ECE TYPE-APPROVAL CERTIFICATE

E24

Communication concerning[2] Approval granted
~~Approval extended~~
~~Approval refused~~
~~Approval withdrawn~~
~~Production definitively discontinued~~

of a type of compressed hydrogen storage system with regard to the safety-related performance of hydrogen-fuelled vehicles pursuant to Regulation No. 134

Approval No: ***E24*134R01/02*0018*00***

Reason for extension: ***- N/A***

1.	Trademark:	***Kolon Spaceworks Co., Ltd***
2.	Type and trade names:	***KSW052-HS01***
3.	Name and address of Manufacturer:	***Kolon Spaceworks Co., Ltd. 53, 1gongdan-ro, Gumi-si, Gyeongsangbuk-do Korea, 39347***
4.	If applicable, name and address of manufacturer's representative:	***N/A***
5.	Brief description of hydrogen storage system:	***54L Hydrogen Storage System See test report 24-00023-IS-MUC-00 and accompanying manufacturer's information document for details***
6.	Date of submission of hydrogen storage system for approval:	***05.01.2025***
7.	Technical Service performing the approval tests:	***TÜV SÜD Auto Service GmbH 10040 Mesa Rim Road San Diego, CA 92121 USA***
8.	Date of report issued by that service	***06.01.2025***
9.	Number of report issued by that service:	***24-00023-IS-MUC-00***

NSAI, 1 Swift Square, Northwood, Santry, Dublin 9, Ireland. Telephone: (+353+1) 807 3800, Facsimile: 01-807 3844

Approval No: ***E24*134R01/02*0018*00***

10.	Approval with regard to the safety-related performance of hydrogen-fuelled vehicles is granted/~~refused~~:[2]	***Granted***
11.	Place:	***Dublin***
12.	Date:	***07th March, 2025***
13.	Signature:	
14.	The information document annexed to this communication:	***BB2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01***
15.	Any remarks:	***N/A***

NSAI, 1 Swift Square, Northwood, Santry, Dublin 9, Ireland. Telephone: (+353+1) 807 3800, Facsimile: 01-807 3844

Approval No: ***E24*134R01/02*0018*00***

Index to the Information Package

Date of issue:	***03rd March, 2025***
Date of latest amendment:	***N/A***
Reason for extension/revision:	***N/A***

1. Additional conditions, and advisory notes on legal alternatives.

2. Test report(s)

- numbers(s):	***24-00023-IS-MUC-00***
- date of issue:	***06.01.2025***
- date of latest amendment:	***N/A***

3. Information document

- number(s):	***BB2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01***
- date of issue:	***06.01.2025***
- date of latest amendment:	***N/A***
Documentation:	***41 pages***

NSAI, 1 Swift Square, Northwood, Santry, Dublin 9, Ireland. Telephone: (+353+1) 807 3800, Facsimile: 01-807 3844

Approval No: ***E24*134R01/02*0018*00***

Appendix: **Additional conditions, and advisory notes on legal alternatives**

A: Additional conditions:

1. The attached technical report, with any of its attachments, forms part of this Type Approval certificate.
2. Each type from series production shall be to the measurements specified in the attached drawings, and shall be manufactured only from the materials specified in the Approval documents.
3. Changes in the type are permitted only with the explicit permission of NSAI. Breaches of this requirement will lead to a withdrawal of the Type Approval, and in addition may be subject to criminal prosecution.
4. At regular intervals, any tests or associated checks prescribed by the applicable legislation to verify continued conformity with the approved type shall be carried out. The manufacturer shall demonstrate compliance with this by submitting to NSAI evidence of adequate arrangements and documented control plans for each type approved.
5. Any set of samples or test pieces showing evidence of non-conformity shall give rise to further sampling and testing and all steps shall be taken to restore conformity of production.
6. This Type Approval will expire when it is surrendered by the holder, or withdrawn by NSAI, or when the approved type no longer conforms to legal requirements. The recall of the Type Approval can be issued by NSAI when the conditions required for the issuing or continuation of the Type Approval are no longer current, or when the Approval holder is in breach of the duties attached to the Type Approval, or when it is established that the approved type no longer meets the requirements of traffic safety.
7. Changes in the company name, address or manufacturing site, as well as in any of the sales or other agents specified in the issuing of the approval must immediately be notified to NSAI.
8. The duties imposed by the issuing of this certificate are not transferable. The legal protection of third parties is not affected by this certificate.
9. When the manufacture or sale of the system, component or separate technical unit has not been started within one year of the date of issue of this certificate, then NSAI is to be informed. This requirement also applies when the manufacture or sale has been halted for more than one year, or when it ought to have been halted for more than one year. The initial commencement of manufacture or sale, or the resumption of manufacture or sale, shall then be notified to NSAI within one month of commencement or resumption.

B: Legal Options:

Any objection to the requirements set out in this certificate shall be made within one month of the date of issue. The objection shall be made, in writing, to NSAI in Dublin.

NSAI, 1 Swift Square, Northwood, Santry, Dublin 9, Ireland. Telephone: (+353+1) 807 3800, Facsimile: 01-807 3844

TÜV SÜD Auto Service GmbH
10040 Mesa Rim Road
San Diego, CA 92121 USA

T E S T R E P O R T

24-00023-IS-MUC-00

About the Tests of a Cylinder for Hydrogen Storage of Type KSW052-HS01,
for Hydrogen-Powered Motor Vehicles

According to:

ECE-REGULATION No. 134

Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen fuelled vehicles (HFCV).

Revision 1 – Amendment 2

Supplement 2 to the 01 Series of amendments of the Regulation –
Date of entry into force: 5 January 2024.

Approval Status	
☑	Granting of a type approval no.
☐	Extension/correction to type approval no.

E24*134R01/02*0018*00

0 Reason of Extension:

N/A. This is an initial type approval.

I General and Description:

The following Specific Component was tested according to the requirements of Regulation ECE Regulation No. 134.

1.	H2 component / Storage System considered: ☒ Designed to use CGH ☐ Designed to use LH2	54L Hydrogen Storage System	
2.	Make:	Kolon Spaceworks Co., Ltd.	
3.	Type: Variant: Drawing:	KSW052-HS01 N/A 35910-05401 Rev.- (2022.11.16)	
4.	Location of type marking:	On the Hydrogen Storage Container Label	
5.	Name and address of the manufacturer:	Kolon Spaceworks Co., Ltd. 53, 1gongdan-ro, Gumi-si, Gyeongsangbuk-do Korea, 39347	
6.	Location and method of affixing of the ECE R134 mark:	Label sticker located under the glass fiber layer and readable	
7.	Name and address of the manufacturer's representative (if any):	N/A	
8.	Name and Address of Manufacturing plant:	Kolon Spaceworks Co., Ltd. 53, 1gongdan-ro, Gumi-si, Gyeongsangbuk-do Korea, 39347	
9.	Operating Conditions:	Nominal working pressure: Maximum allowable working pressure: Operating temperature: Capacity:	70,0 MPa @ 15°C 87,5 MPa -40°C to +85°C 54 litres
10.	Number of filling cycles / Service life:	11000 cycles / 15 years.	

II Information Folder:

This Test Report is based on the following information:

- Application for a type approval by Kolon Spaceworks Co., Ltd.
  (file: *VG2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01*)
- Declaration by the Manufacturer Kolon Spaceworks Co., Ltd.
  (file: *DO2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01_decl.by manuf*)
- Information Document acc. to ECE R-134, Annex I, Part I, Model I
  (file: *BB2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01*)
- Annex 1 to Test Report No.: 24-00023-IS-MUC-00 – Test Results
  (file: *PB2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01*)
- Drawing No. 35910-05401 Rev.- (2022.11.16) - 54L Hydrogen Storage System, and Drawing No. 35912-05401 Rev.- (2022.11.16) - 54L Hydrogen Tank
  (file: *DO2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01_dwgs*)
- Instruction Manual for the 54L Hydrogen Storage System,
  (file: *DO2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01_manual*).

III Test Samples, Performed Tests and Test Results:

The test samples, the performed tests, and the test results are described and summarized in Annex 1 – Test Results (file: *PB2025.01.06_Kolon Spaceworks_24-00023-IS-MUC-00_KSW052-HS01*).

IV Approval History:

	Type	Variant(s)	Content of Extension(s)	MAWP (MPa)	Temp (°C)	Report No. and Date
Initial approval / Hydrogen Storage System	KSW052-HS01	N/A	N/A	87,5	-40 to +85	Annex 1_24-00023-IS-MUC-00, 2025.01.06

V Statement of conformity:

The mentioned information folder and the type described therein are in accordance with the test basis mentioned above. The sampling plan or method resulted from the requirements of the test basis. The worst-case configuration was selected in accordance with process description "Requirements for Test Reports (AS-PB-T-02)". Valid decision rule in accordance with ILAC G8:2019, 4.2.1: in question of meeting the limits the measurement uncertainty was ignored.

The manufacturer is responsible for the information (II.) and the test specimens provided by him. The test results relate only to the test specimens as received and mentioned (III.). The test specimens are representative for the type described (II.).

The test report may be reproduced and published in full and by the client only. It can be reproduced partially with the written permission of the test laboratory only.

Test report no. 24-00023-IS-MUC-00 and the previous test report(s) issued by the Technical Service of TÜV SÜD Auto Service plus all documents and measurement results necessary for evaluation had been submitted. The above test reports continue to apply to the type of vehicle/vehicle component. This test report provides a summary of, and covers the full scope of, type testing, including the documentation of the vehicle/vehicle component.

