VOLKSWAGEN

AKTIENGESELLSCHAFT

Group Standard

TL 52435 Issue 2010-09

Class. No.: 55163 Descriptors: barrier layer, multi-layer pipe, fuel line, co-extrusion process, conductive

Fuel Line, Multi-Layer Pipe

Material Requirements 5 types: without Index, A, B, C, D

Preface

Type C must no longer be used for new designs and drawing changes.

The requirements for type C will remain part of this standard for current series production.

Previous issues

TL 52435: 1993-12, 1996-04, 2002-12, 2010-04

Changes

The following changes have been made compared with TL 52435: 2010-04:

Type C: Note for restricted usage added

1 Scope

This Technical Supply Specification (TL) specifies the material requirements for multi-layer pipes, e.g., fuel lines (supply and return) with special requirements for diffusion resistance.

2 Description

Description example for type with EVOH barrier layer, 5-layer:

Multi-layer pipe according to TL 52435

Verify that you have the latest issue of the Standard before relying on it.

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3 Requirements

3.1 General requirements

Approval of first supply and changes according to Volkswagen standard VW 01155.

Emission behavior according to VW 50180.

Resistance to open-air weathering according to VW 50185.

Avoidance of hazardous substances according to VW 91101.

Limit deviations according to DIN 73378.

Required for complete testing: quantity of finished parts, e.g., assembled fuel lines, that contains approx. 10 m of multi-layer pipe. Forming operations must be carried out using the procedure planned for series production.

3.2 Appearance

The surface and interior of the multi-layer pipes must be free of flaws and processing defects, such as blisters, voids, score marks, cracks, irregularities, and foreign matter. The multilayer pipes must exhibit a flawless bond between the layers. The multi-layer pipes must not exhibit any weak spots arising in connection with processing steps required for assembling, such as pipe flaring operations and installation of support sleeves and quick fittings.

3.3 Manufacture

Co-extrusion process, thermoforming

3.4 Types

- TL 52435 Multi-layer pipe with barrier layer of EVOH, 5-layer
- TL 52435-A Multi-layer pipe with barrier layer of PVDF
- TL 52435-B Multi-layer pipe with PA6.12 and barrier layer of EVOH
- TL 52435-C Multi-layer pipe with barrier layer of EVOH, conductive Note for restricted usage
- TL 52435-D Multi-layer pipe with barrier layer of EVOH, 4-layer

3.5 Marking according to VDA 260

- TL 52435 > PA6-HIP,EVOH,PA12-P <
- TL 52435-A > PA6-HI,PVDF,PA12-P <
- TL 52435-B > PA6-HIPH,EVOH,PA6.12-HIHL<
- TL 52435-C > PA12-P-ESD,EVOH,PA12-P < Note for restricted usage</p>
- TL 52435-D > PA6-HIP,EVOH,PA12-HIP <

3.6 Conditioning

Prior to testing, the specimens required for the individual tests must be conditioned for at least 48 h in the ISO 554–23/50 standard climate.

3.7 Evaluation of the measurement results

The requirements apply to all points on the pipe or pipe assembly. The required numerical values apply to each individual measurement.

4 Material requirements

4.1 Material and layer thicknesses

See Section 6.1.

4.1.1 TL 52435

Multi-layer pipe, consisting of (from the inside out):

- PA6, impact-modified, softened, heat-stabilized; thickness (0,45 ± 0,05) mm
- EVOH barrier layer; thickness (0,15 ± 0,03) mm
- PA6, impact-modified, softened, heat-stabilized; thickness (0,05 ± 0,03) mm
- Bonding agent; thickness (0,05 ± 0,03) mm
- PA12, softened, light- and heat-stabilized; thickness (0,30 ± 0,05) mm

4.1.2 TL 52435-A

Multi-layer pipe, consisting of (from the inside out):

- PA6, softened, heat-stabilized; thickness (0,46 ± 0,05) mm
- PVDF barrier layer; thickness (0,08 ± 0,03) mm
- PA12, softened, light- and heat-stabilized; thickness (0,46 ± 0,05) mm

