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GUIDELINES

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Flow Erosion II

Test method for suitability testing of coolant additives for cooling media

Flow Erosion II

Project no. 1445

Test method for suitability testing of coolant additives for cooling media

Guidelines

Introductory remarks:

These guidelines on the "Suitability testing of coolant additives for cooling media of internal combustion engines and alternative powertrains under thermal-flow dynamic test conditions" is intended as an extension of the guideline FVV R530 - 2005 with regard to a comprehensive description or simulation of real-life stress collectives.

The guidelines are based on the outcome of several research works and projects which were carried out at the Center for Structural Materials (State Materials Testing Institute Darmstadt MPA and Department and Institute of Materials Science IfW) of the Technical University of Darmstadt. The editorial work was carried out by the MPA-IfW in coordination with the steering committee of the “Flow Erosion” working group. The adoption and publication of the guidelines were effected by FVV eV.

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Related reports:	R530 (2005)

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1 Foreword

These guidelines were developed by the "Flow Erosion" working group of the FVV eV in close cooperation with manufacturers and operators of combustion engines and alternative powertrains as well as with manufacturers of coolant additives based on research work at the Institute of Materials Science at the Technical University of Darmstadt. The guidelines build on the existing test guidelines (FVV R530-2005) described in 1.1 and serves to extend it (complex channel loading).

1.1 Previous versions - test guidelines

- FVV guidelines for a test procedure 1986 (issue R 443/1986)
- FVV guidelines for a test procedure 1993 (issue R 476/1993)
- FVV guidelines for a test procedure 2005 (issue R 530/2005)

2 Field of application

These guidelines “Test method for suitability testing of coolant additives for cooling media” apply to the testing of coolant additives for use in cooling circuits of conventional internal combustion engines and alternative powertrains whose heating and cooling systems are based on aqueous cooling media.

2.1 Purpose of the test

The purpose of this test is to investigate and quantify the effect and corrosion protection behavior of corrosion inhibitors in coolant additives on heat-affected material surfaces as used in mobile and stationary cooling circuit systems. The metal surface is directly and indirectly subjected to thermal-flow dynamic complex stresses at elevated mean coolant flow temperatures, which can lead to degradation phenomena. This method allows a differentiated consideration of different types of stress and their superposition as well as a phenomenological description.

3 Applicable documents

DIN 1681 Edition: 1985-06	Stahlguss für allgemeine Verwendungszwecke; Technische Lieferbedingungen // Cast steels for general engineering purposes; technical delivery conditions
DIN EN 573-3 Edition: 2019-10	Aluminium und Aluminiumlegierungen - Chemische Zusammensetzung und Form von Halbzeug - Teil 3: Chemische Zusammensetzung // Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 3: Chemical composition and form of products
DIN EN 1561 Edition: 2012-01	Gießereiwesen - Gusseisen mit Lamellengraphit // Founding - Grey cast irons
DIN EN 10130 Edition: 2007-02	Kaltgewalzte Flacherzeugnisse aus weichen Stählen zum Kaltumformen - Technische Lieferbedingungen (enthält Änderung A1:1998) // Cold rolled low carbon steel flat products for cold forming - Technical delivery conditions (includes Amendment A1:1998)
DIN EN ISO 683-3 Edition: 2018-09	Einsatzstähle; Technische Lieferbedingungen // Case-hardening steels (Technical delivery conditions)
FVV Guidelines R530-2005	Prüfung der Eignung von Kühlmittelzusätzen für die Kühlflüssigkeit von Verbrennungskraftmaschinen // Test method for suitability testing of coolant additives for cooling media

4 Safety instructions

The correct and safe handling of the experimental equipment and chemicals described below should be known to every user.

4.1 Regulations for test equipment

When handling pressure equipment, a number of rules and regulations must be observed to ensure safe operation. The most common regulations and rules to be applied can be found in the applicable documents:

Pressure Equipment Directive (PED) 1997/23/EC Guidelines (Germ. DE: Druckgeräte-Richtlinie (DGRL) 97/23/EG Leitlinien).

Transportable Pressure Equipment Directive (TPED) 1999/36/EC (DE: Richtlinie für ortsbewegliche Druckgeräte (TPED) 99/36/EG)
Ordinance on Industrial Safety and Health (BetrSichV)

Technical rules for

Compressed Gases (TRG)

Pressure Vessels (TRB)

Accident prevention regulations (Unfallverhütungsvorschriften UVV), in particular:

BGV A2

4.2 Safety instructions for working in the laboratory

Appropriate protective clothing must be worn for all work in the laboratory. This includes a work coat, sturdy closed shoes and protective goggles. Protective gloves and full-face shields must also be worn for certain types of work.

Before carrying out a test, the work instructions must be studied carefully. Knowledge of the hazards involved in handling of the chemicals used (R and S phrases) is assumed.

The workplace and the equipment in use may only be used in a condition that excludes any danger to all those present. The workplace must be clean and must be left clean after work.

Eating, drinking or smoking is prohibited in the laboratory. Everyone working in a laboratory must be aware of the location of fire extinguishers, emergency showers, eye showers and first aid cabinets.

The use of special equipment and the application of hazardous chemicals can only be used after prior instruction and in accordance with the generally applicable safety guidelines. When transporting acid bottles or other hazardous chemicals, suitable transport aids must be used.

Any use and destruction of chemicals requiring disposal must be agreed with the laboratory management.