Designated as Technical Service by:

Approval authority	**Country**	**Registration-number**
Kraftfahrt-Bundesamt (KBA)	Germany	KBA-P 00100-10
Vehicle Certification Agency (VCA)	United Kingdom	VCA-TS-006
Approval Authority of the Netherlands (RDW)	The Netherlands	RDWT-082-xx
National Standards Authority of Ireland (NSAI)	Ireland	Technical Service Number: 49
Vehicle Safety Certification Center (VSCC)	Taiwan	DE04-06-2
Société Nationale de Certification et d'Homologation s.a.	Luxembourg	13/B(g)
Swedisch Transport Agency (STA)	Sweden	TT 0024

San Diego, CA USA.
2025.01.06.

Technischer Dienst Technical Service TÜV SÜD Auto Service GmbH 179

André Frégeau
The Signatory.

Annexes:

- Annex 1 - Test Results
- Annex 2 – Information Folder (see chapter II).

TÜV SÜD Auto Service GmbH
10040 Mesa Rim Road
San Diego, CA 92121 USA

Applicant: Kolon Spaceworks Co., Ltd.

Subject of application / Type: 54L Hydrogen storage system / KSW052-HS01

Extension: N/A

Note: This 54L Hydrogen storage system included the testing of a container Type KHT052-700A from Kolon Spaceworks Co., Ltd. and (when applicable) a multifunctional component including a thermally-activated pressure relief device (Type HR-700PF, mounted on the valve, - E4*134R-010009), a check valve (Type HR-700PF, mounted on the valve, - E4*134R-010009), and an automatic shut-off valve (Type HR-700PF, mounted on the valve, - E4*134R-010009) from Youngdo Ind. Co., LTD.
The maximum defuel rate of 0,7 g/s of GH2 was established for this Hydrogen storage system by Kolon Spaceworks Co., Ltd., and tested under this test program.

Test Results:

Addendum 133 – ECE Reg. No. 134	Test Procedure	Requirement	Test Sample	Test Result	Test Laboratory	Remarks
5.1.1 Annex 3, Para. 2.1.	Baseline initial burst pressure	The containers shall be hydraulicly pressurized at 20 (±5)°C with ≤1,4 MPa/sec for pressures above 1,5*NWP (=105 MPa) until burst and have a burst pressure within ±10% of BP_0 and ≥ 2,25*NWP (=157,5 MPa) for carbon-fiber or ≥ 3,5*NWP (=245 MPa) for glass-fiber composite containers BPmin value for this model is 153,85 MPa BP_0 value for this model is 170,94 MPa	3 specimens KHT-2210-11 KHT-2210-14 KHT-2210-16	OK Burst pressures obtained: KHT-2210-11: 174 MPa KHT-2210-14: 170 MPa KHT-2210-16: 167 MPa Minimum burst value obtained is 167 MPa which is greater than BPmin of 153,85 MPa All cylinders burst within the ±10% of BP_0 of 170,94 MPa (153,85 MPa to 188,03 MPa)	Lab # 1628569	At hands.

Addendum 133 – ECE Reg. No. 134	Test Procedure	Requirement	Test Sample	Test Result	Test Laboratory	Remarks
5.1.2 Annex 3, Para. 2.2.	Baseline initial pressure cycle life	The containers shall be hydraulically pressure cycled at ≤ 10 cycles per minute and at 20 (±5)°C between 2 (±1) MPa and 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) without rupture for 22000 cycles or until a leak occurs. Leakage shall not occur until 11000 cycles for a 15-year service life	3 specimens KHT-2210-22 KHT-2210-23 KHT-2210-23	OK All cylinders completed 22000 pressure cycles without rupture of leakage	Lab # 1628569	At hands.
5.2 Annex 3, Para. 3.	Verification tests for performance durability (Hydraulic sequential tests)	The container(s) shall not leak during this sequence of tests. Use 1 specimen, if all three measurements of 5.1.2 are > 11000 cycles or all within 25% of each other, otherwise 3 specimens	1 specimen KHT-2210-18	OK The cylinder completed all test sequences without evidence of leakage	Lab # 1628569	At hands.
5.2.1 Annex 3, Para. 3.1.	Proof pressure test	The container is pressurized to 1,5*NWP (+2/-0 MPa) (=105 +2/-0 MPa) with a non-corrosive fluid and held for > 30 sec	See 5.2 above	OK The cylinder held pressure at 105 MPa for > 30 sec. without evidence of leakage	Lab # 1628569	At hands.

Addendum 133 – ECE Reg. No. 134	Test Procedure	Requirement	Test Sample	Test Result	Test Laboratory	Remarks
5.2.2 Annex 3, Para. 3.2.	Drop test (unpressurized)	The container is dropped: • horizontal position with bottom 1,8 m above the surface • vertical position, ported end upward with a potential energy of > 488 J, with hight of lower end ≤ 1,8 m • vertical position, ported end downward with a potential energy of > 488 J, with hight of lower end ≤ 1,8 m • at a 45° angle from vertical position, ported end downward, with hight of the center of gravity = 1,8 m. Angle might be changed to ensure a hight of lower end ≤ 0,6 m	See 5.2 above	OK The cylinder was dropped on all angles as required No major damage was observed	Lab # 1628569	At hands.
5.2.3 Annex 3, Para. 3.3.	Surface damage test (unpressurized)	a) Two longitudinal saw cuts along the bottom surface of the cylindrical zone close to, but not in the shoulder area. One 1,25 mm deep and 25 mm long toward the valve end and the second 0,75 mm deep and 200 mm long toward the opposite end. b) Five impacts on the upper surface with a distance of >100 mm to each other after 12 h at -40°C using a pendulum having a pyramid with rounded edges (3 mm) and an impact energy of 30 J	See 5.2 above	OK Surface damages comprising of two flaw cuts and, after conditioning, five impacts were applied on the cylinder as required	Lab # 1628569	At hands.

Addendum 133 – ECE Reg. No. 134	Test Procedure	Requirement	Test Sample	Test Result	Test Laboratory	Remarks
5.2.4 Annex 3, Para. 3.4.	Chemical exposure (unpressurized) and ambient-temperature pressure cycling test	The 5 preconditioned (pendulum impact) areas are covered with glass wool pads and each of them is wetted with one of the following solutions: • 19 vol.% sulphuric acid in water • 25 vol.% sodium hydroxide in water • 5 vol.% methanol in gasoline • 28 wt.% ammonium nitrate in water • 50 vol.% methyl alcohol in water The container is held at 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) for 48 h at 20 (±5)°C. Pressure cycling is performed between 2 (±1) MPa and 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) at 20 (±5)°C for 0,6*11000 (=6600) cycles. After removing the pads and rinsing the surface with water, the last 10 cycles of the previous 6600 cycles are performed to 1,5*NWP (+2/-0 MPa) (=105 +2/-0 MPa) at 20 (±5)°C	See 5.2 above	OK The various chemicals were applied and the cylinder was pressurized to a total of 6600 cycles as required. 6590 cycles were performed to 87,5 MPa and 10 cycles performed to 105 MPa at 20 (±5)°C No leakage was observed	Lab # 1628569	At hands.

Addendum 133 – ECE Reg. No. 134	Test Procedure	Requirement	Test Sample	Test Result	Test Laboratory	Remarks
5.2.5 Annex 3, Para. 3.5.	High temperature static pressure test	The container is pressurized to 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) at ≥ 85 (±5)°C for ≥ 1000 h	See 5.2 above	OK The cylinder was pressurized to 87,5 MPa at 85°C for ≥ 1000 h No leakage was observed	Lab # 1628569	At hands.
5.2.6	Extreme temperature pressure cycling	The container is pressure cycled between 2 (±1) MPa and 0,8*NWP (+2/-0 MPa) (=56 +2/-0 MPa) at ≤ -40°C for 0,2*11000 (=2200) cycles and to 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) at ≥ 85°C and 95 (±2)% relative humidity for 0,2*11000 (=2200) cycles	See 5.2 above	OK The cylinder was pressure cycled to 56 MPa at -40°C for 2200 cycles and then to 87,5 MPa at 85°C for 2200 cycles No leakage was observed	Lab # 1628569	At hands.
5.2.7 Annex 3, Para. 3.1.	Hydraulic residual pressure test	The container is pressurized to 1,8*NWP (+2/-0 MPa) (=126 +2/-0 MPa) for ≥ 4 min without burst	See 5.2 above	OK The cylinder was pressurized to 126 MPa for 4 minutes No leakage or rupture was observed	Lab # 1628569	At hands.
5.2.8 Annex 3, Para. 2.1.	Residual burst strength test	The container undergoes a hydraulic burst test to verify that the burst pressure is ≥ 0,8*BP_O (≥136,75 MPa)	See 5.2 above	OK The cylinder burst at 155,5 MPa which is greater than 136,75 MPa	Lab # 1628569	At hands.

Addendum 133 – ECE Reg. No. 134	Test Procedure	Requirement	Test Sample	Test Result	Test Laboratory	Remarks
5.3 Annex 3	Verification test for expected on-road performance	The hydrogen storage system shall not leak during this sequence of tests	1 specimen KHT-2210-26	OK The cylinder completed all test sequences without evidence of leakage	Lab # 2031579	At hands.
5.3.1 Annex 3, Para. 3.1.	Proof pressure test	The cylinder is pressurized to 1,5*NWP (+2/-0 MPa) (=105 +2/-0 MPa) with a non-corrosive fluid and held for > 30 sec.	See 5.3 above	OK The cylinder held pressure without evidence of leakage for > 30 sec	Kolon Spaceworks Co., Ltd	At hands.