4.1.3 TL 52435-B

Multi-layer pipe, consisting of (from the inside out):

- PA6, impact-modified, softened, heat-stabilized; thickness (0,40 ± 0,05) mm
- EVOH barrier layer; thickness (0,10 ± 0,03) mm
- PA6.12, impact-modified, light- and heat-stabilized; thickness (0,50 ± 0,05) mm

4.1.4 TL 52435-C - Note for restricted usage

Conductive multi-layer pipe, consisting of (from the inside out):

- PA12, impact-modified, electrically conductive; thickness (0,20 ± 0,1) mm
- PA12, impact-modified; thickness (0,20 ± 0,05) mm
- Bonding agent PA; thickness (0,05 ± 0,03) mm
- EVOH barrier layer; thickness (0,15 ± 0,03) mm
- Bonding agent PA; thickness (0,05 ± 0,03) mm
- PA12, impact-modified, light- and heat-stabilized; thickness (0,35 ± 0,05) mm

4.1.5 TL 52435-D

Multi-layer pipe, consisting of (from the inside out):

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- PA6, impact-modified, softened, heat-stabilized; thickness (0,45 ± 0,05) mm
- EVOH barrier layer; thickness (0,15 ± 0,03) mm
- Bonding agent; thickness (0,10 ± 0,03) mm
- PA12, impact-modified, softened, light- and heat-stabilized; thickness (0,30 ± 0,05) mm

4.2 Color

According to drawing.

5 Required properties

See Table 1.

No.	Property	Unit		Requi	rement	
		1	TL 52435	TL 52435-A TL 52435-D	TL 52435-B	TL 52435-C Note for re- stricted us- age
1	Yield stress					
1.1	In direction of extrusion acc. to DIN EN ISO 527-2 and Section 6.2	N/mm ²	≥ 24			
1.2	Crosswise to direction of extru- sion acc. to DIN 53504 and Section 6.3	N/mm ²	≥ 30	≥ 26	≥ 26	≥ 26
2	Elongation at tear					
2.1	In direction of extrusion acc. to DIN EN ISO 527-2 and Section 6.2	%	≥ 200			
2.2	Crosswise to direction of extru- sion acc. to DIN 53504 and Section 6.3	%	≥ 200			
3	Equivalent stress acc. to DIN 53758 and Section 6.4	N/mm ²	≥ 25 Brittle splitting open (brittle fracture) must not occur during the short-term internal pressure test.			
4	Low-temperature behavior acc	ording to	ing to Test Specification PV 3905 and Section 6.5			
4.1	Test temperature -25 °C; ball weight 880 g		No fracture			
4.2	Test temperature -40 °C; ball weight 500 g		No fracture			
5	Aging resistance acc. to DIN 53497 and Section 6.6			No fra	acture	

Table 1

No.	Property	Unit	Requirement			
			TL 52435	TL 52435-A TL 52435-D	TL 52435-B	TL 52435-C Note for re- stricted us- age
6	Washing resistance see Section 6.7		The test medium must not exhibit any flocculation or turbidity.			
7	Elevated-temperature behav- ior acc. to DIN 53497 and Section 6.8		There must not be any change in the color, surface, or form, particularly of thermoformed areas.			
8	Operating behavior see Section 6.9 The requirement applies to new-sample and first-sample deliveries (basic test of materi- al suitability). Volkswagen AG reserves the right to draw on this also for the evaluation of series production deliveries.		There must	not be any in tween th	npairment of t le layers.	he bond be-
8.1	Length change of the free length between the connec- tions	%		≤ 2	2,0	
8.2	Equivalent stress acc. to DIN 53758 and Section 6.4	N/mm ²	Brittle splittir during th	≥ ng open (brittl ne short-term	25 e fracture) m internal press	ust not occur sure test.
8.3	Yield stress in direction of ex- trusion acc. to DIN EN ISO 527-2 and Section 6.2	N/mm ²		≥	24	
8.4	Elongation at tear in direction of extrusion acc. to DIN EN ISO 527-2 and Section 6.2	%	≥ 100			
9	Electrical conductivity see Section 6.10	kΩ	-	-	-	≤ 100
10	Burning behavior		(if req	Acc. to uired in draw	TL 1010 ing and/or rel	ease).

