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PLASTIC PIPE
Cooling systems

Part must comply with VCC Restricted Substance Management Standard (RSMS) VCS 5036,5

TECHNICAL REGULATION

PLASTIC PIPE

Approved by (dept, name, phone)	Issued by (dept, name, phone)
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001	2017-04-27	Mattias Ansebo	New TR based on TR 8888162949
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1 REQUISITED DOCUMENTS

VCS 5036,5	VCC Restricted Substance Management Standard (RSMS)
VCS 1212,362	PA 12
VCS 1212,069	PA 66
VCS 5089,19	Tightness requirements
VCS 5091.159	Cleanliness of parts, components and/or systems
ISO 4650:1984	Infrared spectrometry
ISO 9924:2000	Thermo gravimetric analysis
TR 31836088/002	Hose sealing for cooling system, worm screw clamps
Drawing on actual coolant	
Drawing on actual pipe	

2 FUNCTIONAL ENVIRONMENT

2.1 General

The pipe shall distribute coolant between the various components in the cooling and heating system of the engine. Expected lifetime is at least 15 years or 240 000 km. The pipe shall be secured to the pipe connections with pipe clamps or quick connectors. The coolant can consist of water or a mixture of water and glycol. The temperature of the coolant can vary between -40°C and +135°C. Normal working temperature is +90 to +105°C. For GEP engines normal working temperatures are +105° to + 115°C. The pressure (wP) in the pipe can vary from –97kPa (during filling of the cooling system in the plant) to a maximum pressure as stated in a table. All pressures stated in this ES are gauge pressures. Certain pipes shall take up movement between the engine and other components in the cooling system (drawing is provided with an arrow in the direction of the movement). The pipe is subjected externally to engine cleaning agents and overflow of oil and grease.

Test liquids as per vehicle installation if otherwise not stated.

2.2 General component requirement

All components shall withstand the environment which they may be exposed to in a vehicle. The component shall be capable to withstand vehicle sign-off tests such vehicle durability (e.g. VPT1 and VPT2) and vehicle corrosion (CORCAR previously called LPK) and not cause functional problems within the vehicle.
If the supplier believes that the component tests are missing in the Technical Regulation which are attached to the corresponding ESOW, the supplier shall respond with:
- What is missing
- Why
- Proposal(s) for additional or modified tests
- Reason for the additional/modified test(s) and any form of failure modes which the test(s) will help to detect.
- Agreement for additional test must be made with CEVT design department.

2.3 Temperature profile

Table 2.2.3 Time- temperature spectra for plastic pipe oil cooler VEP, calculation based on 240.000km.

Ambient temperature (°C)	Coolant temperature (°C)	Proportion (%)	Time (h)
115	125	0,1	10
110	115	0,9	50
105	110	9	500
95	100	35	2000
80	95	24	1400
65	75	31	1800

Table 2.2.4 Time- temperature spectra for plastic pipe oil cooler VED, calculation based on 240.000km.

Ambient temperature (°C)	Coolant temperature (°C)	Proportion (%)	Time (h)
110	115	0,1	10
105	100	0,9	50
90	95	9	500
80	85	35	2000
65	80	24	1400
50	60	31	1800

Table 2.2.5 Time- temperature spectra for air ventilation hose GEP, calculation based on 200.000km.

Ambient temperature (°C)	Coolant temperature (°C)	Proportion (%)	Time (h)
125	135	<0,1	10
120	130	<0,1	20
115	125	4	190
110	120	15	700
100	110	32	1500
70	105	23	1130
60	60	25	1200

Table 2.2.6 Time- temperature spectra air ventilation hose GEP, calculation based on 200.000km.

Ambient temperature (°C)	Coolant temperature (°C)	Proportion (%)	Time (h)
115	125	<0,1	10
110	120	<0,1	20
105	115	4	200
100	110	15	710
90	100	32	1520
70	90	17	800
60	60	31	1500

Table 2.2.7 Time- temperature spectra Electric drivetrain cooling circuit hybrid, calculation based on 200.000km.