5.3.2 Annex 3, Para. 4.1.	Ambient and extreme temperature gas pressure cycling test	The system is pressure cycled as follows: a) 250 cycles before first Extreme temperature static pressure test (5.3.3): • 25 cycles to 0,8*NWP (+2/-0 MPa) (=56 +2/-0 MPa) at ≤ -40°C • 25 cycles to 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) at ≥ 50°C and 95 (± 2)% relative humidity • 200 cycles to 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) at 20 (±5)°C b) 250 cycles after first Extreme temperature static pressure test (5.3.3): • 25 cycles to 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) at ≥ 50°C and 95 (±2)% relative humidity • 25 cycles to 0,8*NWP (+2/-0 MPa) (=56 +2/-0 MPa) at ≤ -40°C • 200 cycles to 1,25*NWP (+2/-0 MPa) (=87,5 +2/-0 MPa) at 20 (±5)°C c) The hydrogen gas fuel temperature is ≤ -40°C d) During the first 250 cycles: • 5 cycles with fuel temperature 20 (±5)°C after temperature equilibration of the system at -40°C • 5 cycles with fuel temperature ≤ -40°C	See 5.3 above	OK All 250 pressure cycles for each paragraph a) and b) were completed at required temperature and humidity. A total of 500 cycles were performed (2 groups of 250 cycles) The performed defuelling rate was based on the manufacturer's specifications of 0,7 g/s No leakage was observed	Lab # 2031579	At hands.

Addendum 133 – ECE Reg. No. 134	Test Procedure	Requirement	Test Sample	Test Result	Test Laboratory	Remarks
		• 5 cycles with fuel temperature ≤ -40°C after temperature equilibration of the system at ≥ 50°C and 95 (±2)% relative humidity e) 50 cycles using a de-fuelling rate ≥ the maintenance de-fuelling rate				
5.3.3 Annex 3, Para. 4.2/4.3	Extreme temperature static pressure leak/permeation test	a) Test is performed after each group of 250 cycles (5.3.2.) b) Pneumatic gas permeation test at 1,15*NWP (+2/-0 MPa) (=80,5 +2/-0 MPa) at ≥ 55°C (≈NWP at 15°C) until steady state permeation or 30 hr. Maximum allowable discharge rate is 46 ml/hr/l water capacity. c) If permestion rate is ≥ 0,005 mg/s, a localized leak check is performed to ensure no point of localized external leakage is > 0,005 mg/s	See 5.3 above	OK No leakage was observed during all 500 pressure cycles (2 groups of 250 pressure cycles) The permeation rate after the first group of 250 cycles was determined to be 2,20 Nml/hr/l after a steady state of 195 hours The permeation rate after the second group of 250 cycles was determined to be 1,85 Nml/hr/l after a steady state of 115 hours No permeation rate was ≥ 0,005 mg/s (3,6 Nml/min). Therefore, the localized leak testing was not performed/required	Lab # 2031579	At hands.

Addendum 133 – ECE Reg. No. 134	Test Procedure	Requirement	Test Sample	Test Result	Test Laboratory	Remarks
5.3.4 Annex 3, Para. 3.1	Residual proof pressure test	The container is pressurized to 1,8*NWP (+2/0 MPa) (=126 +2/-0 MPa) for ≥ 4 min without burst	See 5.3 above	OK The cylinder was pressurized to 126 MPa for 4 minutes No leakage or rupture was observed	Lab # 2031579	At hands.
5.3.5 Annex 3, Para. 2.1	Residual strength burst test (hydraulic)	The container undergoes a hydraulic burst test to verify that the burst pressure is ≥ 0,8*BP_O (≥136,72 MPa). BP_O value is 170,9 MPa	See 5.3 above	The cylinder burst at 167,7 MPa which is greater than 136,72 MPa minimum requirement	Lab # 2031579	At hands.

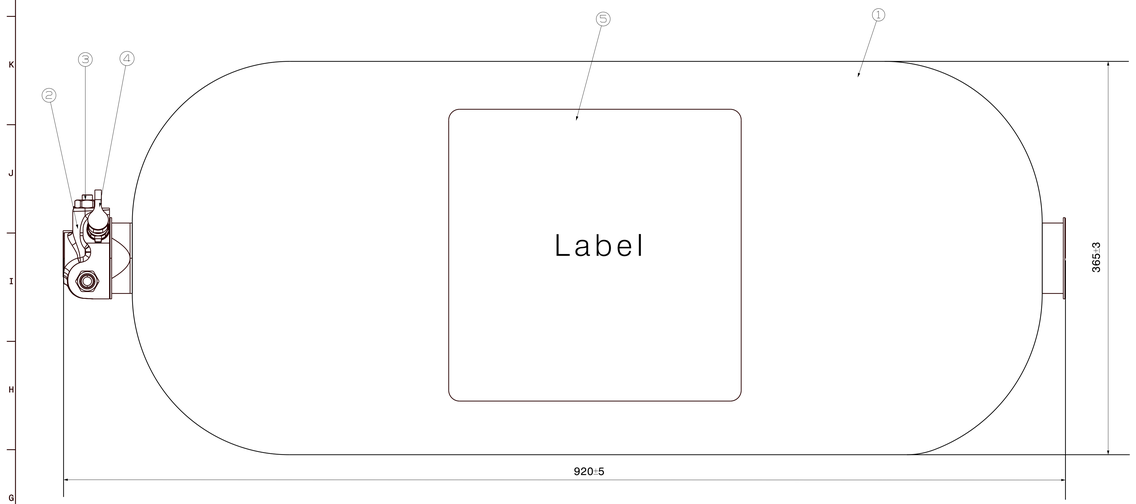
5.4 Annex 3, Para. 5.1	Verification test for service terminating performance in fire	The container assembly is positionned 100 mm above a fire source at NWP (+2/-0 MPa) (=70 +2/-0 MPa). A temperature-activated pressure relief device (TPRD) shall release the contained gas in a controlled manner without rupture of the cylinder The manufacturer selected Method 1; qualifying for a generic vehicle A localized followed by an engulfed fire must be achieved For the localized portion, the fire must reach 300°C and 600°C respectively within the 1st and 3rd minute. The 600°C should be maintained until the 10th minute without exceeding 900°C For the engulfing portion, the fire temperature must reach a minimum of 800°C within 2 minutes (between the 10th and 12th minute mark of the test) The maximum temperature during the engulfing portion of the test shall not exceed 1100°C	1 specimen KHT-2210-26	The cylinder was fire-tested with hydrogen gas at 70 MPa The localized portion reached 300°C and 600°C, respectively before the 1st and 3rd minute of the localized fire. The fire temperature did not exceed 900°C during the initial 10 minutes. The fire temperature did not exceed 1100°C during the engulfing portion of the fire test. The TPRD activated during the engulfing portion of the fire test after 00:11:20. The TPRD activation pressure was 77,3 MPa The rolling average temperature at the 3rd minute within the localized fire portion was 786°C. The rolling average temperature at the 10th minute within the localized fire portion was 771°C. The rolling average temperature at the 11th minute during the engulfing fire portion was 861°C. The rolling average temperature at the time of venting during the engulfing fire portion was 843°C. The rolling averages temperature requirement was met throughout the localized and engulfing fire test The complete cylinder vented the hydrogen gas content, without interruption, via the TPRD in a controlled manner and without rupture	Lab # 1628569	At hands.

The measurement uncertainties were considered according to the test basis and the Process Description of TÜV SÜD Auto Service “AS-AM-PB-CRC-006”.

The technical expert confirms that the tests have been performed as required by ECE/TRANS/WP.29/2014/78 and have yielded the results as described above.

The Technical Expert
André Frégeau.
2025.01.06

Technischer Dienst Technical Service TÜV SÜD Auto Service GmbH 179



PLAN HISTORY					
REV.	DATE	DESCROPTION	DWN	CHK	APP'D
-	22.11.16	NEW DRAWING	S.H.CHOI	I.H. PARK	H.J. KIM

1. SPECIFICATIONS

* Fuel Storage System Type : 54L Hydrogen Storage System
* Gas Type : Compressed Hydrogen Gas (CHG)
* Function : Storage and Supply Compressed Hydrogen Gas for Vehicle
* Water Capecity : 54 ± 2.0 L
* Weight : 38.4 ± 1.5 kg
* Nominal Working Pressure : 70.0MPa @ 15°C
* Max. Fueling Pressure : 87.5MPa @ 85°C
* Min. Working Pressure : 2.0 MPa
* Temperature Range : -40 ~ 85°C

2. NOTE

* Mounting Type : Belly Mounting

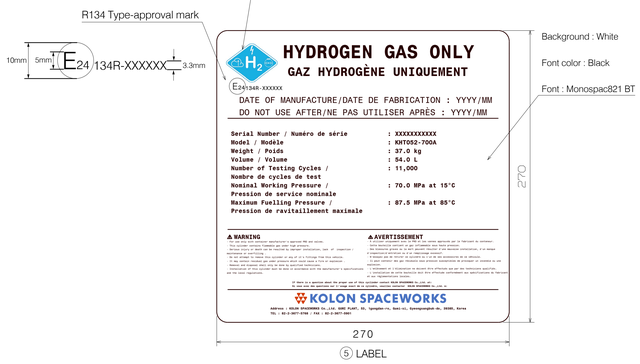
3. Certification Hydrogen Storage System : KSW052-HS01

* Components

ITEM	Hydrogen Tank	VALVE / SOLENOID	TPRD
ECE R134	E24 134R-XXXXXX	E4 134R-010008	E4 134R-010009

