rate is not necessary.

Determining the standard helium rate

3. Connect the test equipment with the test space by the test adapter.
4. Assemble a suitable calibrated device for measurement of the helium partial pressure to the cover.

5. Close all valves.
6. Start the helium leak detector. After reaching the measuring readiness of the helium leak detector: Start the recorder.
7. Open valve V_P and evacuate the space to [redacted]
8. Open valve V_{LD} and start the helium leak detector.
9. Close valve V_P.
10. Flush first the cover with nitrogen and fill the cover subsequently with helium.
11. All openings of the cover must be closed immediately after filling with aluminum adhesive tape.
12. The helium partial pressure p_{He} in the helium chamber is conservatively estimated to be [redacted] and is used for the following calculation.

Note:
The minimum helium partial pressure of [redacted] must be verified by a suitable calibrated measuring device.

Is the helium partial pressure [redacted] repeat step 9!

13. Carry out the measurement of the first helium leak rate Q_{He1}. Read Q_{He1} and record it in the F04.
14. Open valve V_{TL}.
15. Carry out the measurement of the test leak rate during leak rate determination Q_{TL3}. Read Q_{TL3} and record it in the F04.
16. Close valve V_{TL}.
17. Carry out the measurement of the second helium leak rate Q_{He2}. Read Q_{He2} and record it in the F04.
18. Close all valves.

Note:
The minimum helium partial pressure of [redacted] must be verified by a suitable calibrated measuring device.

Is the helium partial pressure [redacted] start the test procedure again from step 9!

19. Stop the recorder. Shut down the equipment according to the specifications of the test record. Dismantle the test equipment and the filling equipment incl. adapter.
20. Determine and record the average helium leak rate Q_{He} according to F04.
21. Determine and record the sensitivity of the leak rate E_3 according to F04.
22. Determine and record the corrected helium leak rate Q_{HeK} according to F04.

23. Determine and record the standard helium leak rate Q_{ST} according to F03 and F04.
24. Dismantle the [redacted]

11.3 Test procedure for the blind flange Item 89, (Fig. 4)

1. Test preparation (carry out according appendix 1 and section 10).

Determining the corrected background leak rate

2. Connect the test equipment with the test space by the test adapter.
3. Close all valves.
4. Open valve V_{LD} and start the helium leak detector.
5. Open valve V_P and evacuate the helium space to [redacted].
6. Start the helium leak detector. After reaching the measuring readiness of the helium leak detector: Start the recorder.
7. Close valve V_P.
8. Determine and record the pressure in the helium chamber after evacuation p_1 according to F04.
9. Determine and record the background leak rate Q_U according to F04.
10. Open valve V_{TL}.
11. Carry out the measurement of the test leak rate during background determination Q_{TL2}. Read Q_{TL2} and record it in the F04.
12. Close valve V_{TL}.
13. Determine and record the sensitivity of the background determination E_2 according to F04.
14. Determine and record the corrected background leak rate Q_{UK} according to F03 and F04.

Determining the standard helium rate

1. Open valve V_{He} and fill the helium space with a pressure from [redacted] to [redacted] with helium.
2. Close valve V_{He}.
3. Determine and record the average helium leak rate Q_{He} according to F04
4. Determine and record the pressure in the helium chamber after filling p_2 according to F04.
5. Determine and record helium partial pressure in the helium chamber p_{He} according to F04.
6. Carry out the measurement of the first helium leak rate Q_{He1}. Read Q_{He1} and record it in the F04.
7. Open valve V_{TL}.

8. Carry out the measurement of the test leak rate during leak rate determination Q_{TL3}. Read Q_{TL3} and record it in the F04.
9. Close valve V_{TL}.
10. Carry out the measurement of the second helium leak rate Q_{He2}. Read Q_{He2} and record it in the F04.
11. Close valve V_{LD}.
12. Stop the recorder. Shut down the equipment according to the specifications of the test record. Dismantle the test equipment and the filling equipment incl. adapter.
13. Determine and record the average helium leak rate Q_{He} according to F04.
14. Determine and record the sensitivity of the leak rate E_3 according to F04.
15. Determine and record the corrected helium leak rate Q_{HeK} according to F04.
16. Determine and record the leak rate after deduction the background Q_L and the standard helium leak rate Q_{ST} according to F03 and F04.
17. Dismantle the test adapter and assemble the quick snap coupling.