5 Performance of the tests

The recommended overall test consists of the following individual tests in freshly prepared test fluid:

- Cavitation tests (ultrasonic coupling transducer) according to (FVV R 530/2005),

- circulation system with cavitation chamber (knocking chamber) according to (FVV R 530/2005),

- Corrosion tests under heat passage (hot test) according to FVV R 530/2005),

- Thermal flow induced corrosion test (FDC) (Guidelines "Test method for suitability testing of coolant additives for cooling media" for suitability testing of coolant additives for cooling media).

The requirements that coolant additives must meet for use in specific cooling circuits are defined qualitatively and quantitatively by the engine manufacturers or system managers in their respective supply regulations and specifications, depending on the design and intended use of the engine/unit.

5.1 Corrosion antifreeze and water-soluble corrosion inhibitors

5.1.1 General

For the overall test according to the FVV guidelines R530/2005 and guideline "Test method for suitability testing of coolant additives for cooling media" for suitability testing of coolant additives for cooling media the following types of test liquids are required:

I. Preparation with ion-exchanged water (Appendix 7.1) and the required application concentration (test concentration) of the coolant additive for tests on the circulation system with cavitation chamber and hot tests.

II. preparation with synthetic hard water (Appendix 7.2) and the required application concentration (test concentration) of the coolant additive for cavitation tests, tests on the circulation system with cavitation chamber and hot test.

III. approach with synthetic hard water (Appendix 7.2) and the agreed sub-concentration (half application concentration) of the coolant additive for cavitation tests.

The residual amount of coolant additive not initially used is set aside for any repeat tests that may be required.

If water preparations deviating from the above types are to be used in tests using the thermal flow-induced degradation test method (Guideline "Test method for suitability testing of coolant additives for cooling media" for suitability testing of coolant additives for cooling media) (e.g. corrosive water according to ASTM, various test water qualities), this is permissible under explicit marking and documentation.

5.1.2 Approach of the corrosion antifreeze agents

The coolant additive to be tested is prepared with ion-exchanged water according to Appendix 7.1 or with synthetic hard water according to Appendix 7.2. The quantity of coolant additive (concentrate) required for the test is based on the specified test concentration.

5.1.3 Preparation of the water-soluble corrosion inhibitors

The coolant additive to be tested is prepared with ion-exchanged water according to Appendix 7.1 or with synthetic hard water according to Appendix 7.2. The quantity of coolant additive (concentrate) required for the test is based on the specified test concentration for water-soluble corrosion inhibitors of the manufacturer or customer.

6 Flow Dynamic Corrosion Test (FDC)

The specific degradation behavior of coolant-loaded metallic material samples and the coolant used is investigated by means of a thermal flow dynamic corrosion test facility (FDC). The metal surface is directly and indirectly subjected to thermal-flow dynamic complex stresses at elevated mean coolant flow temperatures, which can lead to degradation phenomena. By segmenting the flow channel, this method enables a differentiated examination of different types of stress, their superposition and interaction, and their phenomenological description.

6.1 Test setup

The corrosion test facility is a circulation system with fully automated control and regulation. Figure 1 shows the sensor modernized flow dynamic corrosion test facility (FDC).