1. Colors
   Background : Light-blue, RGB code 0. 176.240
   Border : White

2. Dimesion of label
   Width : 50 mm
   Height : 37mm



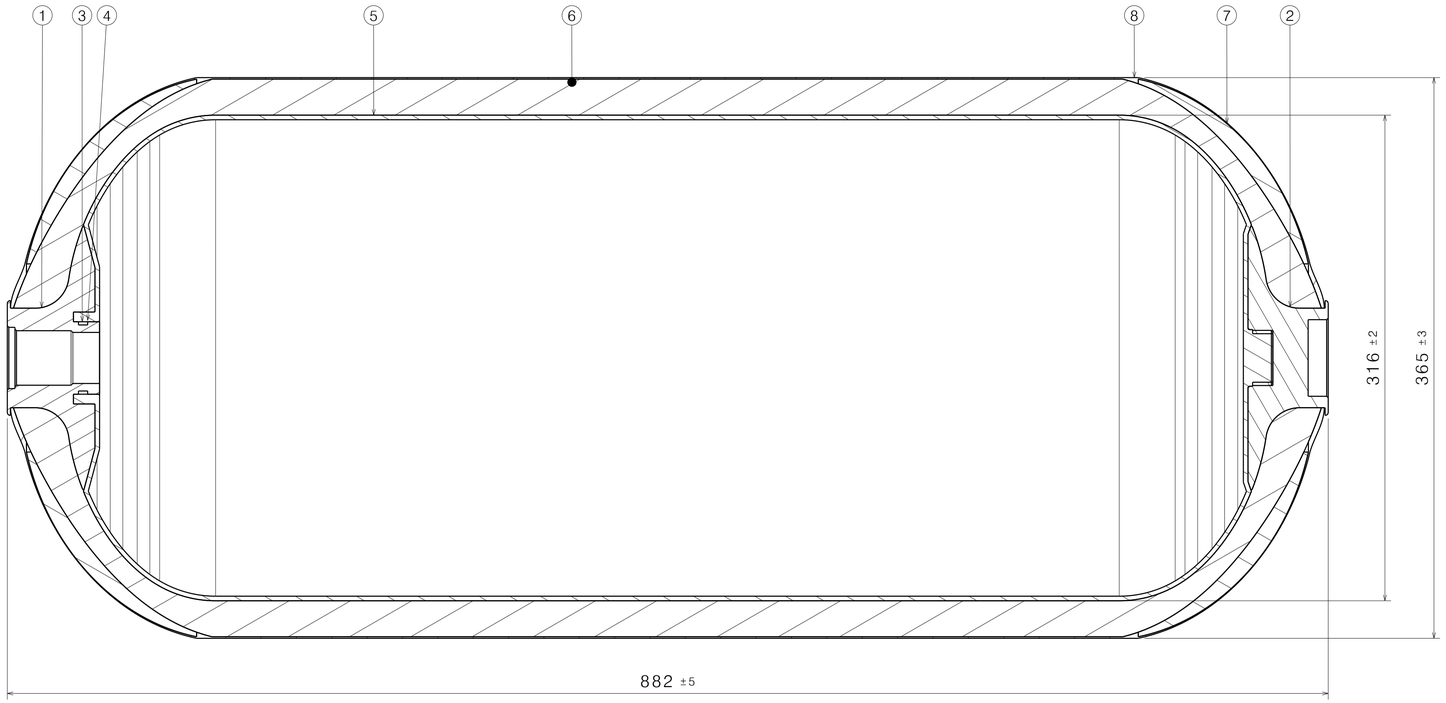
NO.	Part Name	Material	Supplier
⑤	Main Label	PVC	-
④	TPRD	-	YOUNGDO
③	Solenoid	-	YOUNGDO
②	VALVE	-	YOUNGDO
①	54L Hydrogen Tank	-	KOLON SPACEWORKS

Volume[L] 54 ± 2.0	Weight[kg] 38.4 ± 1.5	Name / Date	Drawn S.H. CHOI 22.11.01	Checked I.H. PARK 22.11.02 / Approved H.J. KIM 22.11.02
		Scale 1:2	Size A1	Date 2022.11.02
The copying distribution and utilization of this document as well as the communication of its contents to others without expressed authorization is prohibited. Offenders will be held liable for payment of damages. All rights reserved in the event of the grant of patent, utility model or ornamental design registration.		Title 54L Hydrogen Storage System		Grade --
KOLON		Project -		
		Owner KOLON SPACEWORKS Co.,Ltd.		
		Drawing No. 35910-05401	Ref. Drawing No. -	Sheet No 1/1

Format: A1

E24*134R01/02*0018*00

PLAN HISTORY						
REV.	E.O. Number	DATE	DESCROPTION	DWN	CHK	APP'D
-	KHT22 001	22.11.16	NEW DRAWING	S.H.CHOI	I.H. PARK	H.J. KIM

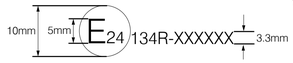


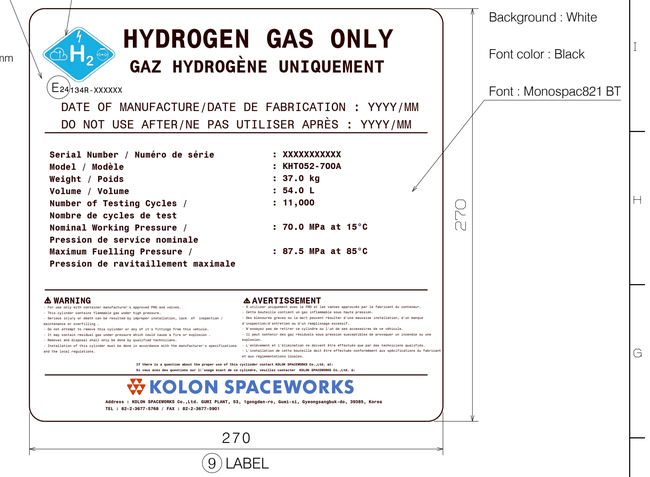
Section view A-A

1. Colors
   Background : Light-blue, RGB code 0. 176.240
   Border : White

2. Dimesion of label
   Width : 50 mm
   Height : 37mm

R134 Type-approval mark





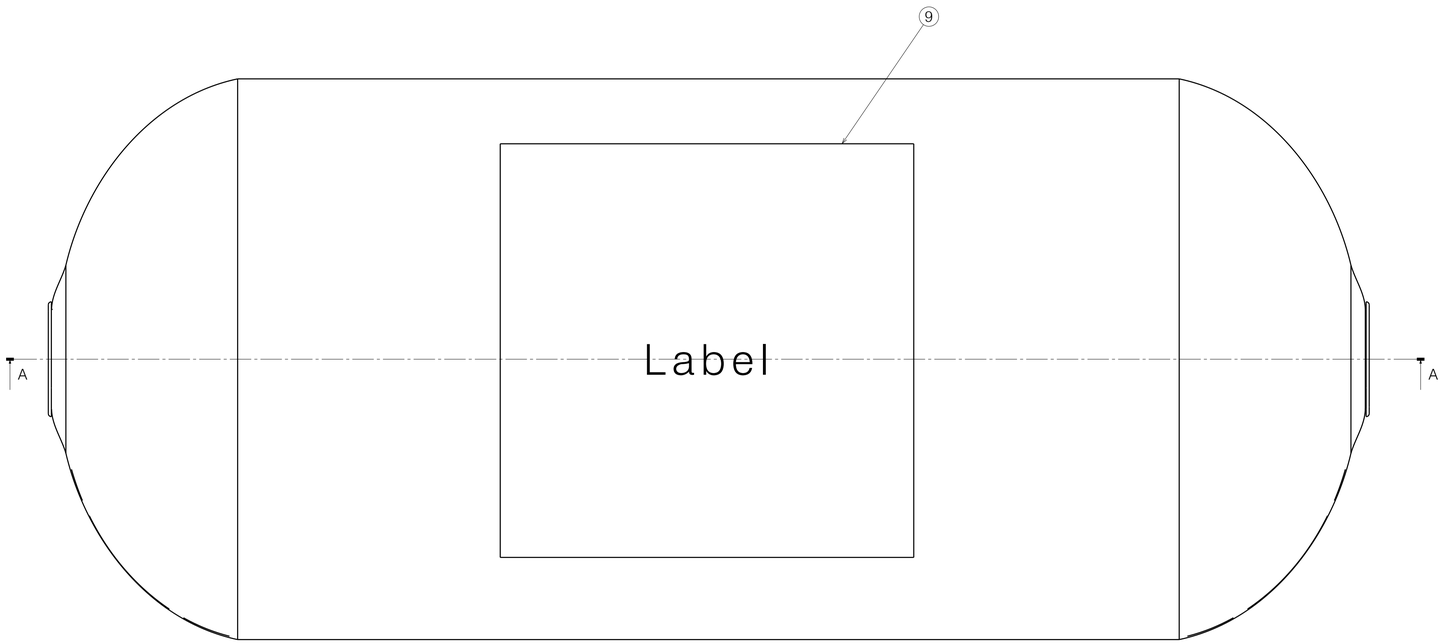
Background : White

Font color : Black

Font : Monospac821 BT

⑨ LABEL

Container Basic Specifications(Note)
1. Container Type : KHT052-700A
2. Gas Type : Hydrogen
3. Weight : 37.0 ± 1.5 kg
4. Volume : 54L ± 2.0 L
5. Norminal Working Pressure : 70.0MPa at 15°C
6. Maximum Fuelling Pressure : 87.5MPa at 85°C
7. Proof Pressure test : 105MPa
8. Minimum burst pressure : 157.5MPa
9. Number of cycles : 11,000
10. Fix Label(⑨) under GFRP



Front view

NO	Q'TY	PART NAME	MATERIAL	MATERIAL SUPPLIER	REMARK
⑨	1	LABEL	PVC	3M	
⑧	1	GFRP	KGIGP-0002	Toray & Kolon Industries	
⑦	2	Dome Proector	Polyurethane	Ace Chemical	
⑥	1	CFRP	KGITP-0002	Toray & Kolon Industries	
⑤	1	LINER	Polyamid(PA6)	KPL	
④	2	BACK UP RING	PEEK-450G	Pyung Hwa Oilseal	
③	1	O-RING	EPDM 9614	Pyung Hwa Oilseal	
②	1	KNOB	AL 6061-T6	Smart Tech	
①	1	BOSS	AL 6061-T6	Smart Tech	

Volume[L]	Weight[kg]	Name / Date	Drawn	Checked	Approved
54 ± 2.0	37 ±1.5		S.H.Choi 2022.11.14	I.H. PARK 2022.11.15	H.J. KIM 2022.11.16

Scale	Size	Date
1:2	A1	2022. 11. 16

Title	Grade
54L HYDROGEN TANK	--

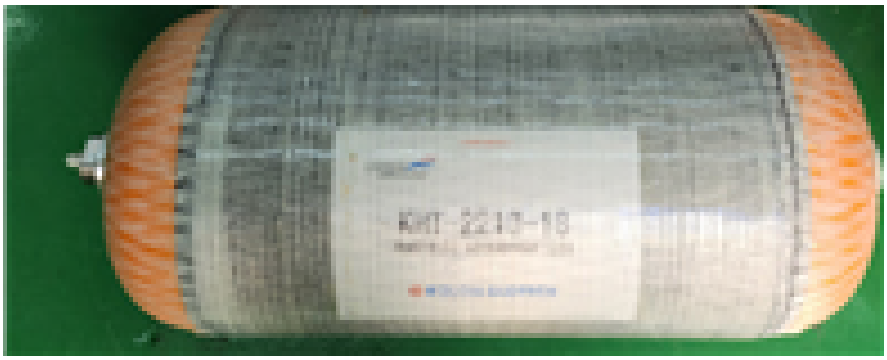
Project	
HYDROGEN TANK	
Owner	
KOLON SPACEWORKS Co.,Ltd.	