11.4 Test procedure for the protection cap Item. 61, (Fig. 5)

Determining the standard helium rate

1. Before assembling of the protection cap, the helium space is flushed with nitrogen and subsequently filled with helium.
2. The helium partial pressure p_{He} in the helium space is conservative estimated to be [redacted] and is used for the following calculation.
3. Test preparation (carry out according appendix 1 and section 10).
4. Connect the test equipment with the test space by the test adapter.
5. Close all valves
6. Open valve V_{LD} and start the helium leak detector.
7. Start the helium leak detector. After reaching the measuring readiness of the helium leak detector: Start the recorder.
8. Carry out the measurement of the second helium leak rate Q_{He1}. Read Q_{He1} and record it in the F04.

   Remark:
   Because of the contamination of the test space with helium, a longer relaxation time of the leakage rate signal Q_{He1} has to be expected.

9. Open valve V_{TL}.
10. Carry out the measurement of the test leak rate during leak rate determination Q_{TL3}. Read Q_{TL3} and record it in the F04.
11. Close valve V_{TL}.

12. Carry out the measurement of the second helium leak rate Q_{He2}. Read Q_{He2} and record it in the F04.
13. Close valve V_{LD}.
14. Stop the recorder. Shut down the equipment according to the specifications of the test record. Dismantle the test equipment and the filling equipment incl. adapter.
15. Determine and record the average helium leak rate Q_{He} according to F04.
16. Determine and record the sensitivity of the leak rate E_3 according to F04.
17. Determine and record the corrected helium leak rate Q_{HeK} according to F04.
18. Determine and record the standard helium leak rate Q_{ST} according to F03 and F04.

11.5 Test procedure for the secondary lid Item 55, (Fig. 6)

1. Test preparation (carry out according appendix 1 and section 10).

Determining the standard helium rate

1. Determine and record the helium partial pressure in the helium space p_{He} according to F04 (Please taken the values from Chap. 11.3).
2. Carry out the measurement of the first helium leak rate Q_{He1}. Read Q_{He1} and record it in the F04.
3. Close all valves.
4. Open valve V_{LD} and start the helium leak detector.
5. Open valve V_{TL}.
6. Carry out the measurement of the test leak rate during leak rate determination Q_{TL3}. Read Q_{TL3} and record it in the F04.
7. Close valve V_{TL}.
8. Carry out the measurement of the second helium leak rate Q_{He2}. Read Q_{He2} and record it in the F04.
9. Close valve V_{LD}.
10. Stop the recorder. Shut down the equipment according to the specifications of the test record. Dismantle the test equipment and the filling equipment incl. adapter.
11. Determine and record the average helium leak rate Q_{He} according to F04.
12. Determine and record the sensitivity of the leak rate E_3 according to F04.
13. Determine and record the corrected helium leak rate Q_{HeK} according to F04.
14. Determine and record the standard helium leak rate Q_{ST} according to F03 / F04.

Appendices

Appendix 1:

Item	Title	Page number
Fig. 1	Test device and the filling device	1
Fig. 2	Test arrangement for testing of the [redacted]	[redacted]
Fig. 3	Test arrangement for testing of the [redacted]	[redacted]
Fig. 4	Test arrangement for testing of the blind flange Item 89	1
Fig. 5	Test arrangement for testing of the protection cap Item 61	1
Fig. 6	Test arrangement for testing of the secondary lid Item 55	1
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Appendix 2:

Item	Title	Page number
PV 360/82 F01	Test record of the helium leak-tightness test	1
PV 360/82 F02	Measurement protocol of the helium leak-tightness test -test leak data-	1
PV 360/82 F03	Measurement protocol of the helium leak-tightness test –device data-	1
PV 360/82 F04	Measurement protocol of the helium leak-tightness test –measurement data-	1
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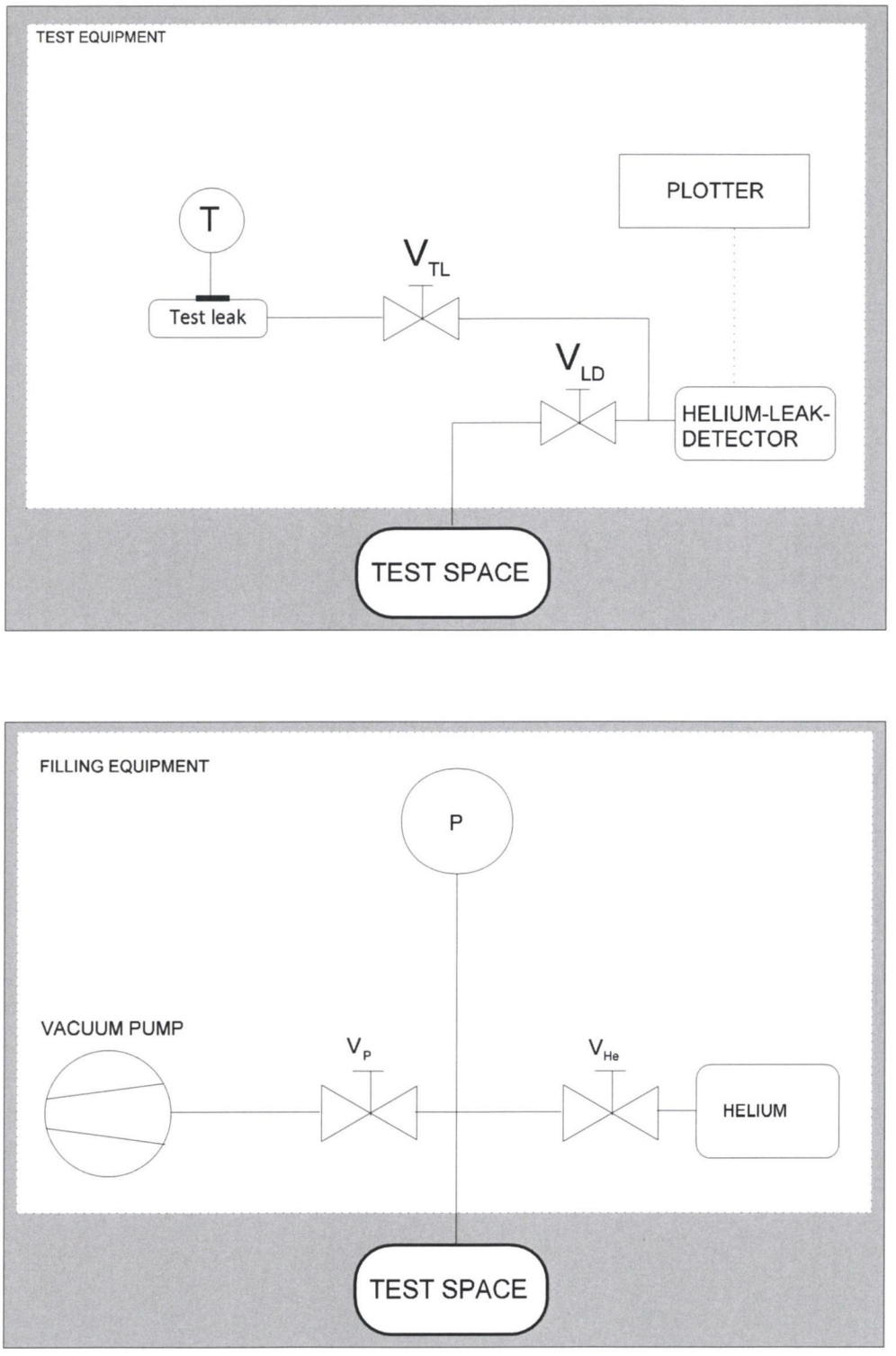

