TECHNICAL SPECIFICATION

ISO/TS 14907-1

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Road transport and traffic telematics — Electronic fee collection — Test procedures for user and fixed equipment —

Part 1: Description of test procedures

Télématique de la circulation et du transport routier — Perception du télépéage — Modes opératoires relatifs aux équipements embarqués et aux équipements fixes —

Partie 1: Description des modes opératoires

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 14907-1 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 204, *Intelligent transport systems*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European pre-Standard..." to mean "...this Technical Specification...".

ISO/TS 14907 consists of the following parts, under the general title *Road transport and traffic telematics — Electronic fee collection — Test procedures for user and fixed equipment*:

— *Part 1: Description of test procedures*

The following parts are under preparation:

— *Part 2: EFC application interface conformance tests specification*

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Foreword

This document (CEN ISO/TS 14709-1:2005) has been prepared by Technical Committee CEN/TC 278 "Road Transport and Traffic Telematics", the secretariat of which is held by NEN, in collaboration with Technical Committee ISO/TC 204 “Intelligent Transport Systems”.

This document supersedes ENV ISO 14907-1:2000.

This document is part of the following series of standards related to testing of electronic fee collection (EFC) equipment and systems:

— CEN ISO/TS 14907-1, *Road transport and traffic telematics – Electronic fee collection – Test procedures for user and fixed equipment – Part 1: Description of test procedures (ISO/TS 14907-1:2005)*

— CEN ISO/TS 14907-2[1)], *Road transport and traffic telematics – Electronic fee collection – (EFC) Test procedures for user and fixed equipment - Part 2: EFC application interface conformance tests specification*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this CEN Technical Specification: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

[1)] To be published.

Introduction

For an EFC system, approvals and tests are required to determine whether the system (or individual modules of the system) conforms to standards and application requirements, and to enable parameters, such as quality, availability and maintainability, to be measured.

There are complete EFC systems including documentation and approvals available which are possibly in operation in some countries of Europe. This document provides a toolbox of tests and procedures for the assessment and proof of such EFC systems that they are suitable for specified EFC applications under specific operational conditions. Dependent on a system to be tested and based on the available documentation and the status of already carried out approvals this document enables parties involved e.g. system provider, operators and test houses to take into consideration already proven references and to identify such parameters which still have to be tested according to the specified applications.

At the time of drafting this document, the determination of common system requirements for Europe (or any other region) has not been agreed. This document therefore does not specify any particular performance requirements unless these are already determined elsewhere (such as safety or radio regulations) but rather identifies the key parameters which will comprise such requirements. Where reference to an existing test is available, this document provides that reference. This document defines only the test and test procedures, not the benchmark figures that these are to be measured against. This document is Part 1 of a series of standards. This Part 1 describes the test procedures. Part 2 describes EFC OBU conformance test procedures. Future standards will provide the benchmark figures to which the systems or components under test must be compared and validated.

This document is furthermore limited to automated (electronic) payment using a standardised dedicated short-range communication (DSRC). The scope of this document does not include manual payment, conventional money transaction, nor does it include payment by means of sticker, vignettes, tickets, or magnetic stripe cards etc. The applications to which EFC is related are Toll Collection, Road Pricing, Parking and Individual Traffic Information.

This is an enabling document to enable groups of operators to determine common specific performance levels and operating conditions, and to enable regional variation where appropriate. It provides operating and environmental parameters (or classes of operating and environmental parameters) within which such systems shall successfully function without impairing interoperability to ensure that the person specified the system can state his requirements clearly to implementation designers and integrators, and to enable the measurement of the performance of such systems.

The following guidelines have been followed when selecting the test procedures for test parameters:

— reference as far as possible to existing standardised test procedures;

— concentrate on those tests which are essential to ensure that EFC equipment is able to exchange information and mutually use the exchanged information.

A brief guide describing how to use this document is provided by Annex A of this document.

Whilst the scope of this document is generic, certain provisions relate specifically to ‘test procedures’ for certification purposes. Some or all of the features of this document are relevant internationally and this document therefore has relevance and is published by both CEN and ISO. However, it is recognised that due to different regulatory requirements outside Europe, extension will be required to make the Technical Specification as comprehensive in non CEN countries, before this document can be submitted for acceptance as a full standard.

1 Scope

This document specifies the test procedures of EFC road-side equipment (RSE) and on-board equipment (OBE) with regard to the conformance to standards and requirements for type approval and acceptance testing which is within the realm of EFC application specifically.

The scope of this document is restricted to systems operating within the radio emission, EMC regulations, traffic and other regulations of the countries in which they are operated and it is therefore a requirement that all required equipment approvals from an authenticated and accredited test house have been obtained in order to claim compliance.

This document identifies a set of suitable parameter and provides test procedures to enable the proof of a complete EFC system as well as components of an EFC system e.g. OBE related to the defined requirements of an application. The defined parameter and tests are assigned to the following groups of parameter:

— Functionality;

— Quality;

— Referenced pre-tests.

An overview of the tests and parameters provided by this document is given in 5.1 and 5.2. OBU conformance testing against EN ISO 14906 (EFC- Application interface definition for DSRC) is covered by CEN ISO/TS 14907-2 (Part 2 of this document).

The Technical Specification describes procedures, methods and tools and a test plan which enables to show the relation between all tests and the sequence of these tests. It lists all tests which are required to measure the performance of EFC equipment. The Technical Specification describes which EFC-equipment is covered by the test procedures; the values of the parameters to be tested are not included. It describes also how the tests are to be performed and which tools and pre-requisites are necessary before this series of tests are undertaken. It is assumed that the security of the system is inherent in the communications and EFC functionality tests and are thus not addressed specifically here. All tests in this document provide instructions to evaluate the test results.

The test procedures can be used for prototype testing, type approvals, test of installations and periodic inspections. Thus this Part 1 is a document that defines only the test and test procedures, not the benchmark figures that these are to be measured against.

Related to a conceptual model of an EFC system this document relates only to the equipment of the user and the service provider as illustrated in Figure 1. Any other entities are outside the scope of this document.

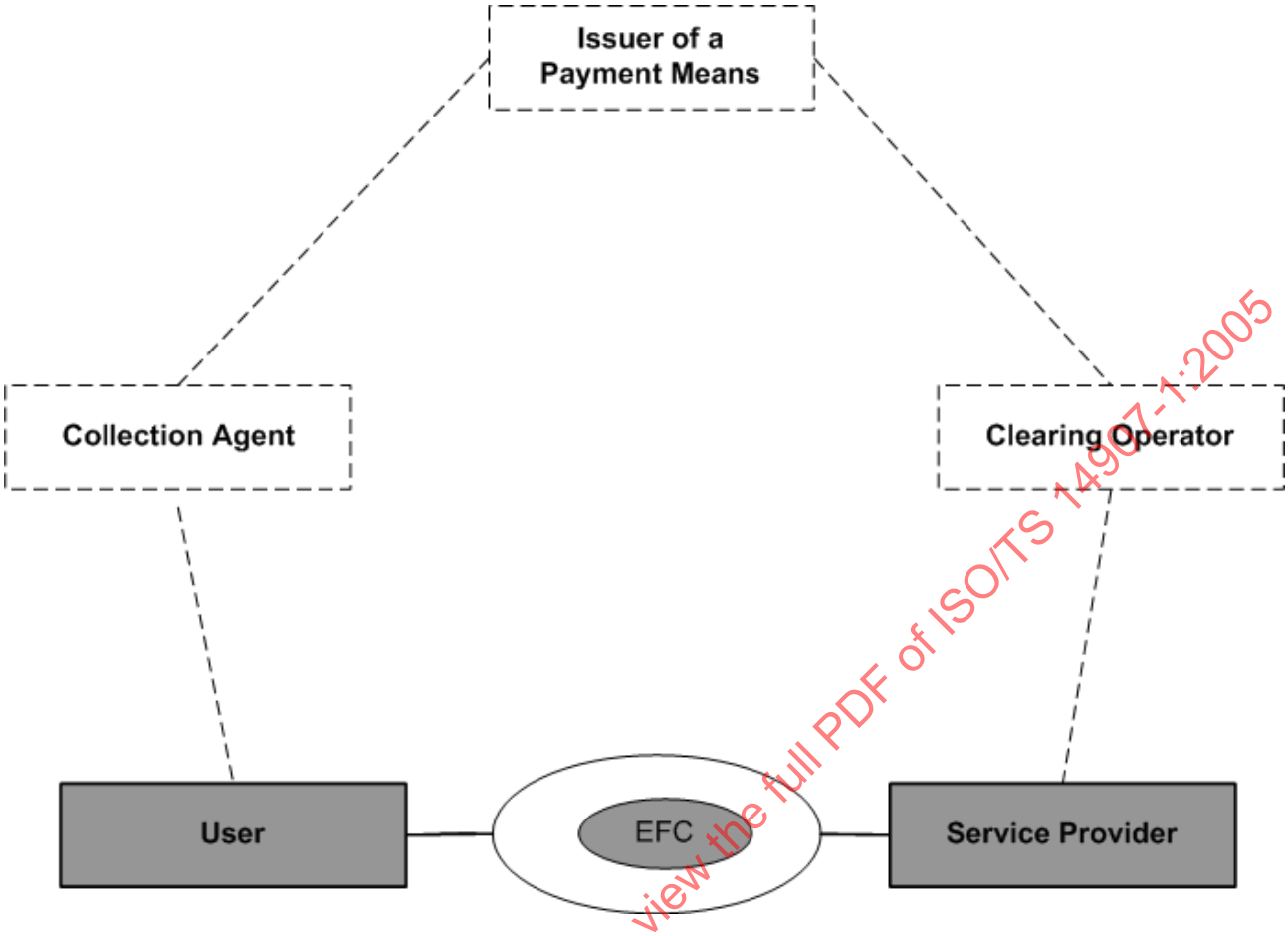

Figure 1 — Conceptual model of EFC

EFC systems for DSRC consist, in principle, of a group of technical components, which in combination fulfil the functions required for the collection of fees by electronic automatic means. These components comprise all or most of the following:

— on-board equipment (OBE) within a vehicle;

— on-board unit containing the communications and computing sub-functions;

— optional integrated circuit card which may carry electronic money, service rights and other secured information;

— communication between OBE and RSE based on DSRC;

— equipment for the fee collection at the road-side (RSE) containing the communications and computing sub-functions;

— equipment for the enforcement at the road-side;

— central equipment for the administration and operation of the system.

The scope of this document relates solely to OBE and RSE and the DSRC interface between OBE and RSE including its functions to perform the fee collection as illustrated by Figure 2. All the equipment used for enforcement (e.g. detection, classification, localisation and registration) and central equipment are outside the scope of this document.