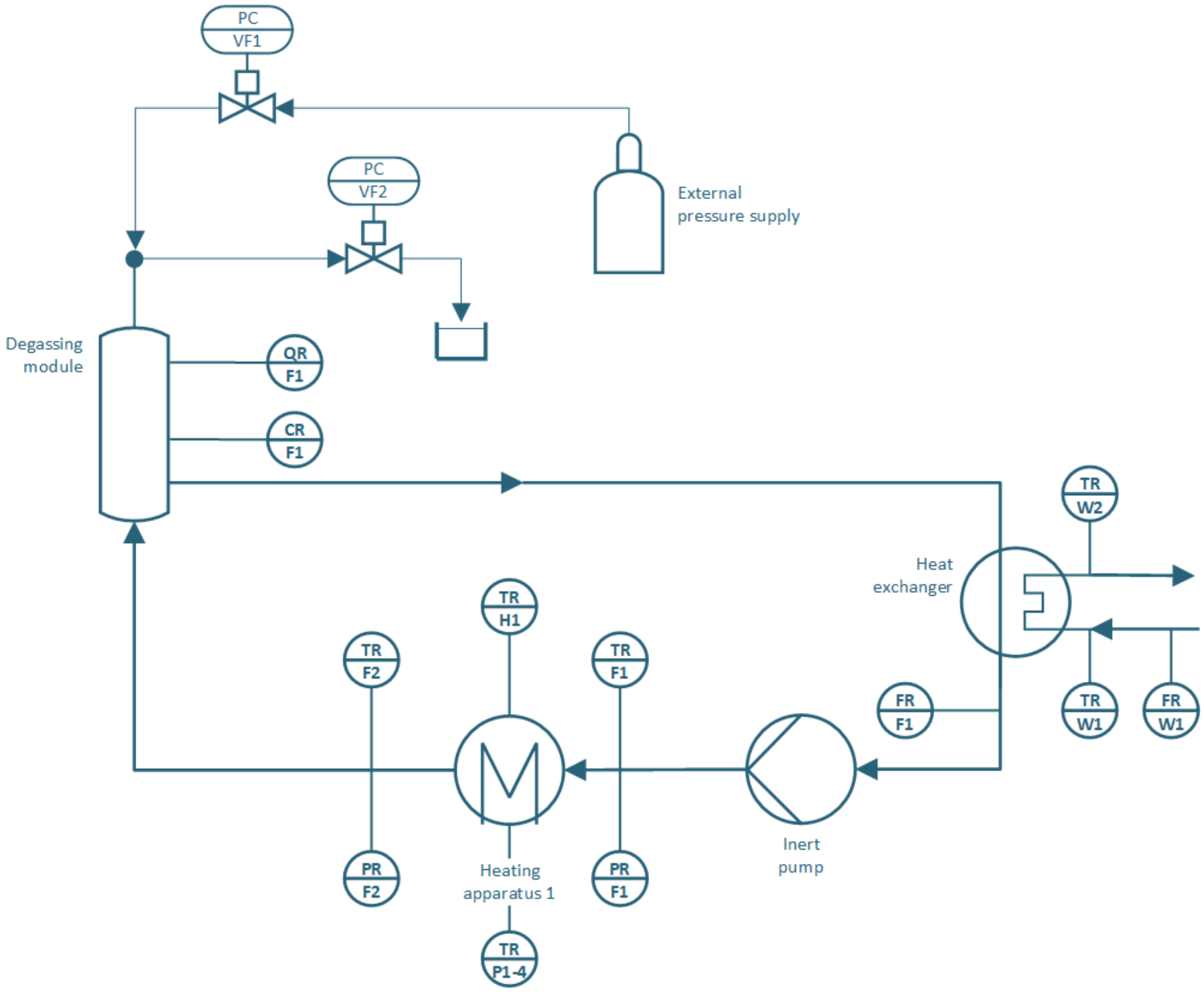

Figure 1: Piping and instrument flow diagram (R&I) of the fluid dynamic corrosion test facility (FDC)(1)

The thermal fluid dynamic corrosion test system (FDC) consists of a test circuit (F) and a cooling water system (W (e.g. chiller or laboratory cooling system)). The thermal flow dynamic corrosion test system

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[1] The corrosion tests described below can be carried out, for example, with a flow dynamic corrosion test facility (FDC) at the Technical University of Darmstadt - Center for Structural Materials - MPA-IfW in the Surface Technology competence area of the Service Materials competence field.

(FDC) consists of a test circuit (F) and a cooling water system (W (e.g. chiller or laboratory cooling system)).

The thermal flow dynamic corrosion test facility (FDC) has two inductive flow sensors for monitoring the cooling water system and the pumped coolant. Adjusted to the test rig are pressure and temperature sensors (TR and PR F1) upstream and downstream (TR and PF F2) of the specimen holder, pH (QR) and conductivity sensor (CR) in the expansion tank, and the cooling water system (TR W1 and W2, FR W1). The temperature and pressure sensors can be used to determine their difference, which is caused by the sample and its cooling channel. The determined differences allow an evaluation and differentiation of the degradations on the material surface of the coolant carrying sample surface in the cooling channel. The sensors used can ensure "real-time monitoring", as a result of which a temporal characterization of the degradation and corrosion processes and their kinetics can be carried out.

6.2 Specimens

The specimens for the thermal flow-induced degradation tests must comply with the dimensions according to Figure 2 and material specifications according to Appendix 9. This geometry is called "complex channel or water spider geometry" and is used to investigate superimposed flow dynamic influences with regard to material degradation behavior under thermal-corrosive loading. The total surface area of the cooling channel of a specimen is 114.4 mm^2 and the channel diameter is 3.5 mm.