Fig. 1: Test device and the filling device

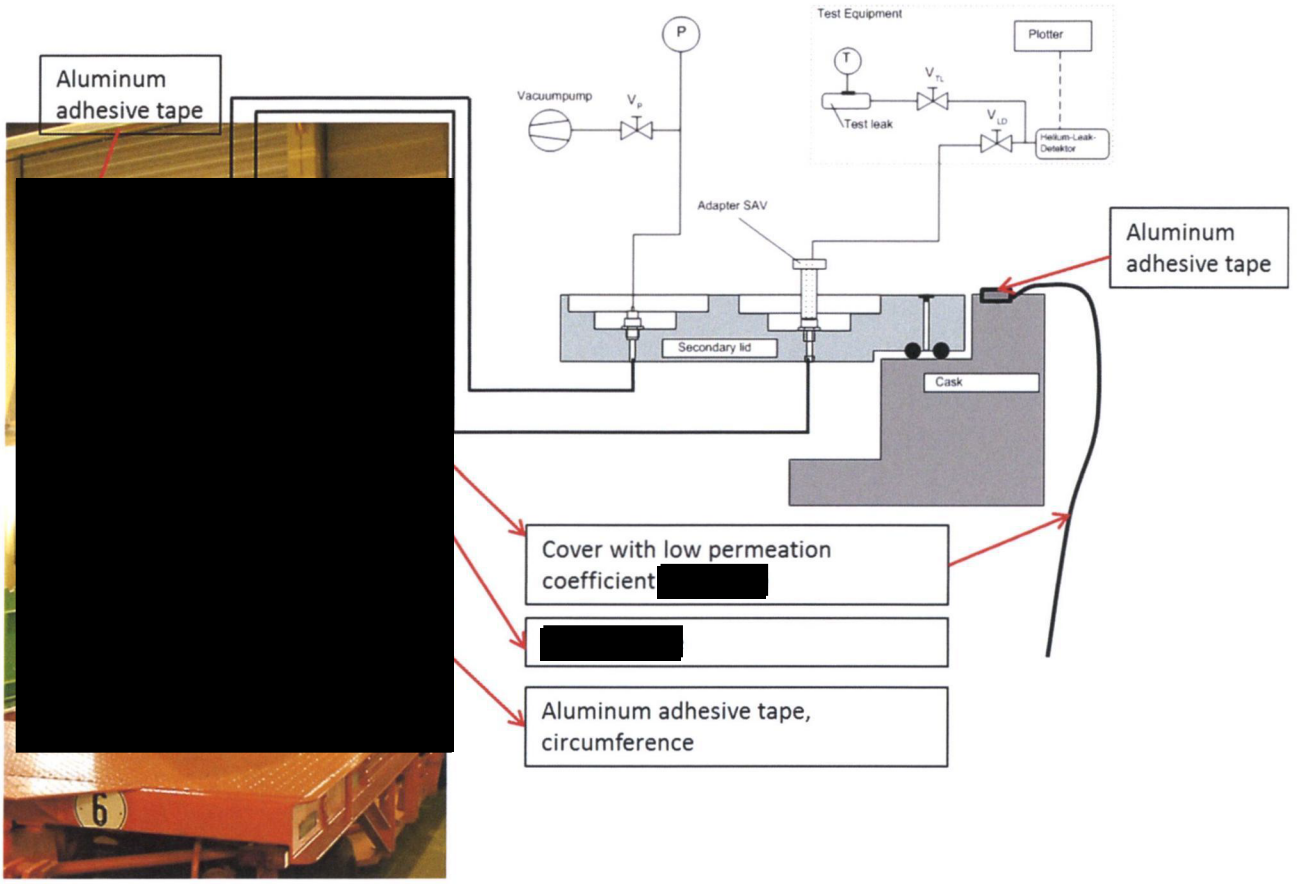

Fig. 2: Test arrangement for testing of the [redacted]