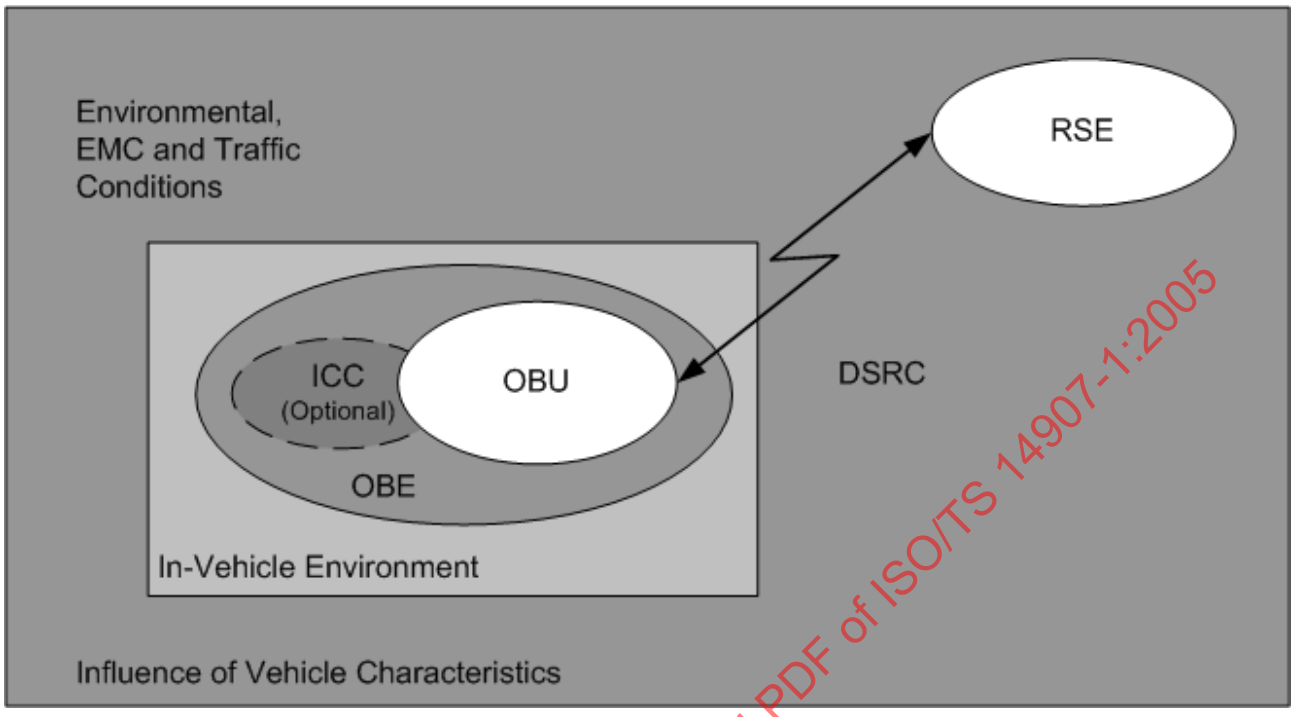

Figure 2 — OBE/RSE interface and associated environments

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 45011, *General requirements for bodies operating product certification systems (ISO/IEC Guide 65:1996).*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:1999).*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
acceptance testing
examination that a duly identified product, process or service is in conformity with the system specification

3.2
EFC equipment
EFC Equipment consists of Roadside Equipment (RSE) and On-Board Equipment (OBE)

3.3
EFC system
system that enables electronic debiting, i.e. paying for a transport service, without any action from the user at the moment of the use of the service

3.4
availability
probability that a unit at a random point in time within a given interval is in least a certain degree of preparedness to function or functioning under given running, environmental and maintenance conditions

3.5
certification
procedure by which a third party gives written assurance that a product, process or service conforms to specified requirements

3.6
compatibility
suitability of products, processes or services for use together under specific conditions to fulfil relevant requirements without causing unacceptable interactions

3.7
evaluation
systematic examination of the extent to which an entity e.g. system, process, product, or a unit is capable of fulfilling specified requirements

3.8
field tests
tests which are performed under real life conditions

3.9
functionality
group of parameter which are able to measure the performance of an EFC system, e.g. communication, application, vehicle and traffic characteristics

3.10
inspection
conformity evaluation by observation and judgement accompanied as appropriate by measurement, testing or gauging

3.11
interoperability
interoperability is the ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together

3.12
laboratory tests
tests which are performed in a laboratory under specified conditions

3.13
maintainability
ability of a device to be maintained or restore to specified conditions within a given period of time

3.14
on-board equipment
equipment located within the vehicle and supporting the information exchange across the interfaces of its sub-units. It is composed of the On-Board Unit (OBU) and other sub-units whose presence has to be considered optional for the execution of the DSRC interface

3.15
quality
all of the features and characteristics of the capability of a product or service to satisfy the requirements of the users (easiness of use, safety, availability, reliability, sturdiness, economy, environmental safety) whether given explicitly or implicitly

3.16
quality of EFC equipment
group of parameter (reliability, availability, maintainability) which are able to define the quality of EFC equipment by qualitative and quantitative figures

3.17
reliability
ability of a device to perform its intended function under given conditions of use for a specified period of time

3.18
roadside equipment
equipment located at a fixed position along the road transport network, allowing for the communication and data exchange with the on-board equipment

3.19
simulation
simulation is the representation of selected behavioural characteristics of one physical or abstract system by another system

[ISO 2382-1].

3.20
simulation of an EFC system
in a simulation of an DSRC-based EFC system, selected behavioural characteristics of the EFC system are represented by a computer model to enable the testing of the EFC equipment in a realistically modelled environment

3.21
test
technical operation that consists of the determination of one or more characteristics of a given product, process or device according to a specified procedure

3.22
test parameter
one or more test parameter which are able to specify one or more characteristics of an EFC system

3.23
test procedure
specific procedure for performing a test

3.24
test status
indication of the nature of a test. Conditional: A test labelled 'conditional' shall be subject to testing if and only if it is a feature of the system or component according to the specification. Basic: A test labelled 'basic' indicates a highly recommended test as part of a foundation for meaningful evaluation

3.25
test type
kind of test, e.g. inspection, simulation, lab-test and field test

3.26
test house
third party by a person or body that is recognized as being independent of the parties involved, as concerns the issue in question

3.27
type approval
approval based on conformity testing on the basis of one or more specimens of a product representative of the production

3.28
validation
confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled

3.29
verification
confirmation by examination and provision of objective evidence that specified requirements have been fulfilled

4 Abbreviations

4.1
DSRC
Dedicated Short Range Communication

4.2
EFC
Electronic Fee Collection

4.3
EMC
Electromagnetic Compatibility

4.4
ICC
Integrated Circuit Card

4.5
IEC
International Electro Technical Committee

4.6
IUT
Implementation Under Test

4.7
MMI
Man Machine Interface

4.8
MTBF
Mean Time Between Failure

4.9
MTTF
Mean Time To Failure

4.10
MTTR
Mean Time To Repair

4.11
OBE
On Board Equipment

4.12
OBU
On Board Unit

4.13
RSE
Road Side Equipment

4.14
SUT
System Under Test

5 Test parameters and test procedures for EFC

5.1 Tests overview

5.1.1 Introduction

The test parameters for EFC systems or components are categorised in three groups as follows:

a) Functionality Tests;

b) Quality Tests;

c) Referenced Pre-Tests.

Figure 3 shows the general structure of all test parameter groups relevant for EFC systems and those which are relevant to this document. The test parameters of the already mentioned pre-tests are referenced from sources other than this document. The specific test parameters which are ultimately deemed relevant for a specific EFC system shall be identified and listed in the test plan according to 5.3. The individual test plan for type approval or acceptance testing shall take into account the already passed tests of the pre-tests, e.g. for EMC, DSRC and environment.

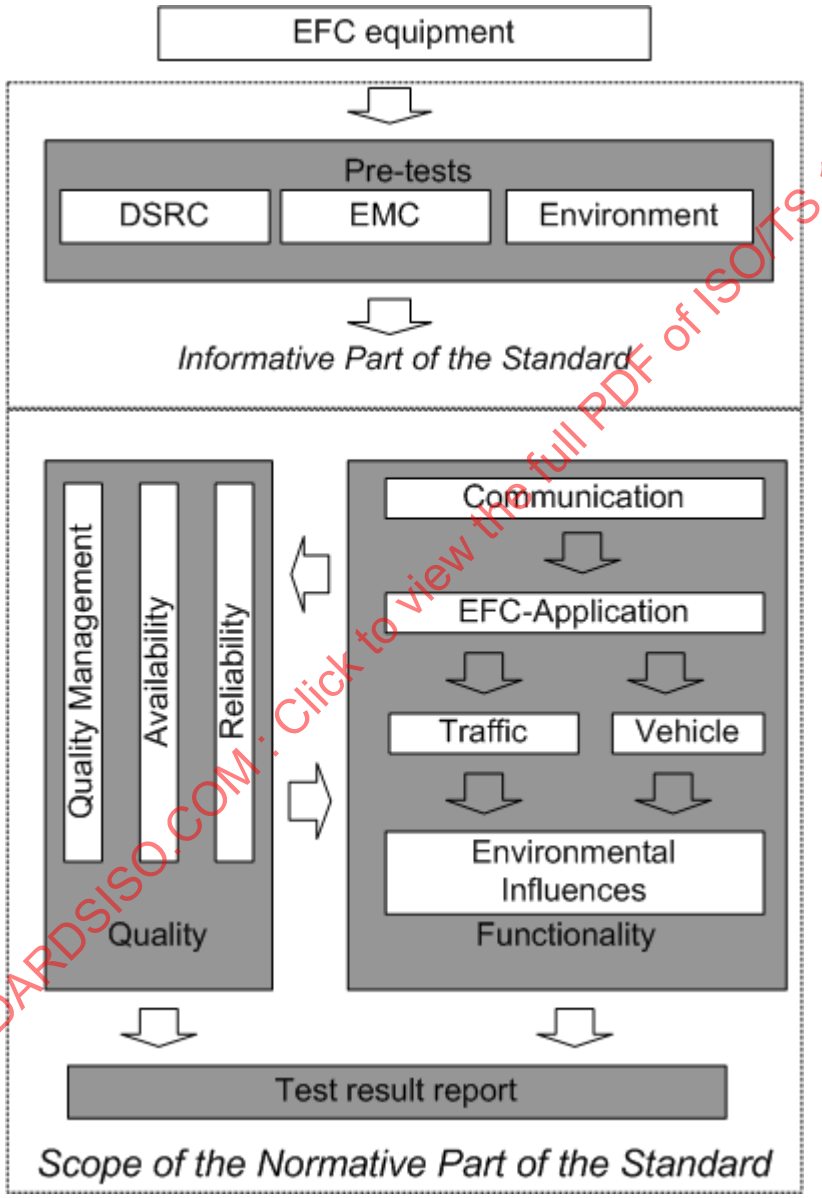

Figure 3 — Test plan - interdependencies

5.1.2 Functionality tests

The first category of tests is related to test procedures which aim to verify the functionality of the EFC equipment.

The functionality tests are related to the essential test parameters which need to be applied to verify the performance and capability of EFC equipment of different vendors and system operators.