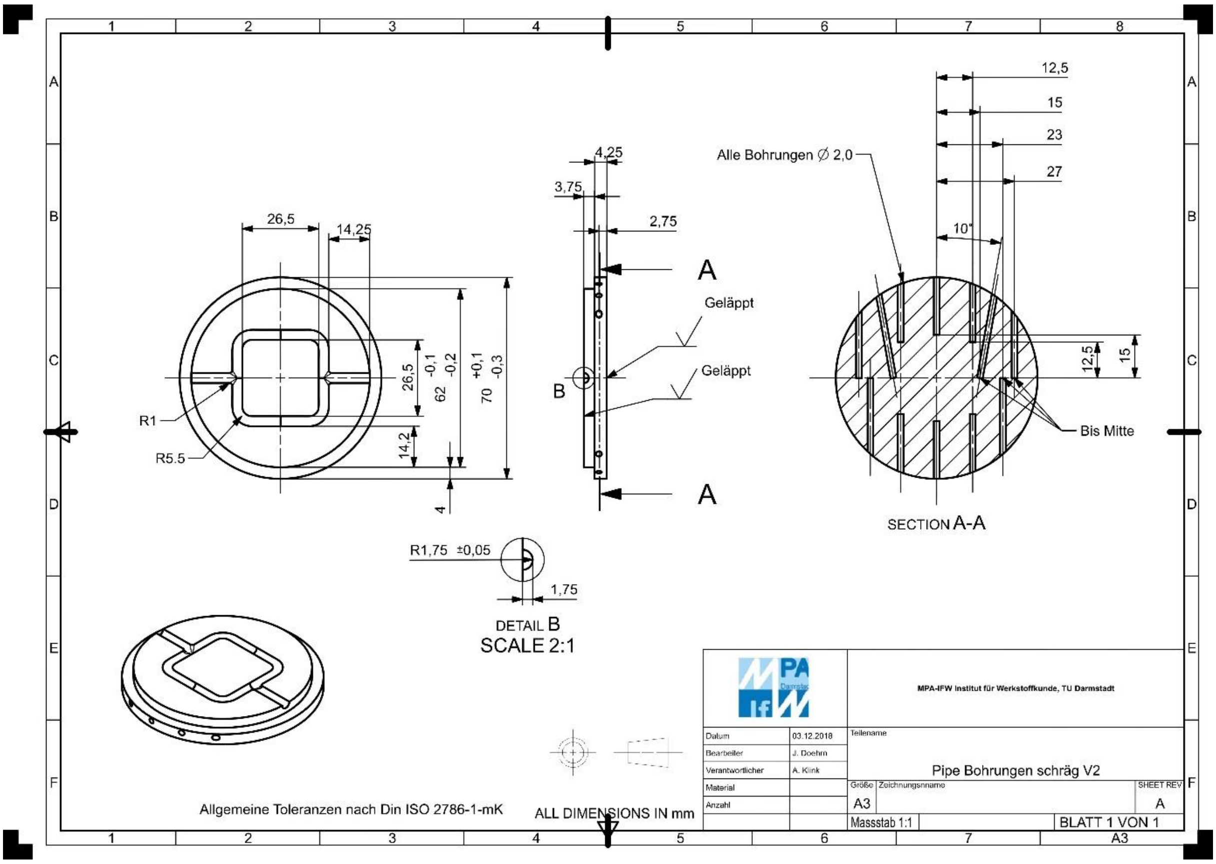


Figure 2: Technical drawing of the specimen "Complex channel geometry".

This complex channel reproduces the relevant elementary geometries in the real aggregate circuit - branching (impact and merging) and curvature (deflection). Two millimeters below the cooling channels, there are holes for implementing the temperature sensors in order to record the heat distribution as well as temperature differences within the specimen. The complex channel geometry has a total of 12 holes, of which at least eight sensors must be used for a coolant investigation.

6.3 Scope of tests

At least two tests with different water qualities and preparation concentrations are recommended:

a) Test of the coolant additive in application concentration with ion-exchanged water according to Appendix 7.1

b) Test of the coolant additive in application concentration with synthetic hard water according to Appendix 7.2

6.4 Performance

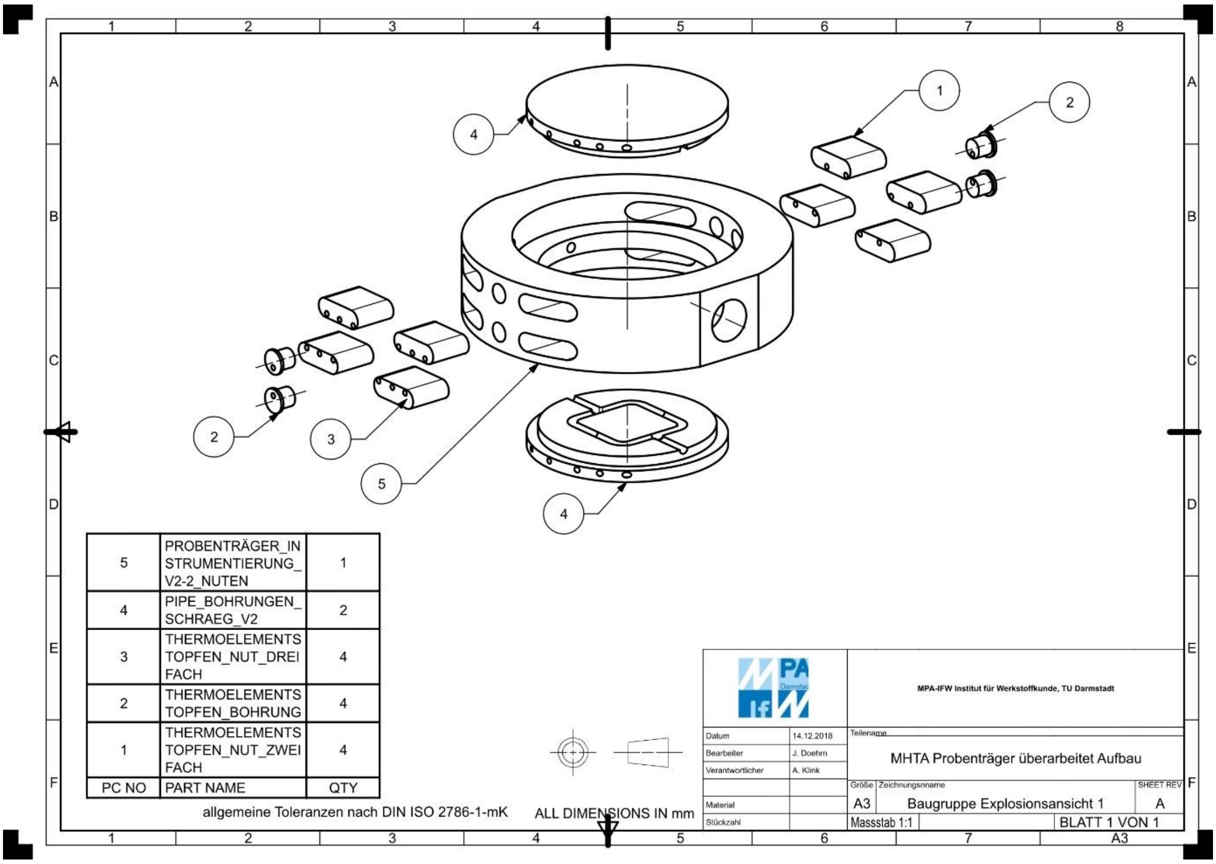
6.4.1 General

An actively heated hot specimen and a passively heated specimen (counter specimen) with the specimen geometry "complex channel" are installed in the system. The hot test investigation is performed continuously (without interruptions). No alternating test cycles are used to focus on degradation phenomena depending on the test conditions.