Ambient temperature (°C)	Coolant temperature (°C)	Proportion (%)	Time (h)
105	90	<0,1	200
90	70	8	500
90	50	33	2000
50	50	55	3300

Table 2.2.8 Time- temperature spectra Battery cooling circuit hybrid, calculation based on 200.000km.

Ambient temperature (°C)	Coolant temperature (°C)	Proportion (%)	Time (h)
105	90	<0,1	200
100	35	8	500
90	35	33	2000
50	35	55	3300

2.4 Test conditions

Table 2.3.1 Pressure and equivalent temperatures and time for different applications.

Application	Maximum pressure,Pmax	Equivalent temperature for temperature resistance tests	Time in test
Oil cooling pipe, VEP	220 kPa	Ambient 115°C Coolant 120 °C	1100 h
Oil cooling pipe, VED	400 kPa	Ambient 100°C Coolant 105 °C	1100 h
Air vent hose, GEP	200 kPa	Ambient 130°C Coolant 130 °C	1600 h
Electric Drivetrain circuit, hybrid	220kPa	Ambient 100°C - Coolant 100°C	700 h
Battery cooling hybrid	70 kPa	Ambient 100°C - Coolant 100°C	700 h

Temperature requirements can be higher depending on application and environment.
All pressure values given in this TR are gauge pressures.

Table 2.3.2 Test conditions properties.

Application	Pipe to be considered as flexible (Y/N)	Coolant
FOH coolant pipe assy.	No	glycol/water (70/30)
Oil cooling pipe VEP/VED	Yes	glycol/water (70/30)
Air vent hose GEP/GED	Yes	glycol/water (70/30)
Engine Drive circuit, hybrid	Yes	glycol/water (70/30)
Battery cooling hybrid	Yes	glycol/water (70/30)

2.5 Surface requirements

The pipe shall be free from folds, cracks, pores and blisters. The internal surface of the pipe shall be smooth. All pipes must be black in appearance except for markings.

Test report
Note where pipes failed and preferably include picture.

2.6 Spigot design

Spigot supplier must insure compability with the quick connector. This should be done by addition of quick connector part numbers on the spigot drawing. Spigot design at pipe could be according to: SAE standard, VDA standard, DIN 3021-3.

3 PROPERTY REQUIREMENTS

3.1 Test and documentation

The documentation should be so complete that it would be possible to repeat the tests and evaluations at any time in the same way and at the same conditions.

What shall be reported is described in connection with each test below and in the concerned standards and serves as a minimum specification of what the TR test report must include.

The report must also include the following items:
TR number and issue.
Supplier number and supplier's designation.
Test object: Pipe part number and issue.
Polymer/Compound.
Manufacturing method.
Reason for TR test (example: new supplier, new construction of the pipe).
Deviations discussed and approved by design department (date +reference/No).
TR reviewed together with CEVT (date +reference/No) (Testing at supplier).
Assessment of test equipment and evaluation methods by CEVT (date +reference/No).
Main test laboratory.
Signature, clarification of signature, and date.

The repeatability of each test is important. Therefore the following must also be documented for each test in this TR:
Equipment.
Test method.
Test laboratory if other than stated above.
Date of the test.
Any other pertinent details of the entire test and any relevant comments and observations.

3.1.1 Amount of test samples

Test flow chart diagram show how many test pieces that is necessary in each test.