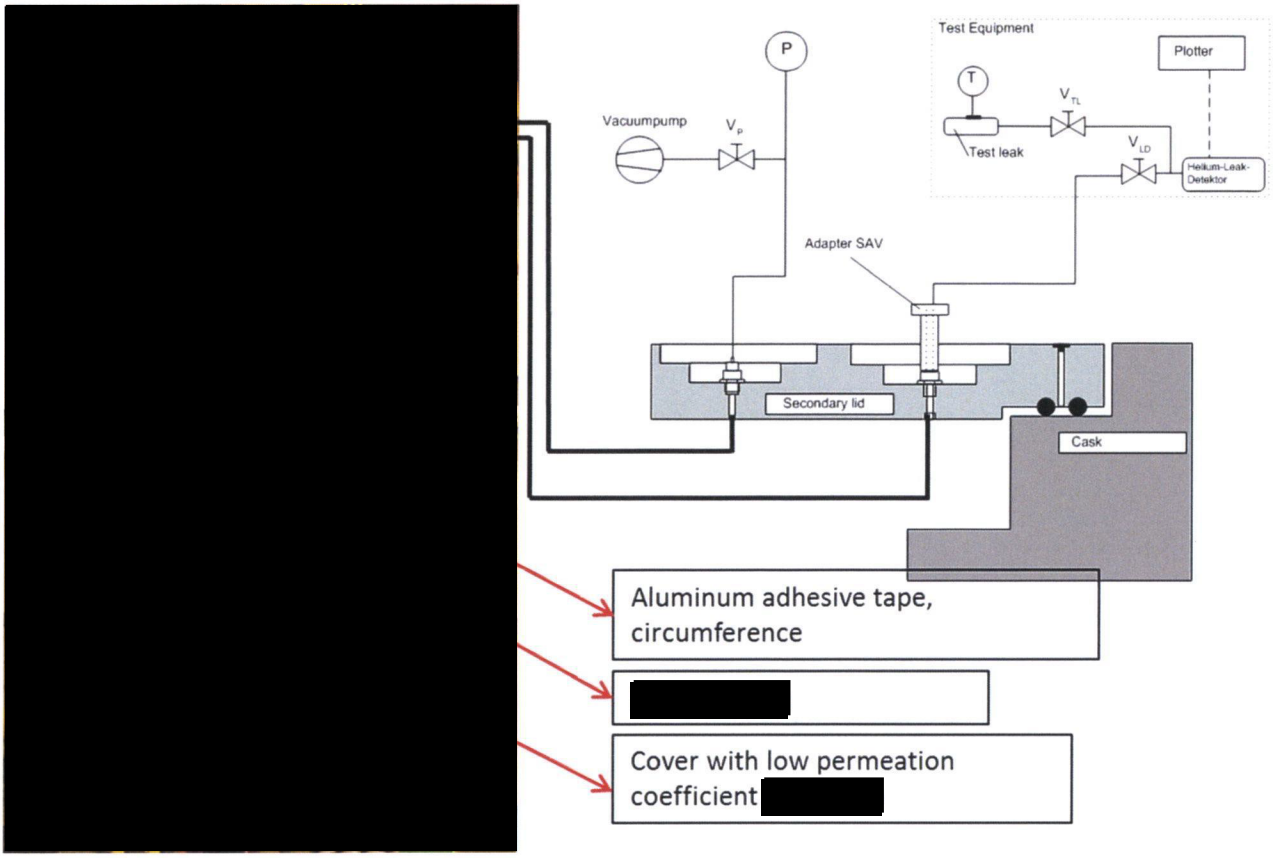

Fig. 3: Test arrangement for testing of the [redacted]

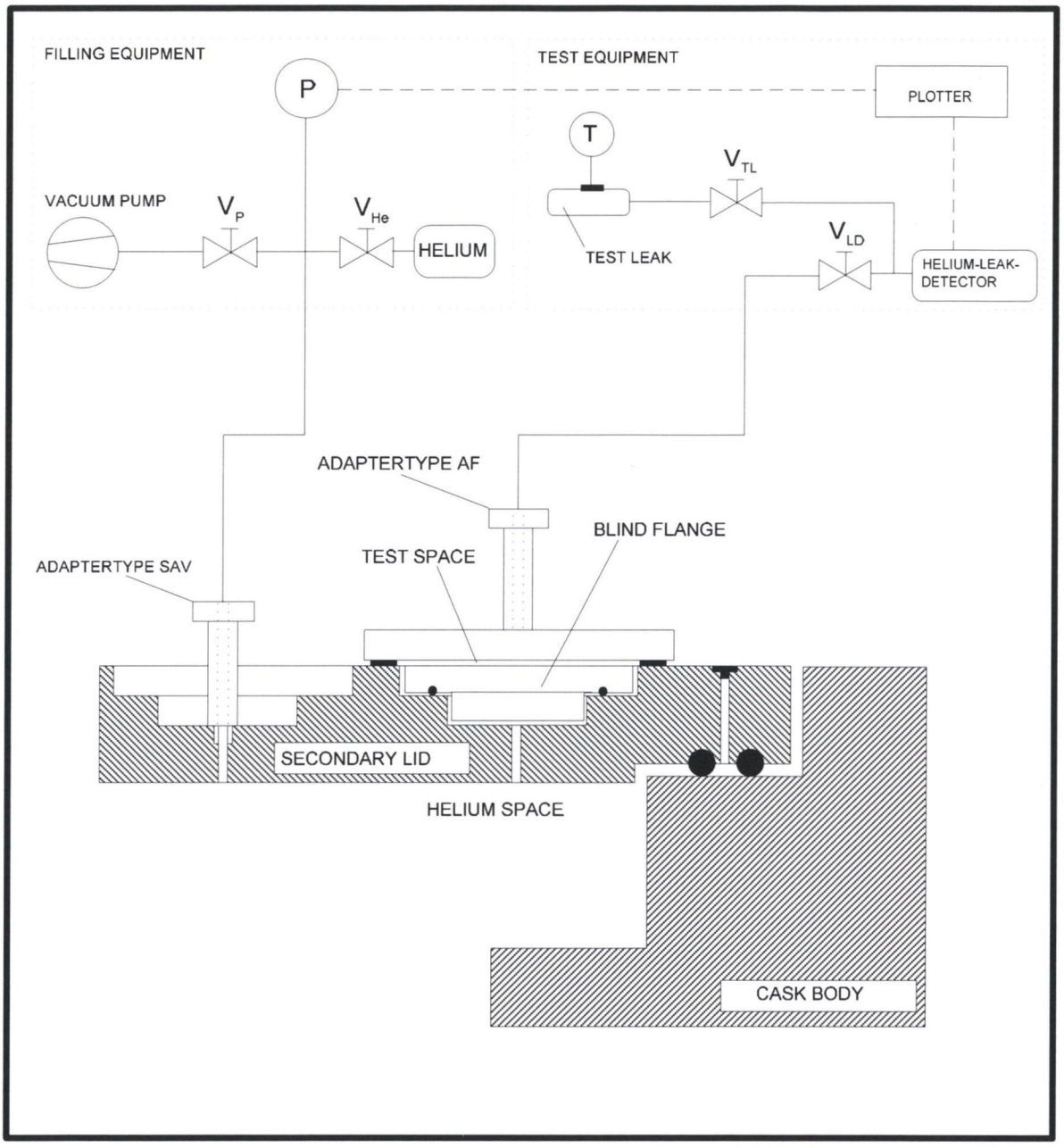

Fig. 4: Test arrangement for testing of the blind flange (Item 89)