The following test parameters shall be tested:

— Communication;

— EFC Application;

— Vehicle Characteristics;

— Traffic Characteristics;

— Environmental Influences.

Communication and EFC application tests are described in 6.1. Tests related to vehicle and traffic characteristics and environmental influences are listed in Annex B.

5.1.3 Quality tests

The second category of tests is related to test procedures which aim to test the quality of the EFC equipment. These are relevant for both operators and users.

Within the scope of the document, the following test parameters shall be tested:

— Quality Management;

— Reliability;

— Availability.

For some of these test parameters, there are partly existing test procedures available, which are referenced.

These tests are described in 6.2 and Annex C.

5.1.4 Referenced pre-tests

The third category of tests is related to test parameter which are fundamental for the performance of EFC equipment. The specific parameters and requirements are not in the scope of this document. The parameters which are relevant can be assigned to the following groups:

— DSRC;

— EMC;

— environment.

5.2 Parameter overview

The following tables provide a comprehensive list of the parameters that are relevant for type approval or acceptance testing of a complete EFC system as well as components of an EFC system. The tables are divided according to the aforementioned three sections, namely functionality, quality and referenced pre-tests. The section in this document where the tests are described or referenced is shown. An indication as to the nature of these tests (basic or conditional) is provided as not all tests are relevant to all operators and their specific operating situations and environment. **Basic** used in these tables does mean that the identified tests are highly recommended tests as part of a foundation for meaningful evaluation. **Conditional** means that a test labelled 'conditional' shall be subject to testing if and only if it is a feature of the system or

component according to the specification, e.g. lane changing test (T6) if the RSE is characterised as multilane.

Table 1 provides an overview of the parameters for which tests are defined in this document to measure the performance and assess the level of conformance of an EFC system or components under test.

Table 2 provides a list of the quality tests.

Table 3 provides a list of parameters that are necessary pre-tests and whose performance and conformance is tested by reference to existing standards or Technical Specifications.

It shall be noted that the tests have been categorised into inspection tests, laboratory tests, simulation tests, and field tests. The appropriate test or types of tests are indicated, in the following tables, for each parameter. It is not expected that all the named types of tests for a parameter will be performed on that parameter. Where a set of appropriate tools are available to a test house it is up to the test house to decide which type of test is most appropriate to meet their specific remit.

Where a particular category of test shall be performed to conform to this document the test is indicated in the following tables with a ‘p’. Where a particular category of test is optional this is indicated with an ‘o’.

Table 1 — Functionality

Tests			Location	Test Status	Applicable Test Type (p = shall be performed, o = optional)			
Parameter	**Item**	**Name**	**Reference to sub-clause**	**Basic/ Conditional[a]**	**Inspection**	**Laboratory**	**Simulation**	**Field test**
PART 1								
Communication	C1	Conformance assessment	6.1.1	B	-	p	o	o
EFC Application Tests	F1	Validation of the specification	6.1.2	B	p	-	-	-
	F2	Implementation test	6.1.2	B	p	o	o	o
	F3	Functionality tests	6.1.2	B	p	o	o	p
Traffic Conditions	T1	Longitudinal distance between vehicles	6.1.3, B.2	B	-	-	o	p
	T2	Lateral distance between vehicles	6.1.3, B.2	C	-	-	o	o
	T3	Lateral distance between OBE's	6.1.3, B.2	C	-	-	o	o
	T4	Speed of vehicles	6.1.3, B.2	C	-	-	o	o
	T5	Driving angle	6.1.3, B.2	C	-	-	o	o
	T6	Lane changing	6.1.3, B.2	C	-	-	o	o
	T7	Shadowing	6.1.3, B.2	B	-	-	o	p
	T8	Traffic scenarios - free flow	6.1.3, B.2	C	-	-	o	o
	T9	Traffic scenarios – restricted flow	6.1.3, B.2	C	-	-	o	o

Tests			Location	Test Status	Applicable Test Type (p = shall be performed, o = optional)			
Parameter	Item	Name	Reference to sub-clause	Basic/ Conditional[a]	Inspection	Laboratory	Simulation	Field test
	T10	Traffic volume	6.1.3, B.2	C	-	-	o	o

Table 1 — Functionality (*continued*)

PART 2								
Vehicle Characteristics	V1	Length of vehicle	6.1.4, aB.3	C	-	-	o	o
	V2	Height of vehicle	6.1.4, B.3	C	-	-	o	o
	V3	Width of vehicle	6.1.4, B.3	C	-	-	o	o
	V4	Length of bonnet	6.1.4, B.3	C	-	-	o	o
	V5	Other vehicle features weight, number of axles, volume, shape paintwork, colour, air conditioner mobile communication equipment	6.1.4, B.2	C	-	-	o	o
	V6	Constructive elements superstructures in the windscreen area lorries with external sun visors car transporter with projecting loading surface sun roof (open/closed)/roof mountings	6.1.4, B.3	C	-	-	o	o
	V7	Attenuation of windscreen, caused by e.g. metallised, coated, heated, dirty windscreen	6.1.4, B.3	C	-	o	o	o
	V8	Angle of windscreens horizontal plane cars, small trucks and vans trucks, bus & touring cars	6.1.4, B.3	C	-	o	o	o

Table 1 — Functionality (*concluded*)

	V9	Angle of windscreens vertical plane location in the outer curve area	6.1.4, B.3	C	-	o	o	o
	V10	Mounting height of OBE antenna	6.1.4, B.3	C	-	o	o	o
	V11	Lateral mounting of OBE antenna from middle of windscreen	6.1.4, B.3	C	-	o	o	o
	V12	OBE behaviour variation of supply voltage operational state of OBE fixing of OBE ICC behaviour	6.1.4, B.3	C	-	o	o	o
PART 3								
Environmental Influences	I1	Width of pavement	6.1.5, B.4	C	o	-	o	o
	I2	Number of lanes	6.1.5, B.4	C	o	-	o	o
	I3	Other topographical influences	6.1.5, B.4	C	o	o	o	o
	I4	Water and dust	6.1.5, B.4	C	-	o	o	o
	I5	Temperature, humidity and day light	6.1.5, B.4	C	-	o	o	o
	I6	Other weather conditions	6.1.5, B.4	C	-	o	o	o

[a] Test only to be applied if function or item is specified.

Table 2 — Quality

Tests			Location	Test Status	Applicable Test Type (p = shall be performed, o = optional)			
Parameter	**Item**	**Name**	**Reference to sub-clause**	**Basic/ Conditional[a]**	**Inspection**	**Laboratory**	**Simulation**	**Field test**
Quality Management	Q1	Design, development, production, installation and servicing	6.2.1	B	p	-	-	-
Reliability Availability	R1	Components, equipment, system	6.2.2, C.1	B	p	o	o	o
	R2	Transaction-level reliability	6.2.2, C.2	B	p	o	o	o
	R3	OBE life duration	6.2.2, C.2	B	p	o	o	o
	R4	OBE battery duration	6.2.2, C.2	B	p	o	o	o
	R5	OBE smart card life duration	6.2.2, C.2	B	p	o	o	o

[a] Test only to be applied if function or item is specified.

Table 3 — Referenced pre-tests

Tests			Location	Test Status	Test Type
Parameter	**Item**	**Name**	**Reference to Section**	**Basic/ Conditional[a]**	**(R = refer to Standards/regulations which specify these pre-tests)**
DSRC	D1	Layer 1	6.3.1, F.1	B	R
	D2	Layer 2	6.3.1, F.1	B	R
	D3	Layer 7	6.3.1, F.1	B	R
Environment	ET1	Basic parameter	6.3.2, F.2	B	R
	ET2	Mechanical	6.3.2, F.2	B	R
	ET3	Electrical	6.3.2, F.2	B	R
	ET4	Chemical/Biological	6.3.2, F.2	B	R
	ET5	Safety	6.3.2, F.2	B	R
EMC	E1.1	Emission	6.3.3, F.3	B	R
	E1.2	Immunity	6.3.3, F.3	B	R

[a] Test only to be applied if function or item is specified.

5.3 Test plan

The test house carrying out the type approval or acceptance testing shall work out an individual test plan for each tested EFC system or EFC component, in accordance to Figure 3, taking into account the system-specific characteristics of the EFC application. In respect of a **type approval**, the requirements of applicable standards or other normative and referenced documents shall be tested by an accredited test house.

In respect of **acceptance tests**, only the features that are specified or implicit in the system specification are mandatory and require to have been tested. Where additional features are provided for contingent use at some future date these shall have been tested if the contingency is included in the system specification. Where additional features are present in products supplied, but are not used nor included in the system specification or implementation there is no requirement that they shall have been tested unless they have an effect on the operation of the system.

Results of already passed pre-tests shall be compared with the application specific requirements. If deviations are detected, additional tests will have to be carried out. The test plan shall make references to each listed test parameter with respect to the following details:

— identification of test parameter and item;

— reference of the related requirements/severity of the test;

— required equipment and documentation;

— selected test type;

— required test equipment, measurement equipment, interfaces and tools;

— required test environment;

— department carrying out the test;

— required documentation of the tests and the results (Annex G.5).

Interdependencies between the results of the different tests are anticipated and shall be taken into account by the test house. An exemplary form of a test protocol is listed in Annex G.5.

5.4 Required documentation

The following listed documentation shall be supplied by the manufacturer to carry out the tests defined by a test plan:

— system description (overview, block diagrams);

— system specification including functions, timing, operational data on a detailed level;

— safety and security concept (Threat analysis, implemented measures to detect and control failures, threats and manipulations);

— user documentation (service provider and user);

— specification of ambient conditions;

— operational directives;

— quality assurance directives, development rules;

— maintenance- and installation directives;

— list of all available documents from the manufacturer relating to the EFC system under test created during the design and manufacture of the equipment.

6 Inspection and tests

6.1 Functionality tests

6.1.1 Communication

The test specifications with regard to communication are defined in CEN ISO/TS 14907-2 (Part 2 of this document). Part 2 specifies the tests that verify OBU conformance of implemented communication (transaction) protocols to the details specified in EN ISO 14906 to be used for EFC applications.

NOTE CEN ISO/TS 14907-2 can also be used as a source of inspiration for roadside equipment testing against EN ISO 14906.

The document describes general requirements for conformance testing and specific test procedures for:

— Basic DSRC L7 functionality;

— EFC application functions;

— EFC attributes;

— addressing procedures of EFC attributes and (hardware) components (e.g. ICC and MMI);

— EFC transaction model;

— behaviour of the interface.

6.1.2 EFC application

6.1.2.1 General

The tests are related to components or to a complete EFC system consisting of an OBE, RSE or both and RSE/OBE in combination. The objective of the tests is to validate that the equipment to be tested fulfils the functional and technical requirements of the specification. The proof consists of inspections, simulations and tests which are to ensure that the system specifications and the equipment of EFC are in conformance with the EFC requirements based on standards and regulations, national requirements and other requirements.