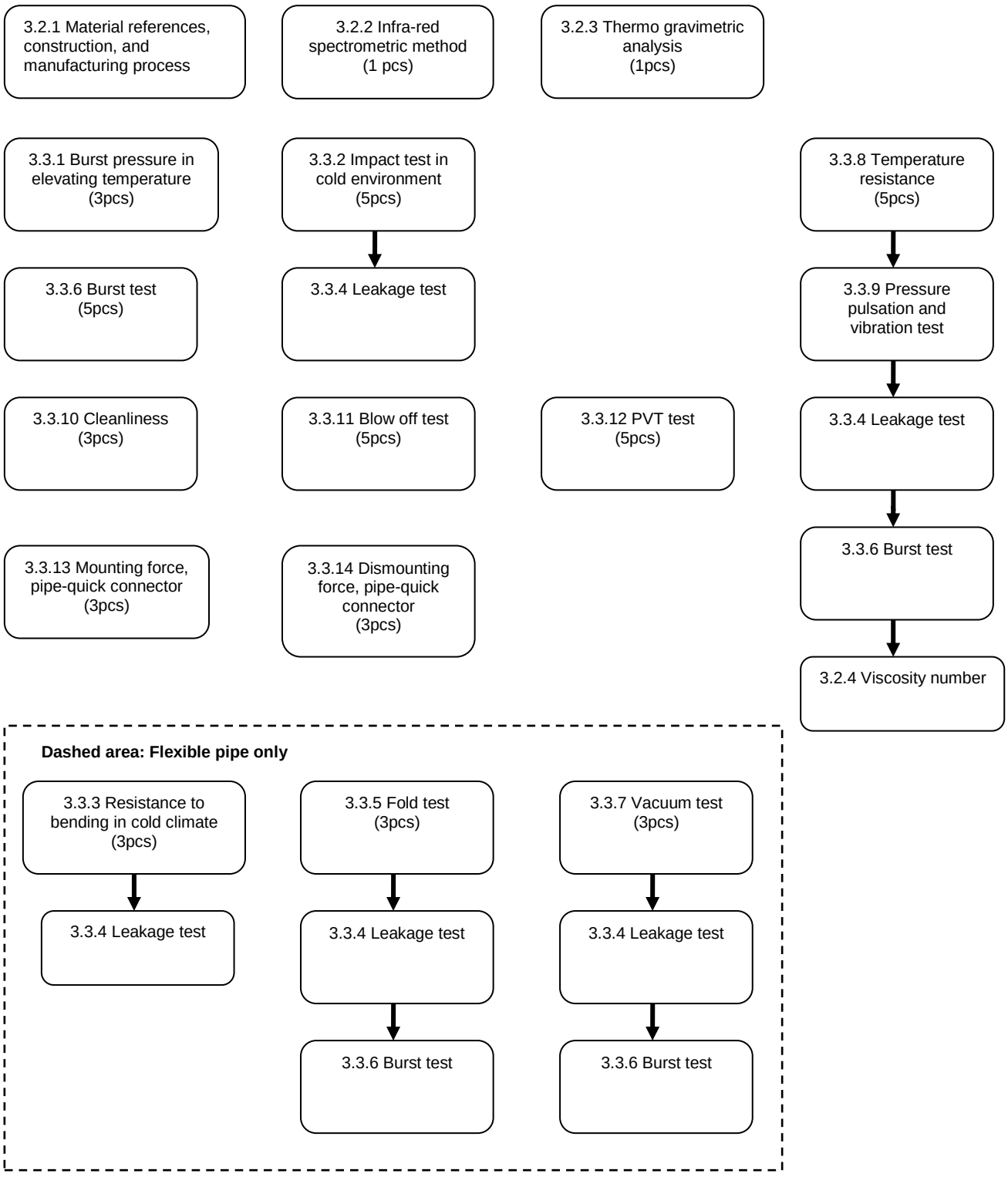
3.1.2 Testing at supplier

It is strongly recommended that the TR is reviewed in detail together with the responsible design department at CEVT at an early stage in order to clarify any doubts before initiating any tests.

The supplier must show evidence to CEVT design department that it has the appropriate test equipment and evaluation methods in order to meet CEVT requirements. The same applies if the supplier decides to make tests at a third part.

An assessment of the suppliers testing capabilities is recommended to be made by means of a TR review according to above and a visit to the supplier by CEVT.

3.1.3 Test flow chart



3.2 MATERIAL PROPERTIES

For unspecified data, the supplier selects a composition, materials, and a manufacturing method of the pipe, which ensures the function of the part during its lifetime in its installation, based on the functional environment and the performance requirements in this TR.

3.2.1 Material references, construction, and manufacturing process

Report the material specification, the construction of the pipe as detailed as possible. Pipe material must follow restrictions according to VCS 5036,5. Chosen material should also meet VCC standard. Example of standards:
PA 12 VCS 1212, 362.
PA 6.6 VCS 1212, 069.
Or equivalent for selected material type.