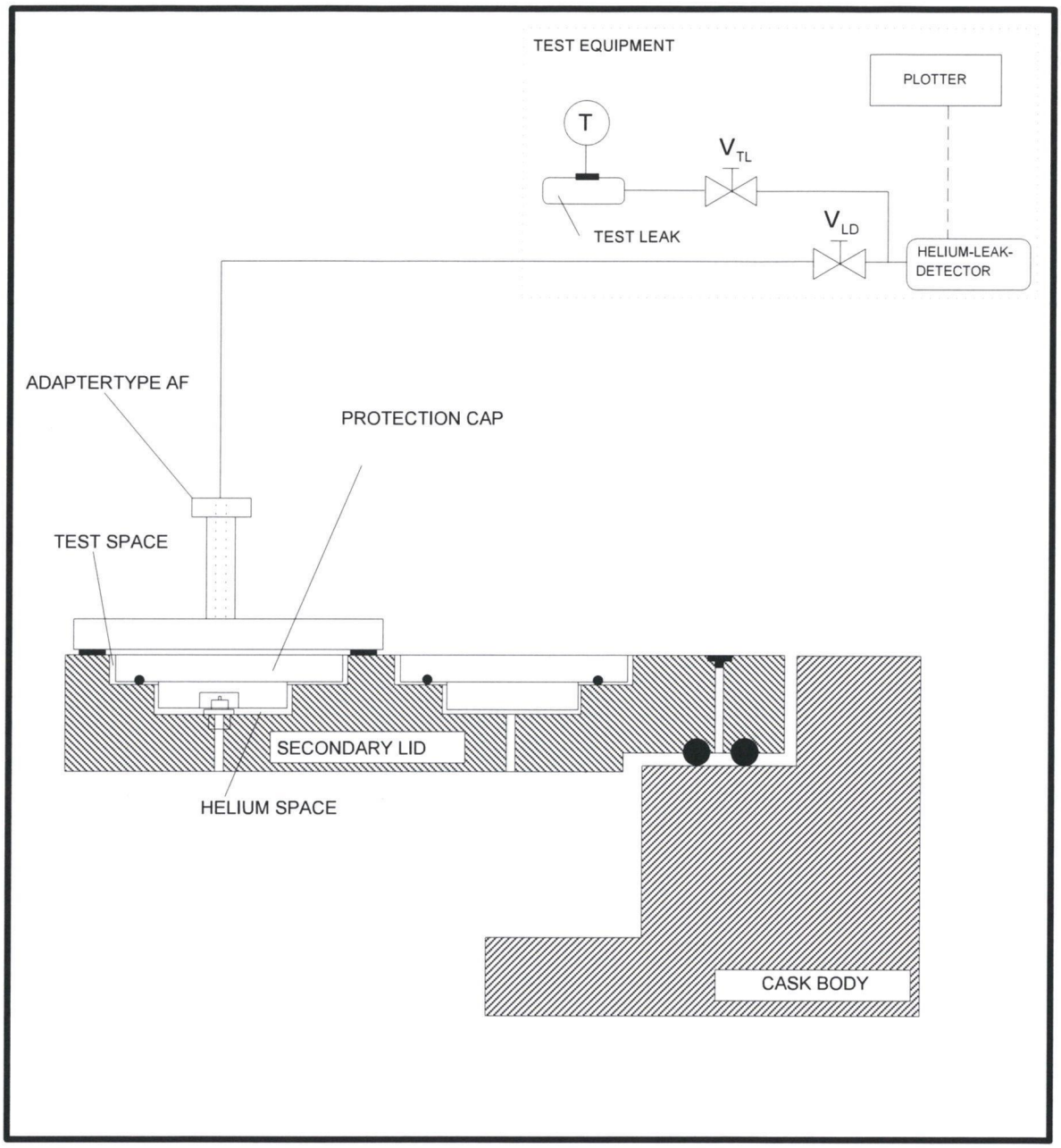

Fig. 5: Test arrangement for testing of the protection cap (Item 61)