In the following a set of tests are described. Which tests are relevant and sufficient to prove the performance of an EFC system or components of it has to defined by a test plan (see 5.3).

The EFC application test is divided into two sections:

a) validation of the EFC specification;

b) inspection and test of the EFC system or component under test (SUT).

The specific tests are subject in the sub clauses below and in Annex B. The relation between the test sections is shown in Figure 4 below:

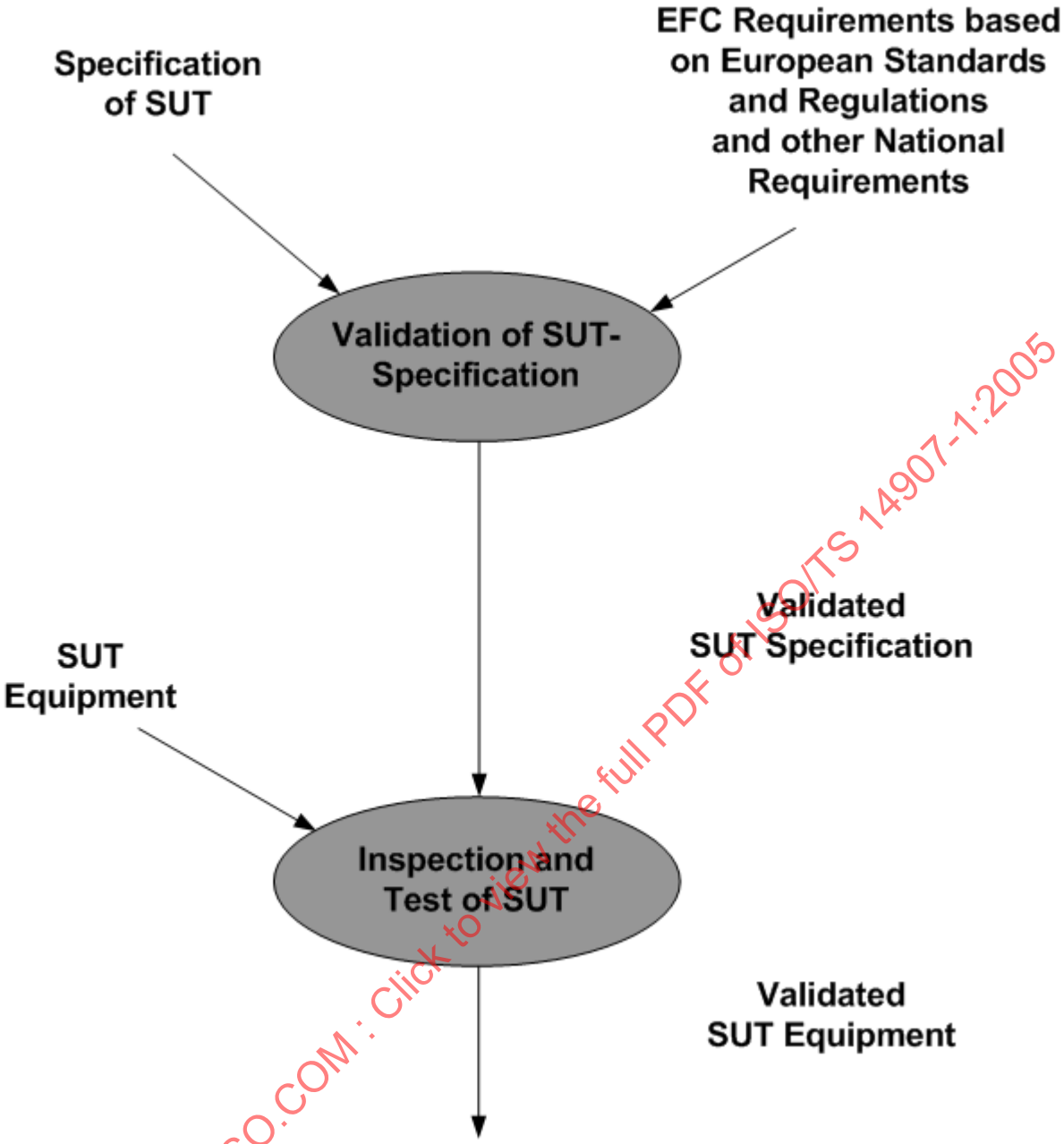

Figure 4 — Structure of application tests

The first section deals with the validation of the EFC system specification respectively design specification. The objective is a validation of the system specification to verify that it is in conformance with the EFC requirements based on standards and regulations, national requirements and other requirements. The activity consists of inspection and analysis of the referenced documentation. The output of this phase is an authorised and valid system specification of the SUT which meets the requirements of the selected standards and regulations. Additionally a test plan will be specified which identifies the required test steps to prove the performance of the SUT.

The second section is related to the EFC equipment which is designed according to a validated system specification. The activities of this section are inspections, simulations and tests. Before the functionality test can start an implementation test (pre-test after installation) is carried out to ensure the principal performance of the system. The implementation includes the activities of installation and commissioning. The objective of the tests is to validate the conformity of the equipment with the specification and compliance with the EFC requirements of standards and regulations, national requirements and other requirements.

The inspection and test shall take into consideration results of already carried out tests e.g. quality tests, reference tests and shall be detailed by a test plan (see 5.3). Annex B contains a list of tests which are related to traffic

conditions, vehicle characteristics and other environment influences. Annex H provides examples of EFC scenarios as part of a functionality test.

6.1.2.2 Validation of the SUT specification

EFC Application Test		
Name:	Validation of the Specification (F1)	
Group:	EFC application	
Purpose:	To ensure that the specification of the SUT or component is in conformance with the EFC requirements of standards and regulations, national requirements and user requirements.	
Requirement reference:	— National requirements for EFC — EFC requirements for a DSRC communication — User requirements of the specified EFC application	
Default:	All specifications to be inspected shall be in conformance regarding the DSRC regulations and DSRC standards applicable in the countries and regions in which the system or component will be operated.	
Test configuration:	A set of documentation as listed in 5.4 is required.	
Behaviour description:	The task consists of inspection and analysis (Annex G) of the provided documentation. The details of the system specification of the SUT are compared with the requirements of the EFC standards and regulations, national requirements and user requirements. The documentation is inspected concerning completeness, validity, unambiguity, consistency and understandability. The analysis is carried out to evaluate the system structure, reliability figures, measures to detect and control failures, timing behaviour, security and safety, maintenance, other technical and non-technical measures concerning system performance.	
Constraints reference:	None	
Verdict:	**Test result** Authorised and valid system specification of the SUT. Test plan for the performance proof. The system specification is not conform to the requirements. List of discovered deviations.	**Verdict** Pass Fail
Comments:		

6.1.2.3 Inspection and Test of SUT

EFC Application Test		
Name:	Implementation Test (F2)	
Group:	EFC application	
Purpose:	The objective of this test is to verify that the specified EFC system (SUT) or component is in conformance with the fundamental requirements of the EFC application.	
Requirement reference:	Validated system specification of the SUT	
Default:	Certified DSRC equipment according to the requirements of DSRC regulations and DSRC standards applicable in the countries and regions in which the system or component will be operated.	
Test configuration:	— Documentation and equipment according to test plan. — Test facilities according to test plan.	
Behaviour description:	The SUT or component shall be tested according to the specified requirements. Prerequisite for the inspection and test is a validation of the system specification, certified DSRC equipment according the DSRC standards and a qualification of the SUT in accordance with other fundamental requirements. Tests which are vacant have to be carried out within this phase. The qualification of this phase consists of inspection, test and simulation. The work is separated into the following steps: — Verification of the quality items of 6.2 and Annex C of this document. — Inspection of the hardware and software to confirm that the system requirements (validated SUT specification) are implemented in the SUT. — Inspection of housing protection, electrical safety, shielding and earthing of installed equipment. — Test of range of electromagnetic emissions, EMC interference and environmental conditions. — Simulation of functions of the SUT to verify its ability to meet the functionality tests (traffic, vehicle, environment and communication requirements). The simulations are carried out according to the specifications of Annex G (simulation). — Test of the basic functions and adjustment of RSE-transmitter/receiver (communication zone) and determination of the footprint range (static test without vehicle). — Test of basic communication functions between RSE and OBE in relation to the determined footprint range of the antenna (static test without vehicle). — Test of sub-systems (OBE, Chipcard and RSE) to perform the functions as specified in the SUT documentation.	
Constraints reference:	The requirements of the tests are according to the details of the documents identified under ”requirement reference”.	
Verdict:	**Test result**	**Verdict**
	The results are stating the SUT ability to meet principal requirements under specific conditions.	Pass
	The SUT does not meet the principal requirements.	Fail
Comments:		

EFC Application Test		
Name:	Functionality Tests (F3)	
Group:	EFC application	
Purpose:	The objective of this test is to validate that the installed EFC system (SUT) or component is in accordance with the specifications of the SUT or component.	
Requirement reference:	— Validated system specification of the SUT — EFC requirements for a DSRC communication — National requirements for EFC — User requirements of the specified EFC application	
Default:	Certified DSRC equipment according to the requirements of DSRC regulations and DSRC standards applicable in the countries and regions in which the system or component will be operated.	
Test configuration:	— Documentation and equipment according to test plan. — Installed EFC equipment according to the manufacturer's instructions. — Test facilities according to the test plan.	
Behaviour description:	The SUT shall be tested according to the specified requirements. Prerequisite for the functionality test is a successful pass of the tests communication, quality and pre-tests. The tests are carried out according to a test plan. The qualification procedure of this section is separated in inspections, tests and simulations. The following steps are required: — Simulation of functions of the SUT to verify its ability to meet traffic, vehicle, environment and communication requirements. The simulations are carried out according to the specifications of Annex G. — Test of the integrated functionality of the selected EFC protocols within the affected communication area including overlapping of different communication units under basic requirements (static and dynamic tests). — EMC interference on realistic applications, e.g. mobile radio, of DSRC functions to verify resistance from outside. — Real time simulation of traffic and vehicle scenarios (Annex B) to verify the ability of the SUT to meet traffic, vehicle, environment and communication requirements. — Real traffic and vehicle scenarios (Annex B use of vehicles or special constructions) to verify the ability of the SUT to meet traffic, vehicle, environment and communication requirements. — Real traffic and vehicle scenarios (Annex B) based on different EFC transaction profiles to verify compatibility and interoperability characteristics.	
Constraints reference:	The requirements of the tests are according to the details of the documents identified under "requirement reference" and the details of selected classes of performance.	
Verdict:	**Test result**	**Verdict**
	The results confirm the ability of the SUT to meet functionality, compatibility and interoperability requirements based on the conditions of all carried out tests.	Pass
	Not in accordance with the specifications.	Fail
Comments:		

6.1.3 Traffic conditions

The following table shows typical **traffic conditions** for which individual test case specifications have been described in Annex B.2:

Table 4 — Traffic conditions

No.	Traffic conditions
T1	longitudinal distance between vehicles
T2	lateral distance between vehicles
T3	lateral distance between OBEs
T4	speed of vehicle
T5	angle of approach
T6	lane changing
T7	shadowing
T8	traffic scenarios - free flow
T9	traffic scenarios - restricted flow
T10	traffic flow (vehicles/h)

The conditions T1 to T3, T5 to T7 are graphically described in the following scheme shown in Figure 5.