Test report
Describe the manufacturing method as detailed as possible and document process control plan.
Note material, including raw material supplier and trade name of used polymer.

3.2.2 Infra-red spectrometric method

Material identification is made by IR-analysis. ISO 4650:1984.

Test report
Spectra of polymer.

3.2.3 Thermo gravimetric analysis

See ISO 9924:2000. The element in the ash is then determined with for example SEM-EDS or XRF. Material for testing must be taken from component.

Test report
Carbon black content.
Polymer content.
Ash content.
Element in ash.

3.2.4 Viscosity number

Determine of viscosity number according to ISO 307.

Test report:
Note viscosity number.
Note statement from material supplier regarding test result.

3.3 MECHANICAL PROPERTIES

3.3.1 Burst pressure in elevating temperature

The test is performed with complete plastic coolant pipe. The test is performed with pre-conditioned parts. The pipes are mounted in a rig with coolant as per vehicle installation. Pipes are installed according to vehicle orientation. Test is performed in climate chamber.

Pre conditioning:

* Ambient temperature:	90±3°C
* Circulating coolant temperature:	90±3°C
* Coolant mixture:	see table 2.3.2.
* Pressure:	100±5kPa
* Time:	96h

After pre-conditioning the pipe/hose are to be conditioned at RT for 2± 1hours before test. The test is performed with complete plastic coolant pipe.

Tested pipes are filled with coolant and put into climate chamber. Let temperature in chamber and coolant be stabilised for 1h at 130°C for applying test pressure.

Test:

Medium:	Circulating coolant in table 2.3.2.
Medium temperature in test:	120±3°C.
Climate chamber temperature at test start:	130±3°C
Increase of climate chamber temperature:	continuously increased 10±3°C/h.
Constant pressure:	See table 2.3.1.

Acceptance criteria
The burst/ blow off temperature is to be minimum 160°C.

Test report
Note burst, leakage or blow off temperature (or OK after 180°C) for all tested pipes and failure mode.

3.3.2 Impact test in cold environment

See TR Hose sealing for cooling system, clamps and quick connectors, 8888162944NOTE TREG TR Clamps and Quick connectors, 3.4.10.

The test is performed on cooling pipes with unconditioned parts. The weight is released over the pipe and spigot serration.

Acceptance criteria
No cracking is permitted.
This test is part of a sequence test. See Test flow chart.

Test report
Note failed or OK.

3.3.3 Resistance to bending in cold environment

This test is only valid for flexible pipes (ex. extruded PA12 pipe). Test is performed on straight pipe. See table 2.3 if test applies for application. A sample is taken from a cooling hose, approximately 30cm long (for hoses with an outer diameter smaller than 12mm) at +110±3°C in a climate chamber for 24 hours. Within 30 minutes after heating the test sample is to be cooled to -35±3°C for 4 hours.
A mandrel, 12 times the nominal external diameter of the hose, is also cooled to -35±3°C together with the hose. Directly after cooling for 4 hours the hose is bent around the mandrel according to figure 1. The bending movement is to be completed in 5±2sec and then held in place for 10±2sec.

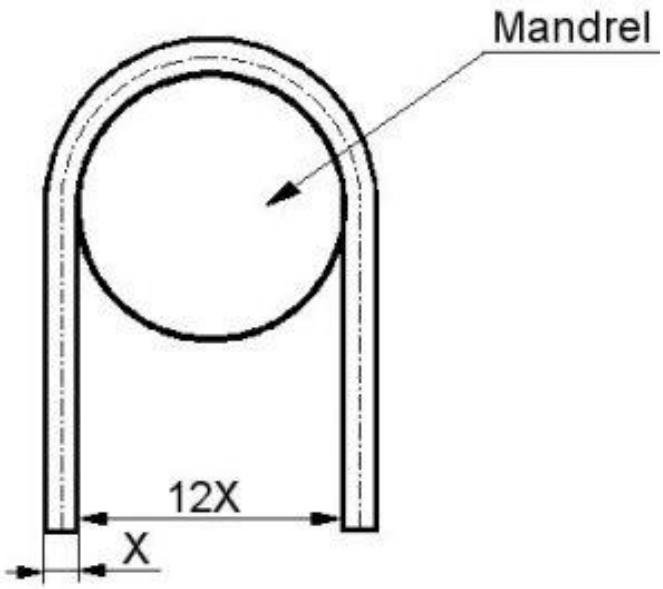


Figure 1. Bending of flexible plastic hose.