Drawing No.	Ref. Drawing No.	Sheet No.
35912-05401	-	1/1

Format: A1

E24*134R01/02*0018*00

KOLON SPACEWORKS



54L HYDROGEN STORAGE SYSTEM INSTALLATION AND MAINTENANCE MANUAL

E24*134R01/02*0018*00

Revision History

No	Date	Revision	Check	Review	Approval
0	13.10.2022	RELEASED	SH CHOI	IH PARK	HJ KIM

Foreword

This User Guide provides the information for the Kolon Type 4 composite hydrogen cylinder manufactured by Kolon spaceworks. and contains instructions for end user installation, maintenance, and self inspection of the cylinder in its installed environment. A thorough and complete understanding of the information contained in this publication is required for the continued safe use of this product. Read this manual in its entirety and keep it for future reference.

The hydrogen cylinder should only be installed by qualified personnel who have read this guide from cover to cover. Individual operator training is the responsibility of the company, firm, or organization performing the installation.

This manual contains Notices, Cautions, and Warnings that must be observed at all times to reduce the risk of personal injury during installation or maintenance. Improper installation or maintenance procedures may damage the cylinder or make the cylinder unsafe to operate. These Notices, Cautions and Warnings are not all inclusive. Kolon cannot possibly warn of all the potentially hazardous consequences caused by a failure to follow these instructions.

If you need further information or have any questions, please contact:

Kolon Spaceworks

53, 1Gongdan-ro, Gumi-si, Gyeongsangbuk-do, 39347, Korea

Tel. 054-468-8261

Fax. 054-461-7297

www.kolonspaceworks.com

How to Use This Publication

This publication contains information specific to the hydrogen cylinder. It does not explain everything you need to know about your vehicle installation. You must use this supplement along with the information provided by the equipment manufacturer(s) for the remainder of the components used, and regulatory requirements applicable to your use. Only then will you be able to properly install and maintain your cylinder.

Please read this supplement from beginning to end when you first receive your product. If you do this, it will help you learn about the special features. In this supplement, you will find that words and pictures work together to make things easy to understand.

Table Of Contents

KOLON SPACEWORKS

DEFINITIONS

Below are a few terms you should be familiar with when reading this manual.

Abrasion damage: Damage to a container caused by wearing, grinding, or rubbing away of the container material by friction.

Carbon fiber: Type of reinforcement fiber used in composite overwrap.

Composite: Structural material composed of load bearing fibers embedded in a protective resin matrix.

Crazing: Hairline cracking of the resin giving it an opaque "frosty" appearance.

Cut damage: Damage caused by a sharp object coming in contact with a composite surface.

External/exterior coating: Clear or colored surface treatment applied to the container for environmental protection and improved appearance.

Foam Dome: Protective impact absorbing component installed on each end of the hydrogen cylinder to protect the cylinder from handling and in use impact damage.

Helical wrap: Layers in the composite overwrap filament wound to provide primarily longitudinal strength and some hoop strength for the cylindrical region of the container.

NOTE-The strands of reinforcing fibers are oriented at an angle to the longitudinal axis of the container.

Hoop wrap: Reinforcement by a composite material applied in a substantially circumferential pattern over the cylindrical portion of the liner so that the filament does not transmit any significant stresses in a direction parallel to the container longitudinal axis.

Impact damage: Damage caused by dropping or by a blow from another object.

NOTE-Impact damage can be at the surface, internal to the structure, or both.

Inspection mark: Mark, label, or tag placed by an inspector on the container indicating acceptance of the container.

NOTE-The mark shall at least identify the inspecting agency and the date of inspection (month and year)

Liner: Internal component of the container that prevents leakage of gas through the composite container structure.

Over pressurization: Pressures exceeding those allowed during filling procedures specified in the standards referenced in this document.

Permeation: Penetration of a small amount of gas through the cylinder wall.

Pressure Relief Device (PRD): Device installed in the container or integrated with a valve that will release the contained gas in specific emergency conditions.

Resin: Plastic material in the composite overwrap that fills the space between individual reinforcing fibers.

Scuff: Minor abrasion damage to the protective coating, paint, or resin-rich composite surface.

Service pressure: Authorized pressure marking indicated on the cylinder labeling.

Valve, manual: Device installed in one of the ports of the container used to regulate gas flow into and out of the container, which is turned on and off manually with a handle.

Valve, solenoid: Device installed in one of the ports of the container used to regulate gas flow into and out of the container, which is turned on and off electronically.

Vent line: High pressure line used to conduct gas from a PRD to a location away from the cylinder or outside the vehicle.

APPLICABLE DESIGN, CERTIFICATION, AND INSPECTION STANDARDS

Kolon hydrogen cylinders are designed to meet the following standards:

- NGV2 (Latest revision) – "American National Standard for Compressed Natural Gas

Vehicle Fuel Containers".

- CSA B51 (Latest revision) – Canadian Standards Association (CSA) "Boiler, Pressure Vessel and Pressure Piping Code", "Part 2, High pressure cylinders for the on-board storage of natural gas and hydrogen as fuels for automotive vehicles".

Kolon hydrogen cylinders may be designed, tested and manufactured to meet additional and/or different standards when required by customer requirements and specifications.

This document guides an installer through the basic steps for safely installing the Kolon hydrogen cylinder onboard a hydrogen -powered vehicle and provides important instruction for safe use and maintenance. Installation will vary according to the use or application of the hydrogen cylinder. The installer must ultimately ensure all local, state and federal regulations were followed when installing the hydrogen cylinder.

RECEIVING INSPECTION

Inspect all shipments for damage at time of receipt in the presence of carrier. If damage is suspected due to shipping package appearance, do not unpack product. Immediately notify your freight carrier and Kolon of the damage. Document condition concerns with photographs, if possible. Note condition on receiving document(s) and obtain driver's signature.
Contact Kolon for assistance in evaluating the damage and possible return of the damaged product.

CYLINDER HANDLING INSTRUCTIONS

Anytime the fuel cylinder(s) are not in the vehicle, store it in a dry and safe location that prevents damage from vehicles or other shop equipment. Protect all open ports and fittings with the appropriate plugs or caps in place. Do not store the fuel cylinders in direct sunlight or in close proximity to a heat source or open flame.

Following a few simple safety precautions will prevent injuries resulting from the use of a damaged cylinder:

CAUTION: Failure to follow these precautions may cause damage to the cylinder assembly resulting in serious injury or death.

MANUFACTURER'S CYLINDER LABEL

The label is wrapped around the cylinder's circumference and contains the following information:

a). Serial Number

b). Model

c). Weight

d). Volume

e). Number of Testing Cycles

f). Nominal Working Pressure

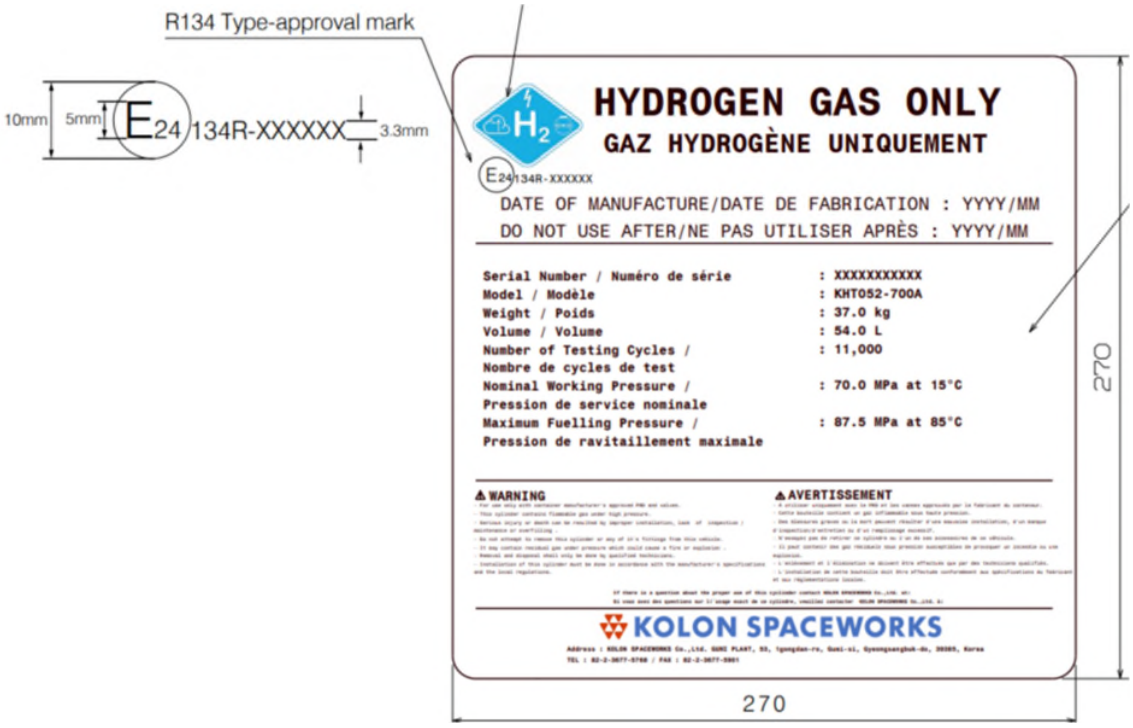
g). Maximum Fuelling Pressure

h). Date of manufacture (YYYY/MM)

i). Do not use after (YYYY/MM)

j). Kolon Contact information

k). The statement "For use only with the manufacturer's approved pressure relief devices and valves"



FILLING PROCEDURES FOR CYLINDERS

There are no filling restrictions in hot or cold weather, and there are no requirements for pre-heating the cylinders or pre-conditioning the gas. When slow filling (filling operations greater than 1 hour duration), the tank must be filled to the rated service pressure indicated on the container label. For fast filling procedures of shorter duration, the fast fill pressure can be up to 125% of the rated service pressure in order to obtain the rated service pressure corrected to 70F once the gas cools and settles.