6 Notes on testing

Deviating procedures must be coordinated with the responsible Volkswagen Group brand laboratory.

6.1 Material

The identity test is performed with infrared spectroscopy.

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6.2 Yield stress and elongation at tear in the direction of extrusion

The tensile test is performed according to DIN EN ISO 527-2, but on 150 mm long pipe sections and at a test rate of 100 mm/min. The DUTs are provided with 30 mm long steel mandrels in the clamping area. The diameter of the mandrels must equal the inside diameter of the DUT (nominal dimension) plus a maximum of 0,5 mm. The mandrels must taper to a point toward the center of the pipe in order to prevent edges; see Figure 1. The tensile test must be performed with vise jaws that are suitable for specimens made of round material. Suitable external elongation sensors must be used to measure the elongation; elongation measurements by means of a cross member are not permissible.



Figure 1 – Example of a possible mandrel geometry

6.3 Yield stress and elongation at tear crosswise to the direction of extrusion

Tensile test according to DIN 53504 on 10 mm long sections of pipe. Devices must be used that allow testing of the specimens as a ring (see schematic in Figure 2); test rate of 25 mm/min. The yield stress σ_s and the elongation at tear ε_R must be computed as follows:

$$\sigma_{\rm s} = \frac{F_{\rm s}}{2A_{\rm o}} \left({\rm N/mm^2} \right) \tag{1}$$

$$\mathfrak{E}_{\mathsf{R}} = \frac{2\mathsf{L}}{\mathsf{D} \times \mathsf{\pi}} \times 100(\%) \tag{2}$$



Figure 2

where:

- F_s = Force at yield point
- A_0 = Initial cross-section
- L = Distance traveled by the pulling cross member at the moment the specimen tears
- D = Outer diameter of the test pivots of the device brought together at zero, which must be identical to the inside diameter of the DUT

For schematic, see Figure 3.



Figure 3

6.4 Equivalent stress

The short-term internal pressure test is performed according to DIN 53758. The equivalent stress is computed according to the following formula:

$$\sigma_{\rm V} = \frac{P_{\rm B} \times d_{\rm m}}{20_{\rm S}} \,({\rm N/mm^2}) \tag{3}$$

Where:

- P_B = Burst pressure, in bar
- $d_m = d_1 s$, average pipe diameter
- d₁ = Outer diameter, measured
- s = Pipe wall thickness
- σ_v = Equivalent stress in circumferential direction

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6.5 Low-temperature behavior

The ball drop test must be performed according to PV 3905, but with a base plate (specimen support surface) of sheet steel \geq 10 mm thick without depression, on at least five 100 mm long pipe sections. The ball drop height is 65 cm. For TL 52435-C (**Note for restricted usage**), the ball drop height is to be reduced to 50 cm.

6.6 Aging resistance

An elevated-temperature aging test according to DIN 53497, method B, must be performed on at least five plane pipe sections \ge 80 mm long. The aging temperature is (150 ± 2) °C, and the aging duration is \ge 200 h. After the specimens have been cooled down in a desiccator, an impact resistance test is performed according to DIN EN ISO 179-1 with a pendulum impact tester, energy storage of 7,5 J, support separation of 62 ^{+0.5}/₋₀.

6.7 Washing resistance

A line section at least 2 m long, or in the case of shorter lines, the multi-layer pipe portion of a complete line, is filled with FAM test fluid according to DIN 51604-2, closed off, and aged for 72 h at 60 °C. After cooling to 23 °C, the DUT is emptied into a beaker.