Acceptance criteria
This test is part of a sequence test. See Test flow chart.

Test report
Note failed or OK

3.3.4 Leakage test

The complete pipes are pressurised and checked for leakage. Connections as in vehicle installation are used. Test is preferable performed under water.

Tightness requirements:	VCS 5089,19.
Medium:	Air.
Temperature:	RT
Pressure:	Pressure in table 2.3.1.

Acceptance criteria
Max leakage: 48 mm^3/s

Test report
Note leakage rate.
If failed note were leakage occurred.

3.3.5 Fold test

This test is only valid for flexible pipes (ex. extruded PA12 pipe). See table 2.3. Contact CEVT design if further guidance is needed. Fold the pipe in three different locations completely together for 10 seconds, according to figure 3.3.9.1. Contact CEVT design department for appropriate locations for folds. Then put the complete hose in test rig mounted on spigots so that the ends of the hose obtain their theoretically correct position.

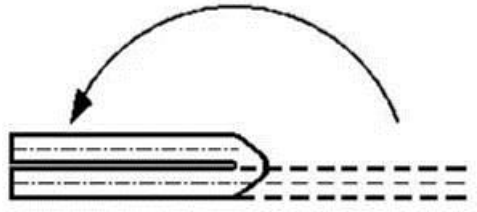


Figure 2. Pictures show how to fold plastic hoses. Distance between the fold and were the hose is completely pressed together should be 100mm.

Media:	Coolant. Se table 2.3.2	
Media temperature	See table 2.3.1	
Ambient temperature:	See table 2.3.1	
Pressure pulsation (low pressure – high pressure):		50% of Pmax – Pressure in table 2.3.1.
Pressure puls:	Trapets shape. One period 6 sec.	
Time:	200 000 pressure cycles (ca 335h).	

Acceptance criteria:
This test is part of a sequence test. See Test flow chart.

Test report:
Note burst pressure/ blow off for all tested hoses and failure mode.
Note with photo how pipe looked like when foldered.

3.3.6 Burst test

The test is performed with complete plastic coolant pipe. The test is performed with pre-conditioned parts.

Pre conditioning of unaged part before burst test is made according to below method:

* Ambient temperature:	90±3°C
* Circulating coolant temperature:	90±3°C
* Coolant mixture:	see table 2.3.2.
* Pressure:	100±5kPa
* Time:	96h

After pre-conditioning the pipe are to be conditioned at RT for 2± 1hours before burst. The test is performed with complete plastic coolant pipe.

Media:	Coolant or water
Media temperature	RT
Pressure increase rate:	30 – 50 bar/min
Ambient temperature:	RT

Acceptance criteria

Unaged parts (pre conditioned):	Min burst pressure is 4 times the pressure Pmax in table 2.3.1.
Sequence tested parts:	Min burst pressure is 3 times the pressure Pmax in table 2.3.1.

Test report
Note burst pressure for all tested pipes.

3.3.7 Vacuum test

Media:	Air.
Pressure:	-97±3kPa.
Time:	5 min.
Temperature:	RT.

Acceptance criteria
This test is part of a sequence test. See Test flow chart.

Test report:
Note: Shape and condition of the hose during test.

3.3.8 Temperature resistance test

The pipe is mounted in a rig on spigots so that the ends obtain their theoretically correct positions. Connections as in vehicle installation are used. Do not dismount quick connector during testing. This methods are tested in different combination with other methods in this technical regulation. See chapter flow chart.