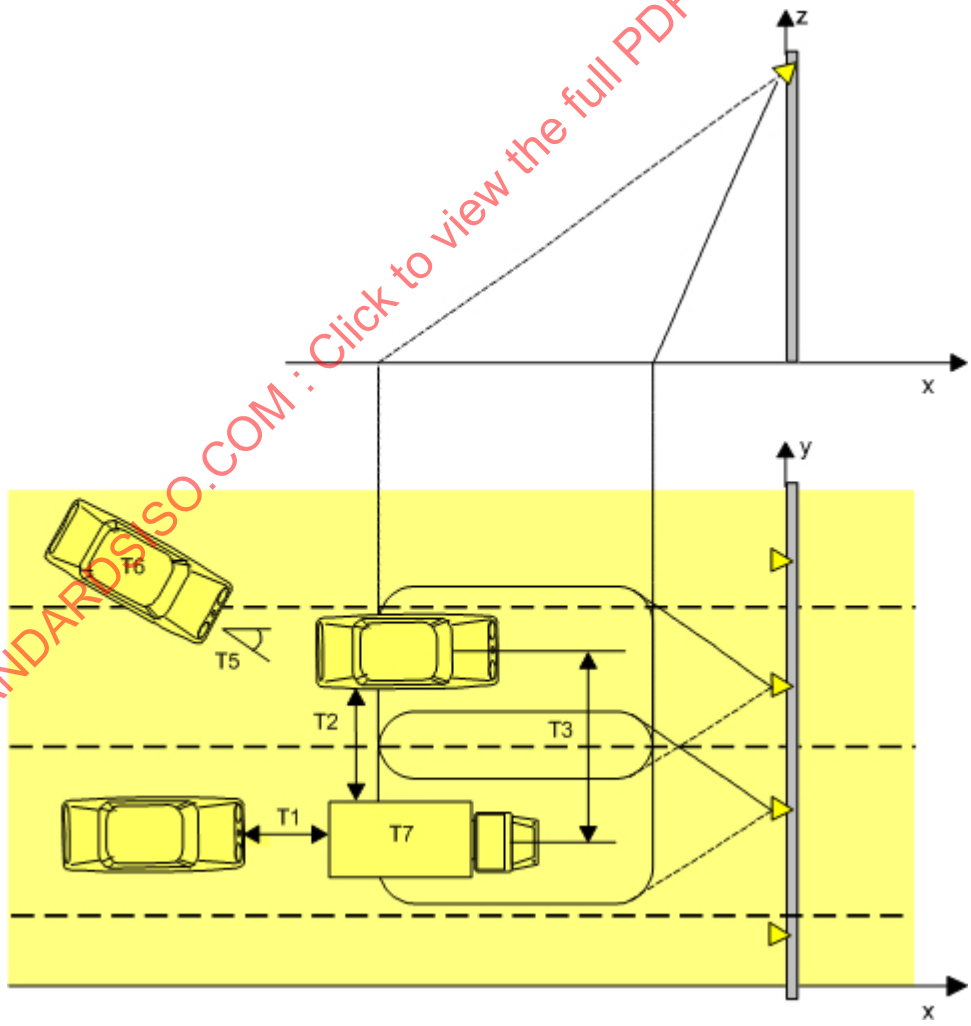

Figure 5 — Traffic conditions

6.1.4 Vehicle characteristics

The following table shows typical **vehicle characteristics** for which individual test case specifications have been described in Annex B.3:

Table 5 — Vehicle characteristics

No.	vehicle characteristics
V1	length of vehicle
V2	height of vehicle
V3	width of vehicle
V4	length of bonnet
V5	other vehicle features weight, number of axles, volume, shape paintwork, colour, air conditioner mobile communication equipment trailer
V6	constructive elements superstructures in the windscreen area lorries with external sun visors car transporter with projecting loading surface sun roof (open/closed)/roof mountings
V7	attenuation of windscreen, caused by e.g. metallised, coated, heated, dirty windscreen
V8	angle of windscreens, from horizontal plane cars, small trucks and vans trucks, bus and touring cars
V9	angle of windscreen, vertical plane location in the outer curve area
V10	mounting height of OBE antenna
V11	lateral mounting of OBE antenna from middle of windscreen
V12	OBE behaviour variation of supply voltage operational state of OBE fixing of OBE ICC behaviour

The above vehicle characteristics excluding V5 to V7 and V12 are shown in Figure 6.

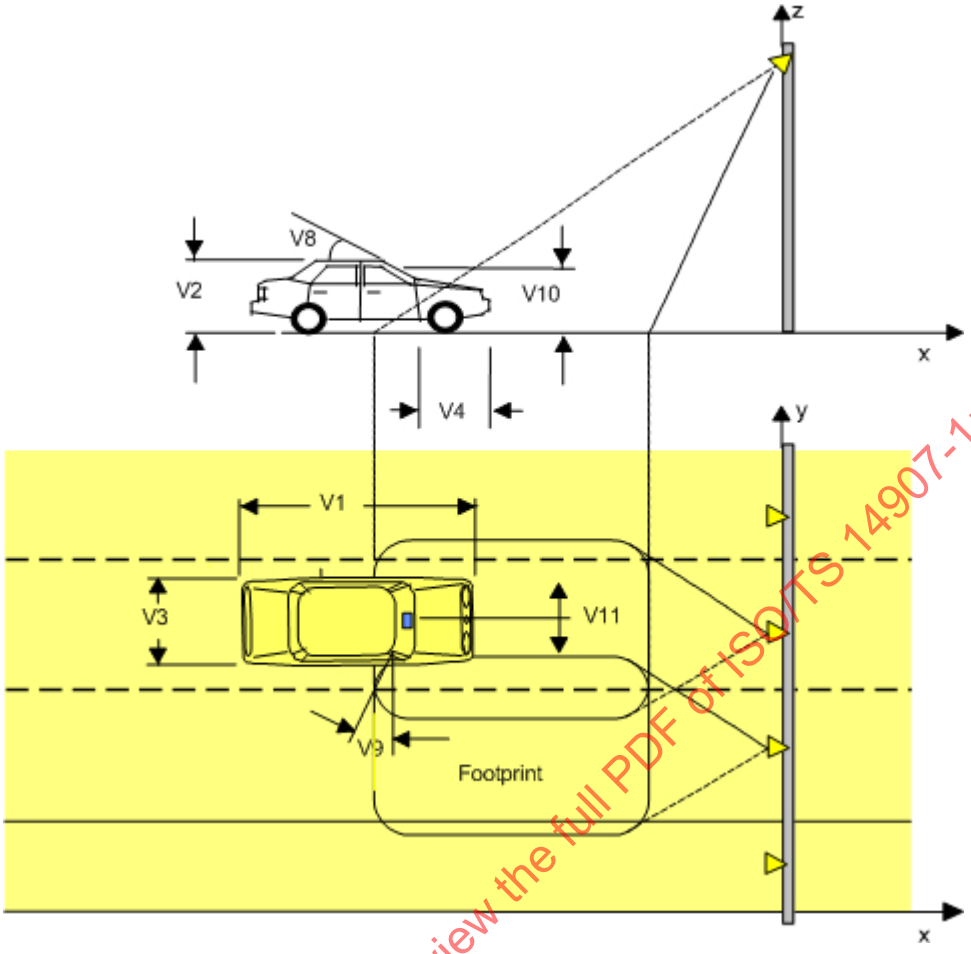

Figure 6 — Vehicle characteristics

6.1.5 Environmental influences

The following table shows other environmental influences for which individual test case specifications have been described in Annex B.4:

Table 6 — Environmental influences

No.	other environment influences
I1	width of pavement
I2	number of lanes
I3	other topographical influences
I4	water and dust
I5	temperature, humidity and day light
I6	other weather conditions

The environmental influences I1 and I2 are shown in Figure 7.

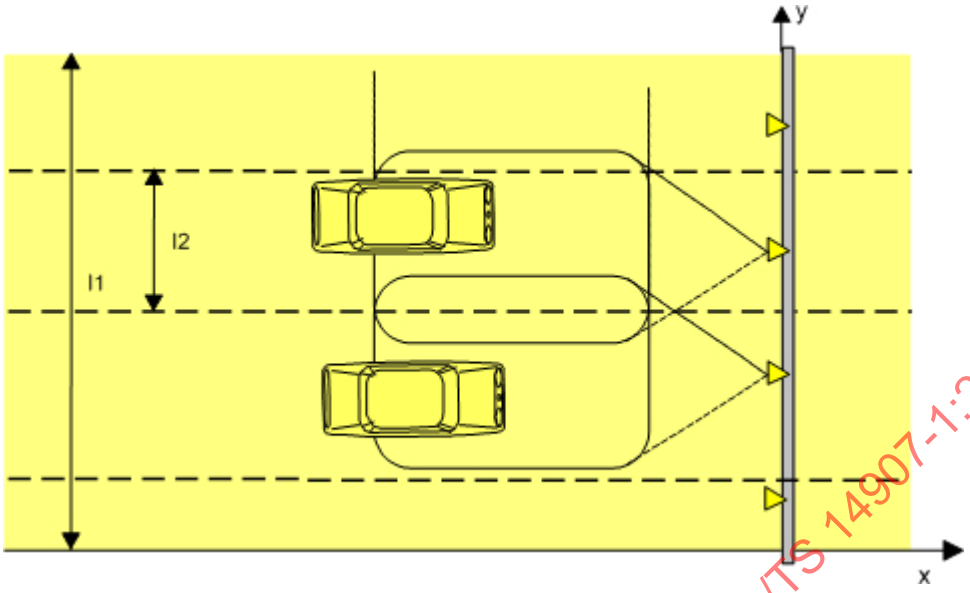

Figure 7 — Environmental influences

6.2 Quality tests

6.2.1 Quality management

6.2.1.1 EN ISO 9000 series standards

The management system of an organisation is influenced by the objectives of the organisation, by its products and by the practices specific to the organisation. A major purpose of quality management is to improve the systems and processes so that continual improvement of quality can be achieved.

EN ISO 9000 describes fundamentals of quality management systems and specifies the terminology for quality management systems. EN ISO 9001 specifies requirements for a quality management system where an organization needs to demonstrate its ability to provide products that fulfil customers and applicable regulatory requirements and aims to enhance customer satisfaction. EN ISO 9004 provides guidelines that consider both the effectiveness and efficiency of the quality management system. The aim of this standard is improvement of the performance of the organization and satisfaction of customers and other interested parties.