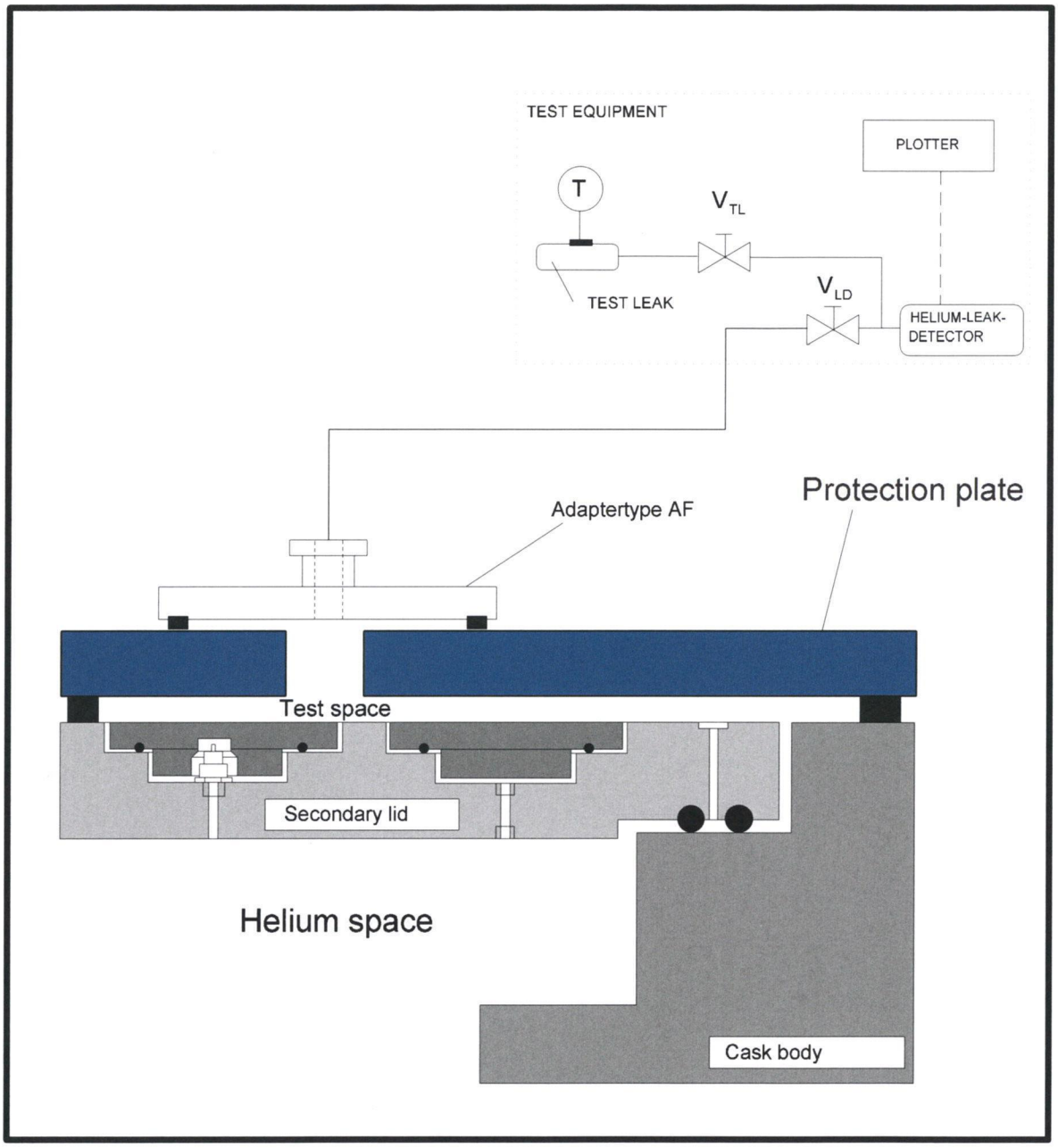

Fig. 6: Test arrangement for testing of the secondary lid (Item 55)

Non-Proprietary Version
Proprietary information withheld
per 10 CFR 2.390

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Record No.:_____ **Page:**____ **of:**___

Test Record Helium Leak Test

Type of Cask: _____ **Ident-No.:** _____

Test Procedure: _____ **Rev.**_____ **Drawing-No.:**_____ **Rev.**___

Leakproof barrier:	
Standard leakage rates determined and integral standard helium leakage rate: according to measurement record No.: _____ Page: ___ of: ___	
No. 1.	Component: _____ Item: _____ Q_{ST} = _____ **Pa·m³/s** Tester: _____ Qualification: _____ Test place: _____ Test date: _____
No. 2.	Component: _____ Item: _____ Q_{ST} = _____ **Pa·m³/s** Tester: _____ Qualification: _____ Test place: _____ Test date: _____
No. 3.	Component: _____ Item: _____ Q_{ST} = _____ **Pa·m³/s** Tester: _____ Qualification: _____ Test place: _____ Test date: _____
No. 4.	Component: _____ Item: _____ Q_{ST} = _____ **Pa·m³/s** Tester: _____ Qualification: _____ Test place: _____ Test date: _____
No. 5.	Component: _____ Item: _____ Q_{ST} = _____ **Pa·m³/s** Tester: _____ Qualification: _____ Test place: _____ Test date: _____
Target integral standard helium leakage rate: Q_{ZUL} = _____ **Pa·m³/s**	
Integral standard helium leakage rate ΣQ_{ST} = _____ **Pa·m³/s**	