After sample preparation (Appendix 8.1, 8.4- 8.6), installation of the samples and checking the tightness of the system, the test shall be started according to the specified test parameters.

6.4.2 Specimen installation

The specimen installation is shown in Figure 3.



PC NO	PART NAME	QTY
5	PROBENTRÄGER_INSTRUMENTIERUNG_V2-2_NUTEN	1
4	PIPE_BOHRUNGEN_SCHRAEG_V2	2
3	THERMOELEMENTSTOPFEN_NUT_DREIFACH	4
2	THERMOELEMENTSTOPFEN_BOHRUNG	4
1	THERMOELEMENTSTOPFEN_NUT_ZWEIFACH	4

allgemeine Toleranzen nach DIN ISO 2786-1-mK

ALL DIMENSIONS IN mm

MPA-IFW Institut für Werkstoffkunde, TU Darmstadt

Datum 14.12.2018
Bearbeiter J. Doehrn
Verantwortlicher A. Klink
Material
Stückzahl
Teilename MHTA Probenträger überarbeitet Aufbau
Größe A3
Zeichnungsnname Baugruppe Explosionsansicht 1
SHEET REV A
Massstab 1:1
BLATT 1 VON 1

Figure 3: Specimen installation of the "Complex Pipe Flow“

6.4.3 Test parameters

The corresponding test parameters can be varied according to the areas limiting plant safety.

Based on current research findings, the following test parameters are recommended.

Table 1: Test parameters for thermal flow-induced degradation tests

Coolant capacity	1.2 l
Pressure	1.5 bar
Volume flow/ Flow rate	3.2 l/min
Heating capacity	2560 W
Heat flux density	66 $\frac{W}{cm^2}$
Mean flow coolant temperature	115 °C
Channel diameter	3.5 mm
Corrosive stressed area per sample half	114.4 mm^2
Test duration	40 h

Note: Information on density and vapor pressure of the test medium is required, since the control parameterization of the relative pressure serves to suppress global boiling

In order to simulate different stress collectives, the test parameters of temperature and flow rate have been varied in the corresponding research studies in the following ranges, which have proven to be suitable for the evaluation.

Table 2: Test parameters for thermal flow-induced degradation tests

Mean flow coolant temperature	95, 105, 115 [°C]
Volume flow/ Flow rate	2,2, 3,2. 4,3 [l/min]

6.4.4 Sample removal

At the end of the experiment, a coolant sample of at least 100 ml is taken and the remaining coolant is drained off. The specimens are rinsed with deionate through a spray bottle to remove the residual coolant. The samples are then stored in a drying oven at a maximum of 80°C for a period of 1h.

6.4.5 Cleaning the FDC

The procedure described here is used for standardized cleaning of the circulation system.

A rinsing sample is installed for the rinsing process, the plant is rinsed with the following media and their corresponding times:

- 10 min deionized water
- 20 min 1 vol.% caustic soda solution
- 10 min deionized water
- 30-40 min acetic acid 10 vol.%
- 10 min deionized water

The caustic soda and acetic acid can be used for a maximum of five cleaning processes.

For the mechanical cleaning all tubes of the experimental unit are dismantled:

1. all parts are cleaned individually with a nylon brush and scouring milk
2. the tubes are soaked in sodium hydroxide solution for 1 h
3. all parts are cleaned with a nylon brush and deionized water
4. the tubes are soaked in acetic acid for 24 hours
5. all parts are cleaned/rinsed with a nylon brush and deionate
6. the tubes are dried for 24h before installation.

If residues from the previous examination can still be found after carrying out the described cleaning procedure, the circulation system must be cleaned separately without residues.

6.5 Evaluation

6.5.1 General

For the test specimens

- Determination of weight change after the test, after the test as well as after cleaning and optional cleaning (see Appendix 8.2)
- Photo documentation after test after test as well as after cleaning and optional cleaning (see Appendix 8.6)
- Change of topography by documentation of the total and segmented channel surface before, after the test as well as after cleaning and optional cleaning (see Appendix 8.3 and 8.4)
- Temperature profile of the individual specimen measuring points (see Appendix 8.9)

For coolant

- Temperature course of the individual coolant measuring points
- Analysis according to Appendix 8.8 before and after the test
- Documentation of the pH value and conductivity over time for the entire duration of the test.

6.5.2 Specimen evaluation

After removal of the specimens, they are rinsed with deionate through a spray bottle to remove the coolant residues. The specimens are then stored for a maximum of 1h at 80°C in a drying cabinet and cooled with a cold hairdryer. Intermediate storage of the samples in the desiccator is permissible until further sample evaluation.

These steps are carried out for the sample evaluation:

Documentation condition after experiment:

1. photographic documentation (Appendix 8.6)
2. gravimetric documentation (Appendix 8.1) and assessment of the coatings (Appendix 8.5)
3. documentation of the topography of the entire and segmented channel surface (Appendix 8.4)

Chemical cleaning and documentation:

4. chemical cleaning of the specimens (Appendix 8.3)
5. photographic documentation (Appendix 8.6)
6. gravimetric documentation (Appendix 8.1) and survey of the coatings (Appendix 8.5)
7. documentation of the topography of the entire and segmented channel surface (Appendix 8.4)

Optional chemical post-cleaning:

8. optional cleaning (Appendix 8.3)
9. photographic documentation (Appendix 8.6)
10. gravimetric documentation (Appendix 8.1) and survey of the pavement (Appendix 8.5)
11. documentation of the topography of the entire and segmented channel surface (Appendix 8.4)

Optional metallographic evaluation and documentation:

12. optional grinding (Appendix 8.7)
13. recommended: XRD and TOF sims

7 Appendix A1 Preparation water

7.1 Ion-exchanged water

Ion-exchanged water is used; the electrical conductivity is a maximum of 2.0 µS/cm.