6.8 Elevated-temperature behavior

An elevated-temperature aging test according to DIN 53497, method B, is performed on three 300 mm long sections of pipe, or in the case of thermoformed lines, on sections that include the formed area. The aging temperature is (110 ± 1) °C; and the aging duration is (22 + 2) h.

6.9 Operating behavior

A test setup must be used in which the following test conditions can be realized:

- At least six 0,75 m long straight pipe sections are mounted in the test setup in such a way that, with the aid of a radius template, an installation radius of r = 50 mm can be kept constant over the entire test duration.
- The DUTs are continuously flushed with FAM test fluid according to DIN 51604-2.
- The temperature of the test medium is (90 ± 2) °C.
- A pulsating pressure of 5,5 bar to 8 bar with a frequency of $(1,77 \pm 0,5)$ Hz must be set.
- The flow rate must be (12 ± 1) l/h.
- The air surrounding the DUTs must have a temperature of (110 ± 2) °C and a flow velocity of (33,5 ± 1) cm/s.
- After 1 000 h, 3 DUTs are removed for the mechanical tests. The designated tests must be performed within 24 h after completion of the flow test.
- The 3 remaining DUTs undergo further dynamic loading in the flow test until the first specimen bursts, or for at least another 2 500 h.

6.10 Electrical conductivity

The measurement of the electrical conductivity is based on VDA AK-LH026 "Definition of Electrostatic Test Procedure", Section 3.2.

The test must be performed in the ISO 554 – 23/50 standard climate. Completely assembled, ready-to-install lines of the original length must be used.

- Preparation of test samples
- 1. Clean the part.
- 2. Place the part on an insulating table.
- 3. Simulate the actual contact positions with the vehicle body (in grounded position).
- 4. Draw a 5 mm wide ring around the ends of the line and the ground contact area using silver paint. Contacts with conductive elastomer or metal film are also possible.
- Measurement

The electrodes are placed onto the two painted areas. The contact area must be 18 mm². Good contact between the electrodes and the conductive paint must be ensured (conductive adhesive material may also be used).

Voltage is applied, if necessary. A minimum value (10 V) is applied at the start. If necessary, the voltage is then increased continuously (maximum permissible voltage = $1\ 000\ V$). The amperage should be less than 1 mA at 1 000 V and less than 5 mA at every other voltage.

7 Other applicable documents

The following documents cited in this Standard are necessary to its application.

Some of the cited documents are translations from the German original. The translations of German terms in such documents may differ from those used in this Standard, resulting in terminological inconsistency.

Standards whose titles are given in German may be available only in German. Editions in other languages may be available from the institution issuing the standard.

PV 3905	Organic Materials; Ball Drop Test
TL 1010	Materials for Vehicle Interiors; Burning Behavior; Material Requirements
VW 01155	Vehicle Supply Parts; Approval of First Supply and Changes
VW 50180	Components in Passenger Compartment; Emission Behavior
VW 50185	Vehicle Parts; Resistance to Open-Air Weathering
VW 91101	Environmental Standard for Vehicles; Vehicle Parts, Materials, Operating Fluids; Avoidance of Hazardous Substances
DIN 51604-2	Methanolic FAM testing fluid for polymer materials; composition and re- quirements
DIN 53497	Testing of Plastics; Hot Storage Test on Mouldings Made of Thermoplastic Moulding Materials without External Mechanical Stressing
DIN 53504	Testing of rubber - determination of tensile strength at break, tensile stress at yield, elongation at break and stress values in a tensile test
DIN 53758	Testing of plastics articles; determination of the effect of internal pressure on hollow objects by short-time test
DIN 73378	Polyamide tubing for motor vehicles
DIN EN ISO 179-1	Plastics - Determination of Charpy impact properties - Part 1: Non-instru- mented impact test

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DIN EN ISO 527-2	Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics
ISO 554	Standard atmospheres for conditioning and/or testing; Specifications
VDA 260	Components of motor vehicles; marking of material