Judgement: O Target fulfilled O Target not fulfilled

	Name	**Signature**	**Date**
Supervisor/Manufacturer's works expert			

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Record No.:_____ **Page:____ of:___**

Measurement Record Helium Leak Test

Type of Cask: _____ **Ident-No.:**

Test Procedure: _____ **Rev.**____ **Drawing-No.:**_____ **Rev.**

TEST LEAK DATA						
Test leak manufacturer / Type / No.:						
Nominal leakage rate:	Q_S =	Pa·m³/s				
Calibration temperature:	T_{REF} =	°C				
Temperature dependency:	ΔQ_1 =	%/°C				
Time dependency:	ΔQ_2 =	%/a				
Calibration date:						
Test No.:		1	2	3	4	5
TEST LEAK TEMPERATURE AND TIME DIFFERENCE						
T_{ACT}	°C					
Δt (time from calibration to test date)	a					
DETERMINATION OF CORRECTED NOMINAL LEAKAGE RATE OF TEST LEAK						
$\Delta T = T_{ACT} - T_{REF}$	°C					
Is $\Delta T > 0$ °C ?	YES/ NO					
If YES:						
$Q_{SK} = Q_S \cdot (1 + 0{,}01 \cdot \Delta Q_1)^{\Delta T_{1,2}}$	Pa·m³/s					
If NO :						
$Q_{SK} = Q_S$ [1])	Pa·m³/s					
ADJUSTMENT OF LEAK DETECTOR						
Q_{UG}	Pa·m³/s					
Q_{TL1}	Pa·m³/s					

1) Cross out non-applicable boxes!
2) Caution: numerical value equation: enter Q_S in Pa·m³/s, ΔQ_1 in %/°C and ΔT in °C!

Test place/plant/institution: **Test date:** **Time:**

	Qualification	Name	Signature	Date
Tester				
Supervisor/Manufacturer's works expert				

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Record No.:_____ **Page:**____ **of:**___

Measurement Record Helium Leak Test

Type of Cask: _____**Ident-No.:**
Test Procedure: _____**Rev.**_____ **Drawing-No.:**_____**Rev.**

EQUIPMENT DATA					
Pressure measuring instrument man. / Type / No.:					
Temp. measuring instrument man. / Type / No.:					
Helium leak detector man. / Type / No.					
AG % of DEW:					
Test No.	1	2	3	4	5
Item of the Component : Ident-No. :					
FILLING TYPE [1])					

1) Information only required for test objects without filling connection (e.g. under spray or PE pipe). For other test objects: cross out box!

Test place/plant/institution: **Test date:**

	Qualification	Name	Signature	Date
Tester				
Supervisor/Manufacturer's works expert				

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Record No.:_____ **Page:____ of:___**

Measurement Record Helium Leak Test

Type of Cask: _____Ident-No.:
Test Procedure: _____Rev.____ Drawing-No.:_____Rev.

CORRECTED BACKGROUND LEAKAGE RATE						
Test No.		**1**	**2**	**3**	**4**	**5**
p_1	hPa					
Q_U	Pa·m³/s					
Q_{TL2}	Pa·m³/s					
E_2 = $(Q_{TL2} - Q_U) / Q_{SK}$)						
Q_{UK} = Q_U / E_2	Pa·m³/s					
STANDARD HELIUM LEAKAGE RATE						
p_2	hPa					
p_{He} = $p_2 - p_1$	hPa					
Q_{He1}	Pa·m³/s					
Q_{TL3}	Pa·m³/s					
Q_{He2}	Pa·m³/s					
Q_{He} = $(Q_{He1} + Q_{He2}) / 2$	Pa·m³/s					
E_3 = $(Q_{TL3} - Q_{He}) / Q_{SK}$						
Q_{HeK} = Q_{He} / E_3	Pa·m³/s					
Q_L = $Q_{HeK} - Q_{UK}$	Pa·m³/s					
Q_{ST} = $Q_L \cdot 1013$ hPa / p_{He} *)	Pa·m³/s					
Test place:						
Test date:						
Tester:						

*) If Q_{ST} is ≤ 0 , then: $Q_{ST} \leq$ (decade final value referring to Q_{He2}) · AG · 1013 hPa / p_{He}

	Name	Signature	Date
Tester			
Supervisor			