6.2.1.2 EN ISO 9001 compliance requirements

The International EN ISO 9000 series standards are intended to provide a generic core of quality system standards applicable to a broad range of industry and economic sectors. EN ISO 9001 specifies the requirements for a quality management system. The compliance to this standard constitutes a minimum requirement for all organizations claiming compliance to EFC equipment standards. Test houses testing EFC-equipment using this standard are required to confirm that all equipment being used has been manufactured in an appropriate EN ISO 9001 environment. The supplier is required to provide evidence to the test house that such current EN ISO 9001 compliance certification is held by the manufacturer and the test house shall examine and confirm that such current EN ISO 9001 compliance certification exists.

6.2.2 Reliability and availability

Reliability and availability shall be determined using standard methodologies, for instance using an analytical reliability model, a simulation model, or test on samples of equipment.

For the RSE, a reliability model shall include factors as:

— number of communication components (i.e. beacons or antennas) involved for a given toll plaza configuration (especially significant in multilane situations);

— possibility of component or subsystem redundancy to avoid failure;

— ability to store transactions in stand alone mode in case of failure of the link between RSE and central system: this is not strictly speaking a DSRC functionality, but shall be performed at the RSE level, and is a key point for most tolling systems.

For the OBE, physical tests will be performed on sample equipment.

There are some issues that are specific to the DSRC environment and which need specific test prescription as:

— RSE-OBE transaction reliability;

— physical life duration of an OBE given the conditions in a vehicle;

— battery duration of an OBE under operating conditions;

— life duration of smart card (e.g. contacts, memory read/write cycle)

Specific reliability and availability tests for these aspects are described in Annex C. Examples for statistical calculations are described in Annex E.

6.3 Referenced pre-tests

The EFC roadside and on-board equipment shall comply with the regulations and standards applicable in the countries and regions in which it will be operated. The relevant parameters have to be considered during the specification of a test plan. Results of already carried out tests and approvals have to be taken into account and have to be compared with the requirements of the specific EFC application.

6.3.1 DSRC

The range of the DSRC tests shall cover the following areas:

— physical layer at 5,8 GHz;

— data link layer;

— application link layer.

An example of referenced DSRC tests is listed in F.1.

6.3.2 Environment

The range of the environment tests shall cover the following areas:

— climate;

— mechanical;

— electrical;

— chemical / biological;

— safety.

An example of referenced environment tests is listed in F.2.

6.3.3 EMC

The range of the EMC tests shall cover the areas:

— Emission;

— immunity.

An example of referenced EMC tests is listed in F.3.

7 Evaluation and certification

7.1 Evaluation

The evaluation of EFC components or complete EFC systems shall be carried out by test houses or test laboratories which are competent in the field of EFC and qualified according to EN ISO/IEC 17025. The objective of the evaluation is to assess a complete EFC system or EFC components regarding compliance with the specified requirements.

Basis of an evaluation are the test results of a type approval and/or an acceptance test. All results shall be documented by a test report. The tested object (EFC component or system) including the used documentation, standards and regulations are unambiguously and completely defined. The test report forms the basis for the certification. The report shall contain the following information:

— identification of the test report;

— identification of the tested equipment or component (manufacturer, type, serial number);

— name and address of the test house;

— purpose of the examination;

— standards and regulations applied;

— test procedures and results;

— summary evaluation result;

— date, signature.

7.2 Certification

The certification of EFC components or complete EFC systems shall be restricted to test houses or certification bodies which are certified according to the requirements of EN 45011.

The identification of conformity with standards and regulations may be done in the form of a certificate and/or a mark of the components or the system. Basis for the certification is the test report. The certificate shall identify the following details:

— identification of the certificate;

— name and address of the certification body;

— tested equipment (manufacturer, type, serial number);

— intended application;

— standards and regulations applied;

— test results;

— specific requirements;

— reference to evaluation report;

— date, company seal, signature.

Annex A
(informative)

How to use this Technical Specification

A.1 General framework

The objective of this annex is to provide guidance to assist the successful implementation of this standard.

The principal parties who will use this document will be manufacturers, operators and test houses.

Manufacturers (first party) will be those designing and producing EFC equipment which has to be in compliance with standards and regulations. Manufacturers should use test procedures of this document for prototype testing to demonstrate and assure a level of performance in accordance to determined EFC requirements. Use of the tests and procedures enables the manufacturer to carry out factory tests which are comparable with tests carried by independent test houses and with tests carried out after installation of the EFC-equipment.

Operators (second party) of EFC equipment need certainty that EFC-equipment is tested by test procedures which are sufficient and capable to guarantee conformance with standards, regulations and own specified requirements. Therefore operators should choose test procedures of this document and define parameter classes in order to specify a test programme for the designed application. Operators are recommended to choose an independent test house to carry out the test programme.

Operators further require to be able to compare EFC equipment of different manufacturers, tested by different test houses. The test procedures determined in this document are designed to enable such comparison.

Test houses (third party) require a common basis of test procedures which is determined and defined to enable them to reliably and consistently test and prove compliance to standards to meet the declared or required performance. The test houses carry out the assessment of an EFC system according to a specified test plan which has to be agreed by the operator of the system and by the national authority which is responsible for the operation of the EFC system. The test house is recommended to be designated and accredited by a national certification body for carrying out the assessment activities.

Finally, although not part of the formal relationship between the manufacturer and operator, the **user of the service** requires highly reliable EFC equipment. Tested and certified equipment based on qualified tests and procedures carried out by independent test houses using this document to ensure that systems meet the claimed performance levels, provide reassurance to users.

This document is designed to enable operators and suppliers of EFC systems to measure conformance with System Functional Requirements. The Technical Specification also assists determination and verification of common criteria and performance to enable interoperability in a commonly determined region (such as pan European) based on the DSRC.

Tests are of a basic or conditional nature. Whether or not a test is basic or conditional depends on the exact nature of the parameter under test in respect of the functionality of the system required by the operator, regional legislation, and agreed parameters between regional groups of operators.

The test parameters and procedures within this document have been functionally organised into groups which are defined in Clause 5.

A.2 Step by step guidance

This clause describes the expected steps required to execute the procedures in this document.

Step 1

The parties are firstly defined and mutually agreed. Normally this comprises one or more operators (second party), one or more equipment and system providers (first party), and one or more test houses (third party).

Step 2

Any accredited and designated test house used to assure compliance of any system or equipment with this document shall first ensure that the system or equipment complies with the radio emission, EMC regulations, safety and other regulations of the countries in which they are to be operated. All manufacturers declarations or results of already carried out tests and approvals from an authenticated and accredited test house are made available. Missing tests are carried out.

Step 3

Where there are general equipment requirements (such as safety, EMC etc.), the appropriate tests are already determined in existing standards. This document provides a check list for test houses which have the responsibility of assuring such compliance, relieves operators of the research, and provides guarantees to both operators and users that mandatory requirements are met.

Step 4

Each parameter of a typical EFC application is normally determined into a number of required performance levels of increasing severity (described as ‘Classes’) to provide clear reference levels of performance for system design. The parties mutually define and agree the particular combination of class requirements for each parameter. (This is normally as part of a system specification, or requirements as part of a ”Call for Tender”, or the declared performance in publicity material of a manufacturer).

Step 5

The test house tests each parameter against the requirements to meet the required class for that parameter, or tests and determine which class level is achieved for the parameter.

Step 6

The test house issues a test report with all results with respect to defined and applied test parameters and test procedures.

Step 7

The qualification department of the test house compares the test results of the test parameters with the defined requirements and the results of existing approvals. In the case that all relevant requirements are fulfilled the test house issues a certificate of compliance.

Annex B
(informative)

Traffic, vehicle and other performance tests

B.1 Traffic conditions, vehicle characteristics and environmental influences

B.1.1 General

Traffic conditions, vehicle characteristics and environmental influences are closely linked in field tests that may be carried out according to the procedures and recommendations stated by this document. In the following a specific test case description is used for each test item of the above mentioned groups. Useful combinations of several items are already identified in the separate tables.

B.1.2 Objective

The objective of the tests regarding traffic conditions, vehicle characteristics and environmental influences is to verify that the EFC equipment (i.e. OBE and RSE), including DSRC air interface, fulfils the requirements of the referenced documents concerning these items.

B.1.3 Requirements

Reference for these tests are the details regarding traffic conditions, vehicle characteristics and environmental influences of the following document sources:

— validated specification of the EFC system or equipment;

— DSRC regulations and DSRC standards applicable in the countries and regions in which the system or component will be operated;

— EFC regulations and standards;

— national requirements for EFC;

— requirements of the specified EFC applications;

— user requirements.

These requirements may be different for different implementations as required and this is indicated with “t.b.d.” for the parameter “Default” in the tables of B.2 to B.4 in cases where no value is specified.

All tests are operated in representative but safe locations and never violate the requirements on traffic safety.

B.2 Traffic conditions

Table B.1 — Traffic conditions - longitudinal distance between vehicles

Dynamic behaviour tests		
Name:	Longitudinal and close longitudinal distance between vehicles (T1)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance for longitudinally distance between vehicles	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicle drivers in order to comply to test definition — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T1, according to speed class (T4) and traffic scenarios (T8)	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test may be usefully combined with traffic scenarios (T8) queue driving with up to five vehicles in accordance to safe distance. d) In case of closely longitudinally spaced vehicles a simulation can be useful (two or three private cars with OBE on a car transporter).	

Table B.2 — Traffic conditions - lateral distance between vehicles

Dynamic behaviour tests		
Name:	Lateral distance between vehicles (T2)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance for closely laterally distance between vehicles	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each bulk of vehicles crossing the communication zone, the transactions are monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of the number of vehicles simultaneously crossing the toll zone, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T2 according to speed class (T4) and traffic scenarios (T8)	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test will be useful in multilane configurations of course, but may be envisaged for single lane and pseudo multilane if motorcycles are involved.	

Table B.3 — Traffic conditions - lateral distance between OBEs

Dynamic behaviour tests		
Name:	Lateral distance between OBEs (T3)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance for closely laterally distance between OBEs	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each bulk of vehicles crossing the communication zone, the transactions are monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of the number of vehicles simultaneously crossing the toll zone, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T3 according to speed class (T4) and traffic scenarios (T8)	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test will be useful in multilane configurations of course, but may be envisaged for single lane and pseudo multilane if motorcycles are involved. d) To carry out test for very closely laterally spaced OBEs simulation can be useful (two or three OBEs each car).	

Table B.4 — Traffic conditions - speed of vehicle(s)

Dynamic behaviour tests		
Name:	Speed of vehicle(s) (T4)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance as a function of vehicle speed	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their speed, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — recording of vehicle speed (e.g. electronic tachograph) — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T4 driving in normal direction according to traffic scenarios (T8, T9) and traffic flow (T10), driving against the normal driving direction and driving in the reverse direction under conditions where traffic safety is not compromised.	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) Vehicle speed is related to vehicle class. d) For each speed class, a number of discrete values may be chosen; for instance, testing high speed multilane may be undertaken at 90 km/h, 120 km/h, 160 km/h and higher (evaluation of recorded speed with electronic tachograph).	