Medium	Coolant. See table 2.3.2
Coolant temperature:	See table 2.3.1 (start with temp. from phase 1. Phase 2 follow if valid within time)
Ambient temperature:	See table 2.3.1 (start with temp. from phase 1. Phase 2 follow if valid within time)
Constant pressure:	See table 2.3.1 , 50% of Pmax (e.g. Oil cooling pipe, GEP: (220*0,5) = 110kPa)
Duration*:	duration in table 2.3.1 – 700h. (e.g. Oil cooling pipe, GEP: (1100-700) = 400h)

* 700h corresponds to duration in Pressure pulsation and vibration test.

Acceptance criteria
This test is part of a sequence test. See Test flow chart.

Test report:
Photo on test setup in heat chamber.

3.3.9 Pressure pulsation and vibration test

The pipe is mounted in a rig on spigots so that the ends obtain their theoretically correct positions. The pipe must withstand a combined pressure pulsation and linear axle movement test. The drawing is provided with an arrow at one of the hose ends, indicating the direction of movement.

Do not dismount quick connector during testing. This test is a part of sequence test.

Medium:	Circulating coolant. See table 2.3.2.
Ambient and Medium temperature:	See table 2.3.1.
Duration:	50 000 000 Vibration Cycles (ca 700h).
Pressure pulsation (low pressure – high pressure)	50% of Pmax – Pmax in table 2.3.1.
Pressure pulsation shape:	Trapets, one period 6 seconds
Pressure tolerance during change of pressure:	±10%
Pressure tolerance at low/high pressure:	±5kPa
Vibration frequency and amplitude:	Peak to peak 2mm, linear vibration at 20Hz.

Acceptance criteria
This test is part of a sequence test. See Test flow chart.

Test report:

Photo on test setup in heat chamber.
Note coolant name.
Show pressure pulsation in diagram.

3.3.10 Cleanliness

The pipe shall be washed clean from loose clinging talcum, grease or other substance used during process manufacture. Test method use VCS 5091.159. Agitation (5.2) or Pressure rinse (5.3) is used, method is decided together with VCC design department.

Test filter size: 0,05 10^{-6} m.

Acceptance criteria
The permitted content of impurities introduced into the cooling system by the pipe is:

Metallic materials:
No particles > 0,5 mm
0,2 mm ≤ max 5 particles ≤ 0,5 mm

Non metallic materials:
No particles > 2,0 mm (Particle size must be within: ratio length/width is more than 15/1.
0,5 mm ≤ max 5 particles ≤ 2,0 mm

Maximum total weight of particles: 0,1g.

This is based on field experience with water pump sealing sticking thermostat

Test report
Note total total weight of particles.
Note how many metallic particles within 0,2 mm – 0,5 mm.
Note how many non metallic particles within 0,2 mm – 2,0 mm.
Used extraction fluid.
Total volume of extraction fluid.
Volume of extraction.

3.3.11 Blow off test

See TR Hose sealing for cooling system, clamps and quick connectors, 8888790893, 3.4.2.

3.3.12 Pressure Vibration Temperature cycling test

See TR Hose sealing for cooling system, clamps and quick connectors, 8888790893, 3.4.4.

3.3.13 Mounting force, pipe – quick connector (SAE standard)

See TR Hose sealing for cooling system, clamps and quick connectors, 8888790893, 3.4.8.

3.3.14 Dismounting force, pipe – quick connector

See TR Hose sealing for cooling system, clamps and quick connectors, 8888790893, 3.4.9.

3.4 VEHICLES TESTS

CEVT design department together with testing departments will decide, based on application, new- or re-design, which vehicle tests that have to be performed prior to start of production. The tests in this chapter are more a sort of guide line what tests that could be done after vehicles tests. This will give us fact about conditions between rig tests and vehicle tests.

3.4.1 Burst pressure after vehicle test

After completed vehicle test from 100% VPT on Hällered and other long mileage tests, hoses should be investigated regarding burst test.

3.4.2 Abrasion

After completed VPT on Hällered vehicle test the hose is analysed regarding abrasion. Any abrasions that may arise should be documented with photographs.

Acceptance criteria:
Max abrasion in hose: 0,5mm.

3.4.3 Crash test

The hose shall fulfil low speed crash without failure.