7.2 Synthetic hard water

The quantities listed below apply to water of 1.78 mmol/l (10 ° dGH)(2) total hardness.

All required salts, which must be present in the purity grade "p.a.", are dried for 12 h at 60 °C before weighing-in.

7.2.1 Preparation of the permanent hard wate

Weigh into 20 l of ion-exchanged water:

1,7 g $CaCl_2 \times 2 H_2O$

2,3 g $MgCl_2 \times 6 H_2O$

2,0 g $CaSO_4 \times 2 H_2O$

2,8 g $MgSO_4 \times 7 H_2O$

This results in a hardness of about 2.314 mmol/l (13° dNKH). This preparation is diluted with ion-exchanged water until the hardness to be determined by titration of 1.78 ± 0.089 mmol/l (10 ± 0.5 ° dNKH) is reached.

7.2.2 Preparing the carbonate hard water

Weigh into 20 l of ion-exchanged water:

5,6 g $CaCO_3$

1,5 g $MgCO_3 \times Mg(OH)_2$

After the salts are added, the water is gassed with CO2 cylinder gas for 12 h under constant stirring at room temperature. It is then left at room temperature for 12 h and then filtered (3).

A hardness of about 2.492...3.026 mmol/l (14...17° dKH) is obtained. Now dilute with ion-exchanged water until the hardness to be determined by titration of 1.78 ± 0.089 mmol/l (10 ± 0.5 ° dKH) is reached.

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[2] The term °dGH is actually no longer permissible according to the nomenclature. However, since it is indispensable in technical language and is frequently used in existing water analyses, it is included in these guidelines for the sake of simplicity and better handling. The new dimension is mmol/l or mol/m³, where 1° dGH = 0.178 mol/m³.

[3] S & S Faltenfilter 595 ½, Ref. No. 10 311 651, Firma Schleicher & Schuell GmbH, Postfach 4, D-37582 Dassel

7.2.3 Preparing the water of 1.78 mmol/l (10° dGH) total hardness

The waters according to Appendix 7.2.1 and 7.2.2 are mixed in a ratio of 1 : 1. This gives a total hardness of 1.78 mmol/l (10 °dGH). A control titration is then carried out (permissible deviation ± 0.178 mmol/l (± 1.0 °dGH)).

When using the indicated recipe, the total hardness is composed as follows:

0,2225 mmol/l	(1,25 °dNKH)	from $CaCl_2$	0,2225 mmol/l	(1,25 °dNKH)	from $CaSO_4$
0,2225 mmol/l	(1,25 °dNKH)	from $MgCl_2$	0,2225 mmol/l	(1,25 °dNKH)	from $MgSO_4$
0,6675 mmol/l	(3,75 °dKH)	from $Ca(HCO_3)_2$	0,2225 mmol/l	(1,25 °dKH)	from $Mg(HCO_3)_2$

8 Appendix A2 Documentation of results

8.1 Weighing of specimens

Weighing accuracy ± 0.1 mg

Weigh the specimens before the test and at positions 2, 6 and 10 of the specimen evaluation (see Section 6.5.2):

- Carry out at least three measurements whose difference is < 0.2 mg, otherwise carry out two further measurements and then calculate the arithmetic mean.

8.2 Mass removal

For all specimens examined, the mass removal (difference from the specimen mass before the start of the test) shall be documented in the following states:

1. after the end of the test
2. after cleaning of the specimens
3. after optional post-cleaning of the specimens

Mass removal (difference between "mass before test" and "mass of current state") is indicated with a positive value in the unit of measurement "mg". An increase in mass, for example due to occupancy (difference between "Mass before test" and "Mass of current state" is less than 0) is indicated with a negative value in the unit of measurement "mg".

8.3 Chemical cleaning

For material $AlS_{i6}Cu_4$: Description Rinsing Drying (1. Dry temperature sensor bores with pipe cleaner)

For material $AlSi_{10}Mg$:

For materials deviating from this, a suitable chemical cleaning process is permissible, provided that it is described in detail and the blank removal rate is known or determined. a blank removal rate of 3.1 mg with an uncertainty of 0.3 mg is recommended.

8.4 Topographic documentation of the surface condition

The topographical recording of the cooling channel of the specimens is carried out before the test and at characteristic positions 3, 7 and 11 of the specimen evaluations (see Section 6.5.2):

The following optical analysis methods are available for selection:

3D digital microscopy: Here, a 2D and 3D overall view of the specimen is taken at 50x magnification and then up to six 2D detailed images of the channel are taken at 200x magnification.