VENTING PROCEDURES FOR FUEL CYLINDERS

Cylinders may be depressurized or vented only by qualified technicians. The technician is responsible to ensure the cylinders are handled safely, that all procedures are followed, and that all local, state, and Federal fire and environmental codes are known and followed prior to venting. The technician(s) must also refer to the vehicle manufacturer's instructions regarding the discharge of hydrogen from the fuel system.

CYLINDER INSPECTION

hydrogen fuel tanks must be inspected for damage at the following intervals:

(1) Upon installation on the vehicle

(2) Every 36 months or 36,000 miles of service, whichever comes first.

(3) After any incident which potentially damaged the cylinders (such as impacts, collisions, fire, accident, exposure to corrosive agents, or similar events)

(4) When there is any unusual fuel system behavior (popping or cracking noises during filling, natural gas odors, hissing, unexpected pressure drops)

(5) As may be required under any state, provincial, or local regulations

Inspection of Kolon hydrogen cylinders shall be performed in accordance with this document and the Compressed Gas Association (CGA) pamphlet C6.4 "Methods for External Visual Inspection of Natural Gas Vehicle (NGV) Fuel Containers and Their Installations".

The inspector must also determine if there is any unusual service history since the last inspection. For example, vehicle accidents, or exposure to corrosive acids. Also, for cylinders mounted on the vehicle undercarriage, whether the vehicle underside received impact damage such as from roadside debris or from "bottoming out" when passing over speed bumps or curbs. Any such unusual service history should be noted in the vehicle and fuel system service records.

EXTERNAL INSPECTION PROCEDURES

Inspectors must have a clear and unobstructed view of the entire cylinder exterior surface. Dirt or grit must be cleaned / removed if it prevents persons from observing possible damage to the cylinder exterior surface. Light dusting on the cylinder can remain and in fact is sometimes useful by providing a witness mark for any impacts, provided that the dusting does not have a corrosive influence and it does not prevent persons from reading the cylinder label or seeing possible cylinder damage.

To gain an unobstructed view of the entire cylinder, users may have to remove protective covers, sleeves, guards, etc that may be installed around the cylinders. Inspectors may also need inspection/dental mirrors, boroscopes, and/or small high intensity lamps for viewing inaccessible areas. If the entire cylinder cannot be viewed with such equipment, then it must be removed from the vehicle for inspection.

Important! Inspectors must check the expiration date on the cylinder label. Make sure that the cylinder(s) are not in use beyond their expiration date.

CAUTION: Never remove or otherwise disconnect a cylinder that contains pressure! Be certain that the cylinder is completely vented before removal.

CAUTION: Do not use paint removers, solvents, acids or harsh chemicals to clean cylinders. These can degrade and weaken the composite. Use water and/or a mild household detergent for cleaning the cylinder exterior.

EXTERNAL DAMAGE

Type 4 cylinders are recognized as an extremely robust and resilient design. However, any fuel tank can be damaged in service and end users must periodically inspect their tanks for possible damage. This section is intended to help end users identify and inspect for various types of damage, which can be defined as the following types:

- Abrasion, cut/gouge damage
- Impact Delaminations
- Heat or fire damage
- Leaking
- Chemical attack
- Ultra Violet (UV) Damage
- Label Damage or illegible label

CYLINDER WRAP INSPECTION PROCEDURE

Important: Gaps of the fiber wrap around the dome area of the cylinder may occur during manufacture. Also, resin and paint runs may appear as a hard circle or spot on the cylinder surface. This is normal. Cylinder strength is not affected and does not require repair.

The following section provides a description of some types of damage that can occur with hydrogen cylinders. As it is not possible to address every possible damage scenario, these are the most common types of damage that your cylinder may experience.

Inspect the surface of your Kolon Type4 cylinder as follows:

How to Measure the Depth of Damage

Due to the way the Kolon hydrogen cylinder is made there are variations in the height of the individual fibers in the hoop wrap, this uneven surface can complicate the measurement of a damaged area on your cylinder. The following process is recommended to provide the most accurate and consistent results when measuring any damaged area on your cylinder

1. Identify the damaged area that needs to be measured.

2. Identify a number of areas in line with the wrap direction of the fiber, adjacent to the damaged area but where the damaged area will not interfere with a depth measurement.

3. Using a depth gauge measure the depth of the lowest point in the wrap in the areas selected adjacent to the damage.

Record the largest reading observed when making these measurements.

4. Using a depth gauge measure the depth of the lowest point in the damaged area being inspected. Record the largest reading observed when making these measurements.

5. Subtract the reading obtained in step 3 from the reading obtained in step 4. The result of this calculation will indicate the depth of the damaged area being measured.

Level 1 Cut or Abrasion:

• Level 1 cut, scratch or abrasions are minor cuts or abrasions that are less than 0.010" (0.25 mm) deep.

• It is not necessary to resurface Level 1 abrasions.

Level 2a Cut or Abrasions:

Level 2a cuts or abrasions have some exposed fibers or have flat spots with a depth between 0.011-0.035" (0.26-0.89 mm). It may be necessary to remove loose fibers in order to accurately gage the depth of the cut or abrasion.

Level 2b Cut or Abrasions:

Important: Cylinders with cuts or abrasions that meet or exceed Level 2b specifications must be removed from service.

• Level 2b cuts or abrasions have some exposed fibers or have flat spots with a depth between 0.036-0.050" (0.90-1.27 mm). It may be necessary to remove loose fibers in order to accurately gage the depth of the cut or abrasion.

• The final disposition of the cylinder will depend on the severity, location and direction of the damage to the cylinder. Contact Kolon for assistance in dispositioning a cylinder with level 2b damage.

Level 3 Cut or Abrasions:

• Level 3 cuts or abrasions have some exposed fibers or have flat spots with a depth greater than 0.050" (1.27 mm). It may be necessary to remove loose fibers in order to accurately gage the depth of the cut or abrasion.

• Any cylinder that has sustained level 3 damage must be removed from service.

DELAMINATION BRUISES

Delamination bruises are a fracture of the epoxy/resin bond between adjacent fiber strands or adjacent fiber layers. Delaminations are evidenced by whitish bruising or by a raised surface compared the surrounding composite surface as shown in Figure below. **Users must contact Kolon concerning any delaminations, and cylinders with delaminations cannot be returned to service without consultation with Kolon.**

There are two damage level categories for delaminations:

1. Potentially Serviceable: Cylinders with delamination bruises less than 25mm square (1"square) can possibly be returned to service after consultation with Kolon.

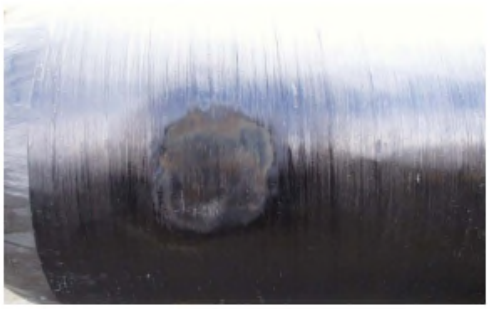
2. Non-Repairable: Cylinders with delaminations larger than 1" square are generally unserviceable unless otherwise indicated by Kolon

HEAT OR FIRE DAMAGE

Cylinders must be inspected after any vehicle fire or when a hydrogen vehicle was very near a fire such that the onboard cylinders may have been exposed to extreme heat. Heat or fire damage is evidenced by discoloration (browning), charring, burning, or melting of the cylinder or its labels as shown in Figure below. Persons must also inspect pressure relief devices for evidence of exposure to heat (e.g. activation). The two categories of heat damage are as follows:

• **Allowable:** The cylinder surface is merely soiled from smoke or soot blown from a distant heat source. There must be no signs of charring, burning, or melting of the composite, and no evidence of pressure relief device (PRD) activation.

• **Unacceptable:** Any charring, burning, or melting on the cylinder surface or any PRD activation. Cylinders with Unacceptable damage must be condemned.