Table B.5 — Traffic conditions - angle of approach

Dynamic behaviour tests		
Name:	Angle of approach (T5)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance on bends in the road without changing the lane	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T5 according to speed class and traffic scenarios (T8) one car in a group of 5 to 10 vehicles	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test is likely to be usefully coupled with vehicle characteristics tests V6, V8, V9, V10, V11, as the performance of the DSRC air interface is affected by the OBE/beacon angle (presence of side lobes, increased effect of adjacent beacons interference, etc.), especially for low speeds/high angle configurations. d) For each speed class, a number of discrete values may be chosen; for instance, testing high speed multilane may be undertaken according to requirement reference.	

Table B.6 — Traffic conditions - lane changing

Dynamic behaviour tests		
Name:	Lane changing (T6)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance for changing the lane	
Requirement Reference:	a) EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] b) EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T6 according to speed class and traffic scenarios (T8) one car in a group of 5 to 10 vehicles	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) Vehicle speed is related to vehicle class. d) For each speed class, a number of discrete values may be chosen; for instance, testing high speed multilane may be undertaken according to requirement reference.	

Table B.7 — Traffic conditions - shadowing

Dynamic behaviour tests		
Name:	Shadowing car behind bus or truck (T7)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance for shadowing	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T7, according to speed class, traffic scenarios (T8)	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test may be usefully combined with traffic scenarios (T8) queue driving with two vehicles. d) The distance between the two vehicles depends on speed and traffic situation according to requirements of safe distance.	

Table B.8 — Traffic conditions - traffic scenarios free flow

Dynamic behaviour tests		
Name:	Traffic scenarios - free flow (T8)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance for traffic scenarios - free flow	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their speed, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — recording of vehicle speed (electronic tachograph) — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T8, according to speed class (T4)	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) Vehicle speed is related to vehicle class. d) For each speed class, a number of discrete values may be chosen; for instance, testing high speed multilane may be undertaken at 90 km/h, 120 km/h, 160 km/h and higher. e) The traffic situation should be combined with all vehicle classes and lane changing.	

Table B.9 — Traffic conditions - traffic scenarios - restricted flow

Dynamic behaviour tests		
Name:	Traffic scenarios - restricted flow (T9)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance as a function of vehicle speed and the duration of staying in the communication zone including 'stop and go' condition and reverse driving.	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — recording of vehicle speed and the duration of staying in the communication zone — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T9, duration of staying in the communication zone	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	— In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. — In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. — Traffic scenarios - restricted flow should be combined with all vehicle classes in a group of up to ten vehicles and lane changing. — For each duration of staying in the communication zone, a number of discrete values may be chosen; for instance 10 min or 20 min.	

Table B.10 — Traffic conditions - traffic flow

Dynamic behaviour tests		
Name:	Traffic flow (T10)	
Group:	Traffic conditions	
Purpose:	EFC transaction performance as a function of traffic flow	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — continually recording of traffic flow — the particular traffic condition will be described and recorded in a data base	
Constraints reference:	T10	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) The traffic flow will be recorded continually and independently from the trials for a later evaluation.	

B.3 Vehicle characteristics

Table B.11 — Vehicle characteristics - vehicle geometry and other vehicle features

Dynamic behaviour tests		
Name:	Vehicle geometry and other vehicle features (V1, V2, V3, V4, V5)	
Group:	Vehicle characteristics	
Purpose:	EFC transaction performance for vehicle geometry and other features	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular vehicle characteristics, vehicle geometry and other vehicle features are described and recorded in central database for evaluation	
Constraints reference:	V1, V2, V3, V4 and V5	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test is obviously intended to ensure that all vehicles that are likely to use the operator's toll system will be reliably charged. Therefore, the possible combinations between V1, V2, V3, V4 and V5 are limited and shall be reasonably chosen among currently available vehicles.	

Table B.12 — Vehicle characteristics - constructive elements

Dynamic behaviour tests		
Name:	Constructive elements (V6)	
Group:	Vehicle characteristics	
Purpose:	EFC transaction performance for constructive elements	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular vehicle characteristics and constructive elements are described and recorded in central database for evaluation	
Constraints reference:	V6	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test is usefully linked with test V10 and T7, as constructive elements may lead to the reduction of the effective length of the communication zone. d) No 'normalised' constructive elements will be defined; it is up to the operator to define his particular requirements for each class of vehicles.	

Table B.13 — Vehicle characteristics - attenuation of windscreens, dirty windscreens

Dynamic behaviour tests		
Name:	Attenuation of windscreens (V7)	
Group:	Vehicle characteristics	
Purpose:	EFC communication performance of windscreens influenced by e.g. metallised, coated, heated, dirty windscreens	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	3 dB one way	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular vehicle characteristics and attenuation and dirtiness of windscreens are described and recorded in central database for evaluation	
Constraints reference:	V7	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) Windscreens with different attenuation or different degrees of dirtying should be used.	

Table B.14 — Vehicle characteristics - angle of windscreens - horizontal plane

Dynamic behaviour tests		
Name:	Angle of windscreens - horizontal plane (V8)	
Group:	Vehicle characteristics	
Purpose:	EFC transaction performance for angle of windscreens - horizontal plane	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	45°	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular vehicle characteristics and angle of windscreens - horizontal plane are described and recorded in central database for evaluation	
Constraints reference:	V8	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test is usefully linked with test V10, as the main effect of angle of windscreens - horizontal plane is the change the effective communication zone.	

Table B.15 — Vehicle characteristics - angle of windscreens - vertical plane

Dynamic behaviour tests		
Name:	Angle of windscreens - vertical plane (V9)	
Group:	Vehicle characteristics	
Purpose:	EFC transaction performance for angle of windscreens - vertical plane	
Requirement Reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	0°	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular vehicle characteristics and angle of windscreens - vertical plane are described and recorded in central database for evaluation	
Constraints reference:	V9	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test is usefully coupled with test T5 (driving at an angle) and T6 lane changing may also be considered.	

Table B.16 — Vehicle characteristics - mounting heights of OBE antenna

Dynamic behaviour tests		
Name:	Mounting height of OBE antenna (V10) measured from the road surface	
Group:	Vehicle characteristics	
Purpose:	EFC transaction performance for various mounting heights of OBE antenna	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	0,7 m to 3,0 m	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular vehicle characteristics and various mounting heights of OBE antenna are described and recorded in central database for evaluation	
Constraints reference:	V10	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) OBE antenna height in closely related to vehicle class and combinations between V1, V5 and V4 are limited. d) This test will be usefully coupled with T4 (speed of vehicles) as the main effect of varying OBE antenna height is to change the effective communication zone.	

Table B.17 — Vehicle characteristics - lateral mounting of OBE antenna

Dynamic behaviour tests		
Name:	Lateral mounting of OBE antenna (V11) from middle of windscreen	
Group:	Vehicle characteristics	
Purpose:	EFC transaction performance for various lateral mounting of OBE antenna	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	0 m	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular vehicle characteristics and various lateral mounting of OBE antenna are described and recorded in central database for evaluation	
Constraints reference:	V11	
Verdict:	<u>Test result</u> No failed transaction One or more transaction failed	<u>Verdict</u> Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) This test applies only if it does not conflict with manufacturer's specification, and is mainly useful where the user is required to mount the OBE in his vehicle.	

Table B.18 — Vehicle characteristics - OBE conditions

Dynamic behaviour tests		
Name:	OBE behaviour (V12)	
Group:	Vehicle characteristics	
Purpose:	EFC transaction performance for OBE conditions	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — the particular vehicle characteristics and different OBE conditions are described and recorded in central database for evaluation	
Constraints reference:	V12	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid.	

B.4 Environmental influences

Table B.19 — Environmental influences: width of pavement, number of lanes & other conditions

Dynamic behaviour tests		
Name:	Width of pavement, number of lanes and other topographical influences (I1, I2, I3)	
Group:	Environmental influences	
Purpose:	EFC transaction performance for width of pavement, number of lanes and other conditions	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — particular environment influences will be listed and recorded in a data base	
Constraints reference:	I1, I2, I3 to all traffic conditions	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) All traffic scenarios influenced by width of pavement and number of lanes. d) The influence of other conditions should be evaluated.	

Table B.20 — Other environment influences - weather conditions

Dynamic behaviour tests		
Name:	Weather conditions (I4, I5, I6)	
Group:	Environmental influences	
Purpose:	EFC transaction performance for weather conditions	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC278 [N318] — EFC application	
Default:	t.b.d (see B.1)	
Test configuration:	— tools: data logger, simulator for communication protocols (transactions) — test location: site — interfaces used: RSE serial interface — required equipment: RSE, OBEs for each vehicle, vehicles, gantry	
Behaviour description:	— methodology: for each vehicle crossing the communication zone, the transaction is monitored on a pass/fail basis, and a data logging of the RSE is recorded — test steps: definition of the desired vehicles, definition of their succession order, choice of the number N of runs, observation of the N runs — instructions: driving instructions given to the vehicles drivers in order to comply to test definition — weather conditions recorded automatically and continually — particular environment influences will be listed and recorded in a data base	
Constraints reference:	I4, I5, I6	
Verdict:	Test result No failed transaction One or more transaction failed	Verdict Pass Fail
Comments:	a) In case any failure has occurred which is not caused by the item under test, the specific test run is repeated. If the failure is of a persistent nature it shall be assigned to the respective test item. b) In case a single transaction fails, which statistically occur for any real transaction error performance, a second identical test run is carried out: If the repeated run after a failed run shows no error, the verdict 'pass' is valid. c) Weather conditions recorded automatically for later evaluation.	

Annex C
(informative)

Reliability/availability tests

C.1 Overview

C.1.1 General

Reliability is considered as equipment reliability and transaction reliability. Equipment is divided further into repairable and non-repairable. RSE is typically repairable, but OBE tends to be non-repairable. This results in the following assignment:

— availability and the MTBF, applicable to repairable equipment;

— reliability and the MTTF, applicable to non-repairable equipment;

— transaction reliability, expressed in a per-transaction probability of failure, or any equivalent measure.

In addition to test for obtaining estimates of the above quantities (point estimates) it is usually also necessary to give figures on the preciseness of these estimates, usually in the form of confidence intervals.

Standard statistical methods are to be used for calculating these quantities from the measurements; some examples are given in informative Annex E.

C.1.2 Availability

For availability calculations there are two basic figures needed, the MTBF and the MTTR. The definition of availability is:

$$A = \frac{MTBF}{MTBF + MTTR}$$

The MTTR is normally obtained from manufacturer guarantees and prescribed repair procedures. The MTBF may be measured statistically, but this is not always feasible. As an alternative, the system failure rate may be calculated from an analysis of the system architecture, combining the failure data of system components and sub-components (at the lowest level, figures can be obtained from standard handbooks of component failure rates).