3D Profilometer: Here, a 3D general overview is taken at 80x magnification followed by up to six 2D detailed images of the channel at 120x magnification. The evaluation includes the recording of volumes, line roughness and height/depth profile sections for the samples before test, after test and after chemical cleaning. (Recommended)

8.5 Description of the surface condition of the round specimens

Visual inspection of the specimens is performed before the test and at the specified locations 2, 6 and 10 of the specimen evaluations (see Section 6.5.2). The following assessments must be carried out for the channel and the rest of the specimen surface:

- Type and degree of coating formation or damage
- Structure of the coating
- Overflow outside the specimen channel

8.6 Photographic documentation of the surface condition

Photographing the specimens provides an overall view of the specimen, with all specimens photographed with the same settings (exposure, exposure time, magnification, etc.) and orientation.

8.7 Metallographic documentation by means of a microsection

Microsections can be made on selected specimens to characterize the microstructure and possible corrosion or layer formation. The influence of temperature and flow rate can be seen.

8.8 Documentation of the test liquid

The following conditions of the test liquid must be documented before and after the end of the test:

1. optical changes
2. filtration of sediments / solids (gravimetry, size, analysis, etc.)
3. changes in conductivity, pH, density, volume concentration, alkali reserve, coolant constituents (including organic and inorganic inhibitors, degradation products, corrosive products) and their amount

8.9 Documentation of the temperature profile of the heated specimen

The temperature course of the heated specimen and the two heaters must be documented over the entire course of the test. The temperature sensors in the specimen are 2 mm below the cooling channel and allow the recording of the temperature changes depending on the flow as well as their elementary geometries.

9 Appendix A3 Specification of specimen materials

9.1 Ferrous materials

9.1.1 Unalloyed gray cast iron EN-GJL-250 (GG 25)

pearlitic matrix, graphite type A, graphite size 3...4, SC 0.85...0.90;

hardness 215...230 HB 5/750

9.1.2 Centrifugal cast iron MMN 380.3 three-strip pearlitic structure, graphite type A or B, graphite size 3 to 6, SC 0.80...0.90; hardness 230...280 HB 5/750A2)

Note: Not feasible under the current test parameters described in Section 6.4.3. Individual adaptation is required with regard to the heat input in the heating phase, since gray cast iron has poorer thermal conductivity.

9.1.3 Unalloyed steel RRSt 14.05Wk-No. 1.03386 05 DIN 1623

9.2 Aluminum materials

9.2.1 EN AC-Al Si6Cu4 ($AlSi_6Cu_4$)

Material No. AC-45000 according to DIN EN 1706 heat treated; hardness 110...150 HB 30

9.2.2 EN AC-Al Si10Mg ($AlSi_{10}Mg$) T6

10 Appendix A4 Cleaning chemicals

10.1 Nitric acid

a) 56 vol.-% nitric acid (HNO_3) p.a.

b) 5 vol.-% nitric acid (HNO_3) p.a.

H/P:	a) H: 290-331-314 EUH071 P: 280-301+330+331-303+361+ 353-304+340-305+351+338-310 b) H: 290-314 P: 280-303+361+353-305+351+ 338-310
MAK values:	5,2 mg/m³ resp. 2 ml/m³
Properties	Clear, colorless liquid with pungent odor. Miscible with water. Strongly corrosive and irritant
Notes on safe handling: Ensure maximum cleanliness at the workplace. Only the quantities of substance required for the progress of the work may be present at workplaces. Do not leave containers standing open. For decanting and transferring, use tightly sealed equipment with extraction if possible. Avoid free fall or minimize fall heights. Avoid splashing. Only fill into labeled containers. Use acid-resistant auxiliary equipment. Avoid any contact during open handling. Prepare mixtures with other substances only according to the instructions of qualified chemical personnel. Release of nitrogen oxides! Prevent penetration into the ground safely (steel pan). When transporting in fragile vessels, use suitable overpacks.	

10.2 Hydrochloric acid

10 vol.-% hydrochloric acid (HCl) p.a. + 1 ml/l Propargyl alcohol (2-propyn-1-ol) acc. to A 15.10

H/P:	H: 290-315-319-335 P: 280-303+361+353-305+351+338+310
MAK values	8 mg/m³
Properties:	Concentrated hydrochloric acid is a 37% solution of hydrogen chloride in water.
Notes on safe handling: Ensure cleanliness at the workplace. Only the quantities of substance required for the progress of the work may be present at workplaces. Do not leave containers standing open. For decanting and transferring, use tightly sealed equipment with extraction if possible. Avoid spillage. Avoid splashing. Avoid free fall or minimize drop heights. Only fill into labeled containers. Use acid-resistant auxiliary equipment. Avoid any contact during open handling. When transporting in fragile containers, use suitable overpacks.	

10.3 Acetic acid

a) 100 vol.-% acetic acid (Ethanoic acid – CH_3COOH) p.a.
b) 1 vol.-% acetic acid

H/P:	a) H: 226-H314 P: 210 P280 P301+P330+P331 P303+P361+P353 305+P351+P338 P310 b) harmless
MAK values	25 mg/m³ resp. 10 ml/m³
Properties:	Acetic acid is a colorless, hygroscopic liquid with a pungent odor.
Notes on safe handling: Ensure cleanliness at the workplace. Only the quantities of substances required for the progress of the work may be present at workplaces. Do not leave containers standing open. For decanting and transferring, use tightly sealed equipment with extraction if possible. Avoid free fall or minimize fall heights. Avoid splashing. Fill only into labeled containers. Use solvent-resistant auxiliary equipment. Use acid-resistant auxiliary equipment. Avoid any contact during open handling. Use suitable overpacks when transporting in fragile containers.	

10.4 Formic acid

5 vol.-% formic acid (methanoic acid - HCOOH) p.a.