CORROSION AND STRESS CORROSION DAMAGE

Corrosion damage can appear as deterioration of the composite fibers and/or resin such as discoloration, tackiness on the cylinder surface, or melt zones that re-solidified. This is shown in Figure A below. The initial stages of stress corrosion is evidenced by very organized micro-cracks that that cut across perpendicular to the composite fiber strands as shown in Figure B. If the damage progresses further, the bands of composite fiber will snap apart and delaminate as shown in Figure C. **Any evidence of corrosion damage or stress corrosion damage is unacceptable and the cylinder must be removed from service and rendered unusable as described in condemned cylinders and their destruction.**

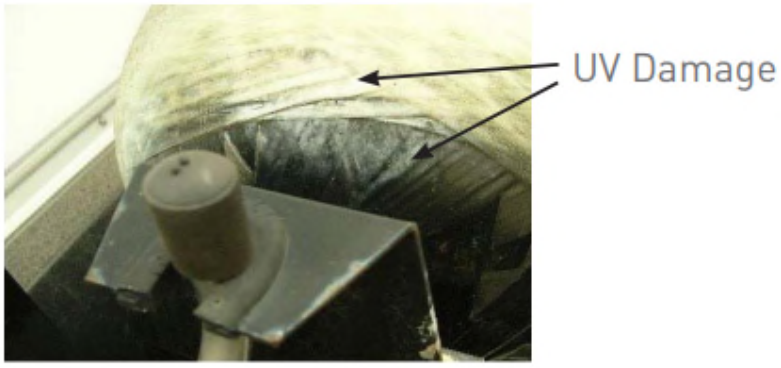
A

B

C

ULTRAVIOLET (UV) DAMAGE

Most types of epoxy resin will react to UV radiation after extended exposure. As shown in Figure below, UV damage is evidenced by an opaque white staining or haze that develops on the outer composite surface layers**. INSPECTORS MUST CONTACT KOLON CONCERNING ANY UV DAMAGE.** Over time, continuous UV exposure can significantly degrade composite laminates. If caught early, the affected areas can be painted with a gloss or semi-gloss black paint conforming with Federal Specification 595-17038. Sherwin Williams, Cardinal, and other companies supply this type of paint. End users must also stay current with Federal regulations, such as 49 CFR 571.304, to make sure that revisions in these codes do not impose new inspection requirements.



CYLINDER LAEKAGE

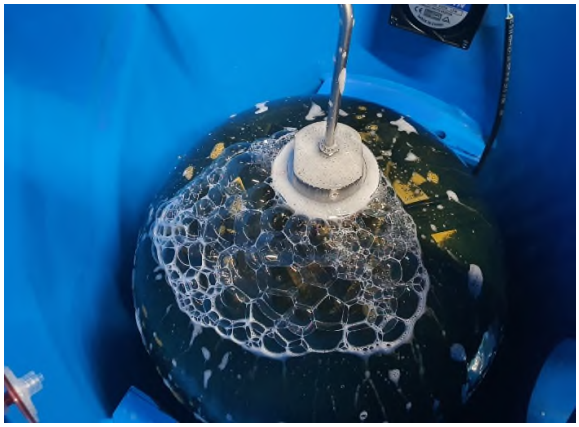
It is possible for a cylinder leak to occur if the liner is damaged on a Type 4 cylinder. A number of indicators may be used to determine if your cylinder is leaking:

• Excessive localized bubbling similar to the picture below or bubbling over a large area may indicate a cylinder leak is present.

• Gas visibly blowing leak detection fluid from the cylinder surface.

• Audible leak or persistent hissing is present.

If you believe any of the conditions above exist and may indicate a cylinder leak is present it is recommended that the cylinder pressure be monitored to confirm the existence of a leak.



Cylinder Pressure Drop Test

A pressure drop test will not provide accurate information if the test is being started less than 4 hours after a vehicle fill or if the starting temperature varies by more than approximately 20°F (11°C) at the end of the test.

1. If a system gauge is not present, install a test gauge in the system with a small enough scale to be capable of reading the pressure drop.

2. Note the system pressure, time and ambient temperature.

3. Isolate all the cylinders on the vehicle from each other by turning off the manual shut off valves.

4. Let the system stand for a 24 hour period.

5. Open one cylinder valve and record the cylinder pressure.

6. Close the cylinder valve.

7. Repeat steps 5-6 for the remaining suspect cylinders on the vehicle or system.

8. Any cylinder that has experienced a detectable pressure drop over a 24 hour period should be carefully inspected for any external source of a leak. It is important to note that significant temperature changes will result in significant pressure changes, if possible the temperature of the cylinder and gas should remain constant during this evaluation.

If a leak is indicated by the pressure drop test verify the cylinder valve connection and or PRD valves are not leaking before removing the cylinder from service.

CYLINDER PORTS

Kolon hydrogen Cylinders have at least one port opening at one dome end of the tank for installation of a valve and attached pressure relief device (PRD). For long hydrogen tanks, there will also be a second port opening in the opposite cylinder dome end with either an end plug, a PRD directly mounted in the port, or an adapter/PRD installed in the port.

Kolon hydrogen cylinder ports are either 1.125 or 2.000 inches inside diameter with 12UNF – 2B threads. The ports are designed with an O-ring gland / cavity for engaging a valve, PRD, or

adapter with an appropriate size o-ring. The seal/mating surfaces on the port opening should be smooth and free from damage to ensure a tight engagement seal. In particular, persons should check for nicks, gouges, or deformities that may prevent effective contact between mating parts or which allow bypass leakage around the O-ring

VALVES, ADAPTERS, AND PRESSURE RELIEF DEVICES (PRD'S) INSTALLED DIRECTLY WITHIN THE CYLINDER PORTS

Initially hand tighten valve, PRD's, or adapter into cylinder ports. The cylinder port threads are aluminum, and persons should make certain of proper alignment to avoid cross threading or other unrepairable damage to the port threads.

For tanks with 1.125" diameter port openings, the recommended installation torque for valves, adapters, PRD's installed directly therein is 125 – 130 Ft x Lbs. For 2.0" tank ports, the recommended installation torque for valves installed therein is 225 Ft x Lbs +/- 20 Ft x Lbs.

Valves and their engagement threads are inspected for function, damage, leakage, and corrosion. Valves must be replaced if the valve body or threads show signs of dents, gouges, deformities, or corrosion.

PRD's are inspected for damage, leakage, activation, and corrosive attack. PRD's must be replaced if there are any deformities, dents, corrosion, or indications of PRD activation in the past, or indications that the PRD's parts have extruded (creeped) under the tank pressure. Activation is indicated if the PRD exterior shows signs of scorching or if the equipment around the PRD vent tubes show signs of high pressure gas release.

Important: hydrogen cylinders are certified for use with specific PRD's based on fire and heat testing of the cylinder and PRD assembly. Users must only install the PRD brand and type that the cylinder was certified with.

Important: The PRD attached to the valve must be connected to the correct valve port so the PRD can vent the cylinder contents regardless of whether the cylinder valve is in the "closed" or "open" position.

PRD'S ATTACHED TO VALVES OR ADAPTERS

A crushwasher seal is sometimes used when PRD's are attached to valves and adapters. The recommended torque when a PRD is attached to a valve or adapter with a crushwasher is 55 - 60 Ft x Lbs. In these cases, persons must be certain the crushwasher is centered within the PRD inlet port to ensure full all-around engagement with the seal rings on the valve boss or adapter boss. This can be accomplished by holding the PRD in a fixed vertical position with its inlet port facing up, such as in a vice, and then placing the crushwasher in a centered position at the bottom of the PRD inlet port. The valve or adapter boss can then be threaded into the PRD inlet port for engagement against the crushwasher.

NOTE: A new crushwasher should be installed during replacement of a PRD or valve, even if the original crushwasher appears to be in good condition. The original crushwasher will have some

deformation and imprinting after its original installation, and it cannot be relied upon to make an effective seal once it is so deformed.

CYLINDER O-RINGS

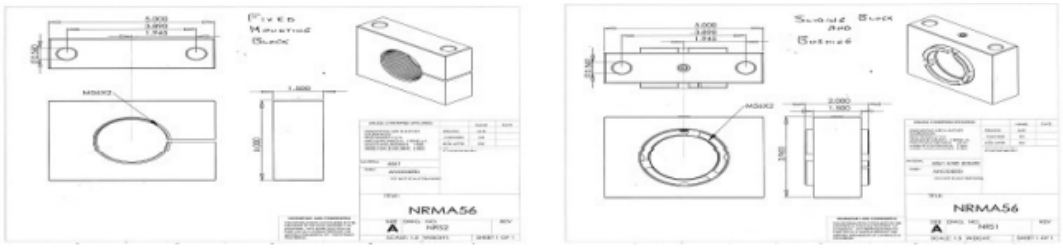
For 1.125" ports, O-rings on valves or PRD's should be Parker NBR Nitrile N756-75, 1.109 inch inside diameter x .139 inch thick. For 2" ports, the O-ring should be Parker NBR Nitrile N304-75, 1.984 inch inside diameter x .139 inch thick. Equivalent O-rings of the same material are acceptable if they have the same dimensions and hardness/durometer.

O-rings have a finite service life and it is recommended to install new O-rings when re-installing a valve, adapter, or PRD into a tank port, even if the original O-ring appears to be in good condition.

When installing a new O-ring, it is recommended to lightly lubricate it with a compatible lube so the O-ring won't be cut or torn when it is pulled across threads.

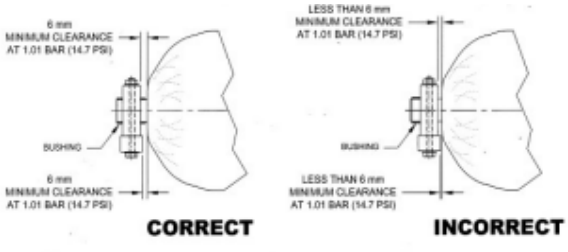
NECK MOUNTING

Cylinders longer than 50" (1270mm) are often neck mounted due to the structural simplicity with this mounting method. To accommodate neck mounting, the cylinders will have extended neck ends for engagement with neck mounting blocks. Referring to Figure 11 below, neck mounting blocks typically comprise two components: (1) a fixed block, and (2) a sliding block assembly. The fixed block typically has a threaded internal bore for engagement with mating external threads on the cylinder neck. The fixed mounting block also has a cut out slit so the fixed block will clamp onto the cylinder neck and thereby lock the position of that cylinder neck onto a mounting frame with bolts (not shown). The sliding block assembly comprises a hard plastic bushing which is installed on the cylinder neck, and a smooth bore mounting block which allows the bushing and cylinder neck to slide through it when the cylinder expands lengthwise 5 – 5.5 mm upon filling.