H/P:	H: 315-319 P: 264-280-302+352-305+351+338-337+313
MAK values	5 ml/m³
Properties:	Methanoic acid is a colorless and clear liquid with a pungent odor.
Notes on safe handling: Only the quantities of substance required for the progress of the work may be present at workplaces. Do not leave containers standing open. For filling and decanting, use tightly sealed equipment with extraction if possible. Avoid splashing. Avoid free fall or minimize drop heights. Only fill into labeled containers. Use solvent-resistant auxiliary equipment. Use acid-resistant auxiliary equipment. Use acid-resistant pumps, fittings and valves. Avoid any contact during open handling. When transporting in fragile vessels, use suitable overpacks, e.g. made of polyethylene.	

10.5 Petroleum gasoline

H/P:	H: 225-304-315-336-350-411 P: 210-243-280-301+310-301+330+331-403+233-501
MAK values	---
Properties:	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists predominantly of cycloparaffinic hydrocarbons having carbon numbers predominantly in the range of C6 to C7 and boiling in the range of about 73°C to 85°C.
Notes on safe handling: Ensure cleanliness at the workplace. Only the quantities of substance required for the progress of the work may be present at workplaces. Do not leave containers standing open. For decanting and transferring, use tightly sealed equipment with extraction if possible. Do not pump with compressed air. Avoid free fall or minimize fall heights. Avoid splashing. Fill only into labeled containers. Use solvent-resistant auxiliary equipment. When transporting in fragile containers, use suitable overpacks.	

10.6 Acetone

Acetone (Propanone – CH_3COCH_3)

H/P:	H: 225-319-336 EUH066 P: 210-240-305+351+338-403+233
MAK values	500 ml/m³
Properties:	Propanone is a clear colorless liquid with an aromatic odor
Notes on safe handling: Only the quantities of substance required for the progress of the work may be present at workplaces. Do not leave containers standing open. For decanting and decanting, use tightly sealed equipment with extraction if possible. Use gas pendulums as an alternative to suction. Do not pump with compressed air. Avoid splashing. Avoid free fall or minimize drop heights. Fill only into labeled containers. Use solvent-resistant auxiliary equipment. When transporting in fragile containers, use suitable overpacks.	

10.7 Monohydric alcohols

Ethanol (Ethyl alcohol - C_2H_5OH) absolute (denatured with 1 % petroleum ether)

H/P:	H: 225-319 P: 210-240-305+351+338-403+233
MAK values	1000 ml/m³
Properties:	Ethanol is a colorless, clear liquid with hygroscopic properties. Together with air it can form explosive mixtures.
Notes on safe handling: Ensure cleanliness at the workplace. Only the quantities of substance required for the progress of the work may be present at workplaces. Do not leave containers standing open. For decanting and transferring, use tightly sealed equipment with extraction if possible. Do not pump with compressed air. Avoid free fall or minimize fall heights. Avoid splashing. Fill only into labeled containers. Use solvent-resistant auxiliary equipment. When transporting in fragile containers, use suitable overpacks.	

10.8 Propargyl alcohol

Propargyl alcohol (2-propyn-1-ol)

H/P:	H: 226-331-311-301-314-411 P: 261-273-280-301+310-305+351+338-310
MAK values	2 ml/m³
Properties:	Toxic, colorless, flammable liquid with pleasant odor. The substance presents acute or chronic health hazards. The substance can be absorbed through the skin. Vapors may form an explosive mixture with air when the substance is heated above its flash point. This is possible even at elevated ambient temperatures. Sensitive to light. Miscible with water. Volatile. The substance is dangerous for the environment.
Notes on safe handling: Provide very good ventilation of the work area. Since vapors/gases are heavier than air, appropriate ventilation must also be provided in the floor area. Ensure maximum cleanliness at the workplace. Only the quantities of substances required for the progress of the work may be present at workplaces. Do not leave containers standing open. For decanting and transferring, use tightly sealed equipment with extraction if possible. Do not pump with compressed air. Avoid free fall or minimize fall heights. Avoid splashing. Fill only into labeled containers. Use solvent-resistant auxiliary equipment. Avoid any contact during open handling. Prevent penetration into the ground safely (steel tray). When transporting in fragile containers, use suitable overpacks.	

10.9 Sodium hydroxide

1 vol.-% sodium hydroxide as alkaline solutions of sodium hydroxide (NaOH) in water

H/P:	H: 290-315-319 P: 280-302+352-305+351+338-332+313-337+313
MAK values	2 ml/m³
Properties:	Toxic, colorless, flammable liquid with pleasant odor. The substance presents acute or chronic health hazards. The substance can be absorbed through the skin. Vapors may form an explosive mixture with air when the substance is heated above its flash point. This is possible even at elevated ambient temperatures. Sensitive to light. Miscible with water. Volatile. The substance is dangerous for the environment.
Notes on safe handling: Provide very good ventilation of the work area. Since vapors/gases are heavier than air, appropriate ventilation must also be provided in the floor area. Ensure maximum cleanliness at the workplace. Only the quantities of substances required for the progress of the work may be present at workplaces. Do not leave containers standing open. For decanting and transferring, use tightly sealed equipment with extraction if possible. Do not pump with compressed air. Avoid free fall or minimize fall heights. Avoid splashing. Fill only into labeled containers. Use solvent-resistant auxiliary equipment. Avoid any contact during open handling. Prevent penetration into the ground safely (steel tray). When transporting in fragile containers, use suitable overpacks.	

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