Importantly, the cylinder must be installed with at least 6mm expansion clearance between the cylinder dome end and the sliding block and as well between the cylinder dome end and the mounting frame that the sliding block is bolted onto. Please refer to figure 12 below. The

recommended torque for the mounting block bolts is 70 – 80 Ft x Lbs (95 – 108 N x M), where the cut out slit on the neck mounting block should normally not be compressed to less than approximately 50% of its orginal width. In no circumstances should the cut out slit be compressed until it is closed.



STRAP MOUNTING

Cylinders less than 50" length are often strap mounted because spatial constraints are limiting the cylinder length, and the cylinder body section length would be further reduced if extended neck ends are added to the vessel design for neck mounting. Strap mounting brackets typically comprise two opposed semi-circular strap halves that are bolted together around the cylinder body. A padding material (typically soft rubber and sometimes called a liner of isolater) is placed between the cylinder and straps to prevent abrasion damage and gouging on the cylinder outer surface. The padding must have opposed lip edges to capture and contain the strap bracket within the opposed edges At least two strap mounting brackets must be used per cylinder. All strap brackets must be positioned with at least 1" (25.4mm) inboard distance from the cylinder dome end shoulder. As well, after the opposed strap bracket halves are bolted together around the cylinder body, there must be some clearance space between the strap mounting bracket halves to ensure that clamping force is being applied to the cylinder body. Kolon recommends a bolt torque of 40 – 60 Ft x Lbs (54 – 81 N x M). In use, persons must inspect the bracket halves to make sure they are not corroding or distorting. As well, persons must verify that the padding material is still intact and in good condition. Lastly. Inspectors must check to make sure the cylinder is not longitudinally slipping within the brackets.

CYLINDER REPAIR PROCEDURE

Kolon must be contacted before any repairs are made to hydrogen cylinders. In addition, repairs can only be carried out by persons approved by Kolon or persons with sufficient hydrogen cylinder experience as specified under CGA Pamphlet C6.4.

1. Position cylinders for full access to the damaged area

2. Clean the damaged area using compressed air or a clean cloth

3. Re-inspect the damaged area to insure that the damage depth does not exceed allowable limits

4. Cut away any loose fibers

5. Lightly abrade the damaged area using 320 (or finer) grit sandpaper or equivalent

6. Mix epoxy resin sufficient to cover the damaged area per the resin manufacturer's instructions A two part epoxy resin system with room temperature curing must be used (such as Devcon 5 epoxy resin having a 5 minute curing period at room temperature with full bonding strength in approximately 1 hour).

7. Apply resin to the damaged area using a brush. Brush all fibers down smooth.

8. Allow the epoxy resin to cure per the epoxy resin manufacturer's recommendations

Note: Re-paint any damaged painted surfaces (paint is typically applied for UV protection and for those cylinders in more severe operating environments)

CONDEMNED CYLINDERS AND THEIR DESTRUCTION

Condemned Cylinders must be rendered incapable of holding pressure and then disposed of in accordance with the following procedure:

• Make sure the cylinder and any attached tubes/fittings are first fully vented and most especially before removing any cylinder attachements.

CAUTION: Pressure inside the cylinder or attached parts can kill/amputate and be strong enough to propel valves, fittings, or other cylinder attachments as lethal projectiles.

• Purge the cylinder using an inert gas or by filling with water.

CAUTION: Without purging, cylinders with open ports may still contain enough residual natural gas to cause an explosive hazard.

• Drill two 1/2" (12.5mm) or larger holes through the cylinder sidewall, saw off a neck end, or cut a similar opening through the vessel structure so it cannot be pressurized

• Dispose of the cylinder in accordance with local regulations.

Urgent: There is an industry wide problem with the re-sale of expired, condemned, and damaged hydrogen cylinders in secondary markets such as on EBay. Persons must ensure that disposed cylinders are no longer functional in the event that a re-seller gains possession of the cylinders.

Note: As of this writing, Kolon is not aware of any restrictions on the disposal of our cylinders' raw material constituents (aluminum, carbon fiber, and cured epoxy/resin materials that are in an inert condition). Some local recyclers may pay for the aluminum (high purity 6061 alloy) or at least pick them up at no cost. As mentioned above, make sure the cylinders are first rendered non-functional.

INSPECTION RECORDS

Cylinder inspectors must keep accurate records of each cylinder inspected.

APPENDIX

Cylinder Part Number	Cylinder Serial Number	Cylinder Date of Manufacture	External Condition Acceptable Y/N	Internal Inspection Required Y/N	Inernal Condition Acceptable Y/N	Repair Y/N	Pass/Fail and Remarks

Declaration by the manufacturer

Our company

KOLON SPACEWORKS Co., Ltd.
(Name)

53, 1gongdan-ro,
(Street)

39347 and Gumi-si, Gyeongsangbuk-do
(Postcode, town)

Republic of Korea
(Country)

has filed an application for approval of the following products:

Name of the product subject to approval 54L Hydrogen Storage System

Type, equipment type, vehicle class KSW052-HS01

We declare herewith that the above named products are assembled in series by the following company

KOLON SPACEWORKS Co., Ltd.
(Name)

53, 1gongdan-ro,
(Street)

39347 and Gumi-si,Gyeongsangbuk-do
(Postcode, town)

Republic of Korea
(Country)

53, 1gongdan-ro Gumi-si, 2024.11.29 SANG HYUN AHN

(Place, date) (Name and signature)

KOLON SPACEWORKS CO.,LTD.
SANG HYUN AHN
PRESIDENT

Information Document acc. to Annex 1 - Part 1, Model - I of ECE R-134

0.	**General**	
0.1.	Make (trade name or manufacturer):	Kolon Spaceworks Co., Ltd.
0.2.	Type:	KSW052-HS01
0.2.1.	Commercial name(s) (if available):	N/A
0.5.	Name and address of manufacturer:	Kolon Spaceworks Co., Ltd. 53, 1gongdan-ro, Gumi-si, Gyeongsangbuk-do, Korea, 39347
0.8.	Name(s) and address(es) of assembly plant(s):	Kolon Spaceworks Co., Ltd. 53, 1gongdan-ro, Gumi-si, Gyeongsangbuk-do, Korea, 39347
0.9.	Name and address of the manufacturer's representative (if any):	N/A
3.	**Power Plant**	
3.9.	**Hydrogen storage system**	
3.9.1.	***Hydrogen storage system designed to use compressed (gaseous) hydrogen***	
3.9.1.1.	Description and drawing of the hydrogen storage system:	54L Hydrogen Storage System Drawing: 35910-05401 Rev.- (2022.11.16)
3.9.1.2.	Make(s):	Kolon Spaceworks Co., Ltd.
3.9.1.3.	Type(s):	KSW052-HS01
3.9.2.	***Container(s)***	
3.9.2.1.	Make(s):	Kolon Spaceworks Co., Ltd.
3.9.2.2.	Type(s):	KHT052-700A
3.9.2.3.	Maximum Allowable Working Pressure (MAWP):	87,5 MPa
3.9.2.4.	Nominal Working Pressure(s):	70,0 MPa
3.9.2.5.	Number of filling cycles:	11000
3.9.2.6.	Capacity:	54L
3.9.2.7.	Material:	See the attached drawing file
3.9.2.8.	Description and drawing:	54L Hydrogen Tank Drawing 35912-05401 Rev.- (2022.11.16) and 54L Hydrogen Storage System Drawing: 35910-05401 Rev.- (2022.11.16)
3.9.3.	***Thermally-activated pressure relief device(s)***	
3.9.3.1.	Make(s):	Youngdo Ind. Co., Ltd.
3.9.3.2.	Type(s):	HR-700PF (mounted on the valve)
3.9.3.3.	Maximum Allowable Working Pressure (MAWP):	87,5 MPa
3.9.3.4.	Set pressure:	N/A
3.9.3.5.	Set temperature:	110°C±10°C
3.9.3.6.	Blow off capacity:	24 m3/h (at 2 MPa)
3.9.3.7.	Normal maximum operating temperature:	85°C
3.9.3.8.	Nominal working pressure(s):	70,0 MPa
3.9.3.9.	Material:	See the attached drawing file
3.9.3.10	Description and drawing:	54L Hydrogen Storage System Drawing: 35910-05401 Rev.- (2022.11.16)
3.9.3.11.	Approval number:	E4*134R-010009

3.9.4.	***Check valve(s)***	
3.9.4.1.	Make(s):	Youngdo Ind. Co., Ltd.
3.9.4.2.	Type(s):	HR-700
3.9.4.3.	Maximum Allowable Working Pressure (MAWP):	87,5 MPa
3.9.4.4.	Nominal working pressure(s):	70,0 MPa
3.9.4.5.	Material:	See the attached drawing file
3.9.4.6.	Description and drawing:	54L Hydrogen Storage System Drawing: 35910-05401 Rev.- (2022.11.16)
3.9.4.7.	Approval number:	E4*134R-010008
3.9.5.	***Automatic shut-off valve(s)***	
3.9.5.1.	Make(s):	Youngdo Ind. Co., Ltd.
3.9.5.2.	Type(s):	HR-700
3.9.5.3.	Maximum Allowable Working Pressure:	87,5 MPa
3.9.5.4.	Nominal working pressure(s) and if downstream of the first pressure regulator, maximum allowable working pressure(s):	70,0 MPa
3.9.5.5.	Material:	See the attached drawing file
3.9.5.6.	Description and drawing:	54L Hydrogen Storage System Drawing: 35910-05401 Rev.- (2022.11.16)
3.9.5.7.	Approval number:	E4*134R-010008

André Frégeau
TÜV SÜD Auto Service
2025.01.06