C.1.3 Equipment reliability

For non-repairable equipment, the MTTF needs to be determined. This can be done either by analysis in the same way as the MTBF was determined, or by direct statistical observation. In the case of OBE, the latter course may be feasible, since OBE units may be available in sufficient quantities to observe the failure rate λ; the MTTF is then equal to $1/\lambda$. If the number of units available is too small, the observation period needs to be very long to achieve the required level of confidence. In any case, the observation period needs to be long enough to eliminate initial errors, or ”burn-in” effects.

The failure-rate curve shows a shape called "bath tub" curve. The failure rate will decrease to a lower value, which remain fairly constant and define the beginning of normal operation period. The failure early period is called the infant-mortality or the burn-in period. Failure occurrence can be discerned by burn-in or aging of the components.

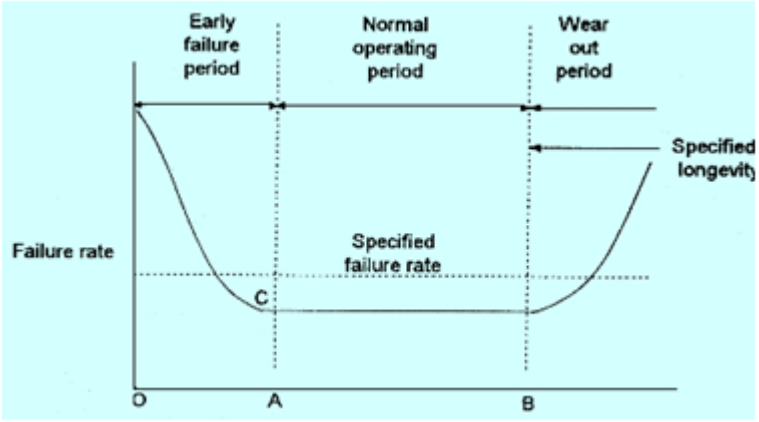

Figure C.1 — Typical failure rate curve

C.1.4 Transaction reliability

Transaction reliability can be determined in a similar way to equipment reliability, either by analysis of the process, or by observation of transactions in reality, in the laboratory, or in a simulation model. In addition to obtaining figures for the reliability of a transaction as a whole it is also important to calculate separate figures for the various ways in which a transaction can fail. Some requirements specifications may be extremely demanding, e.g. 1 in 10^6. This can only be tested experimentally by observing (or simulating) several millions of transactions, or by analytical means. In analysis as well as in simulation, however, the validation of the model becomes a problem in its own right, in particular when applied to real-life traffic situations (true but only background information -little quantitative support). Hybrid approaches, where simulation, observation of real traffic, and analytical techniques are combined, may be used to obtain reliability results with an acceptable level of confidence. As an alternative, the tests may be performed entirely by simulation and analysis, and the model(s) used can be validated against real traffic in the actual operational environment.

C.2 Reliability / availability test

Table C.1 — Transaction level reliability

Reliability/availability tests		
Name:	Transaction-level reliability (R2)	
Group:	Reliability/Availability	
Purpose:	To prove, that the required transaction-level reliability can be achieved, which means that less than *n* transaction fails in *N* transactions	
Requirement reference:	— EFC requirements for the DSRC — EFC Application Interface Definition according to EN ISO 14906 — Specification of the transaction profile	
Default:	The EFC equipment has passed the DSRC and EFC Application Interface Conformance Tests	
Test configuration:	— Any test method, which is able to satisfy the statistical requirements, is acceptable — Usage of simulation techniques is recommended Any test configuration shall ensure, that the system is tested under conditions close to reality	
Behaviour description:	Methodology In order to prove the required transaction-level reliability, long-term testing of the system in selected scenarios as specified in a test plan, see section 5.3, shall be carried out. Test steps For each of the tested scenarios, the number of test transactions shall be sufficient to meet the required confidence level. Instructions The test house carrying out the testing ensures, that with the scenarios selected for testing, the complete functionality of the EFC system will be tested, although it is expected, that no exhaustive testing with every parameter and scenario configuration can be carried out.	
Constraints reference:	Not relevant	
Verdict:	Test result Confirmation of the required transaction reliability. Number of failed transactions in the specified scenarios.	Verdict Pass Fail
Comments:	It is recommended to specify the number of test transactions in order to achieve the desired confidence level. E.2 gives some guidance. It is difficult and unrealistic to execute large numbers of transactions in practical operational environment, as this will require large numbers of vehicle passages. Therefore, a combination of simulation and real-life traffic is most feasible.	

Table C.2 — OBE life duration

Reliability/availability tests		
Name:	OBE life duration (R3)	
Group:	Reliability/Availability	
Purpose:	Evaluation of the OBE life duration, except batteries and smart card physical interface. Assuming that the OBE is not repaired on failure, this is equivalent to the MTTF.	
Requirement reference:	None (operator specific requirement) See Annex E for minimal performance requirement	
Default:	t.b.d.	
Test configuration:	— tools: none — test location: laboratory — interfaces use: none	
Behaviour description:	— methodology: this figure will be derived from the behaviour of the OBE to some environmental tests (vibration, shocks, heat, etc.) and by the manufacturer's demonstration and quality insurance — test steps: not relevant — instructions: not relevant	
Constraints reference:	Not relevant	
Verdict:	**Test result** Compliant with the class specification chosen by the operator. Not compliant.	**Verdict** Pass Fail
Comments:		

Table C.3 — OBE battery duration

Reliability/availability tests		
Name:	OBE battery duration (R4)	
Group:	Reliability/Availability	
Purpose:	Evaluation of the OBE battery duration under operating conditions. Assuming that a battery is not repaired on failure, this is equivalent to the MTTF.	
Requirement reference:	None (operator specific requirement) See Annex E for minimal performance requirement	
Default:	t.b.d.	
Test configuration:	— tools: simulator for communication protocols (transactions) — test location: laboratory — interfaces used: electrical load — required equipment: climate chambers to apply temperature variations. If the battery is connected via contacts, also vibration test equipment may be required	
Behaviour description:	— methodology: batteries shall be tested by applying all operational modes of the OBE according to manufacturer specifications — test steps: Measuring of power consumption in significant operational modes and assessment of the specified battery duration time — instructions: not relevant	
Constraints reference:	Not relevant	
Verdict:	**Test result** Compliant with the class specification chosen by the operator. Not compliant.	**Verdict** Pass Fail
Comments:	The number of OBE will be the choice of the manufacturer, but it is suggested to be at least 50, for the following reasons: — most OBE batteries require a recovery time after a transaction that is much longer than the transaction itself, increasing the number of OBEs will thus speed up the test process — batteries do not have perfectly well controlled performances, and establishing a statistical averaging is mandatory for this test	

Table C.4 — OBE smart card life duration

Reliability/availability tests		
Name:	OBE smart card life duration (R5)	
Group:	Reliability/Availability	
Purpose:	Evaluation of the OBE smart card life duration	
Requirement reference:	None (operator specific requirement) See Annex E for minimal performance requirement	
Default:	t.b.d.	
Test configuration:	— tools: mechanical smart card manipulator, simulator for communication protocols (transactions) — test location: laboratory — interfaces used: serial interface — required equipment: none	
Behaviour description:	— methodology: the card will be inserted and extracted a given number N times (according to class specification) and a transaction with access to the smart card will be performed each time — test steps: choice of N, observation of each transaction — instructions: not relevant	
Constraints reference:	Not relevant	
Verdict:	**Test result** No failed transaction. One or more failed transaction.	**Verdict** Pass Fail
Comments:	This test implies a specific test mode in the OBE for access to the smart card.	

Annex D
(informative)

Classes of equipment

Tables D.1 to D.3 propose a set of equipment parameters. The tables are to be considered as an example, they are not complete. The purpose of the tables are to illustrate the likely parameters which are to be used to form classes of equipment by the assignment of specific requirements. The column 'test procedure' indicates the applicable section of this document. The listed entries of the column 'requirement' are accidental and there is no dependency between columns and lines. The tables may be used by operators to specify frame conditions for the intended EFC-applications. A set of such selected parameters may form together with the assigned requirements a class of DSRC equipment. The proposed equipment parameters are provided for RSE, OBE and Communication.

It is not the intention of this document to define classes of DSRC equipment.

Table D.1 — RSE parameters

Parameter of RSE						
Parameter	**Item**	**Test Procedure**	**Requirements**			**Reference**
Availability	1/MTBF	C.1	10^{-5}	10^{-6}		CEN/TC278 [N318]
Security	defined protection targets		level E4	level E5		ISO/IEC 15408
Environment	different conditions	F.2	4K2	4K3		EN 60721
Traffic conditions	lane configuration	B.2	Single	multi	3 lanes	CEN/TC278 [N318]
	traffic flow/ lane and hour	B.2	< 1 800	< 2 000		CEN/TC278 [N318]
	longitudinal distance	B.2	> 5 m	2 m to 4 m		CEN/TC278 [N318]
	lateral distance	B.2	> 1,5 m	1 m to 1,5 m		CEN/TC278 [N318]
Vehicle characteristics	vehicle speed	B.2	< 90 km/h	< 160 km/h		CEN/TC278 [N318]

Table D.2 — OBE parameters

Parameter of OBE						
Parameter	**Item**	**Test Procedure**	**Requirements**			**Reference**
Reliability	λ	C.2	4 years	5 years		CEN/TC278 [N318]
Security	different protection targets		level E4	level E5		ISO/IEC 15408
Environment	different conditions	F.2	5K2	5K3		EN 60721
Equipment	Type		Tag	OBU	OBU and ICC	CEN/TC278 [N318]
	MMI		-	Display	Display, keyboard	CEN/TC278 [N318]
Functionality	Debiting	6.1	central account	vehicle account		CEN/TC278 [N318]
	Receipt	6.1	central receipt	vehicle receipt		CEN/TC278 [N318]
Vehicle characteristics	Vehicle Speed	B.2	< 90 km/h	< 160 km/h		CEN/TC278 [N318]
	Vertical position OBE	B.3	< 0,7 m	< 1,3 m		CEN/TC278 [N318]
	OBU sensitivity	B.3	3 dB	11 dB		CEN/TC278 [N318]

Table D.3 — Communication Parameters

Parameter of Communication						
Parameter	**Item**	**Test Procedure**	**Requirements**			**Reference**
Communication	EFC communication protocol	6.1.1	protocol a	protocol b		EN ISO 14906
Transaction reliability	λ	C.1	10^{-4}	10^{-5}		CEN/TC278 [N318]
Security	different protection targets		level E4	level E5		ISO/IEC 15408

Annex E
(informative)

Examples for statistical calculations

E.1 Example: The calculation of a quantity from a sample

The methodology of estimating the reliability of the on board equipment (OBE) by means of the **MTTF** can be as described in the following scenario:

The manufacturer and the service provider agree on using a field test with N OBEs in order to estimate the MTTF. They also agree on using statistical analysis on the field test based upon an estimator for the MTTF, MTTF*.

For simplicity reasons the following is assumed:

The N **different** OBEs from the manufacturer are observed in their operation periods until the first failure occurs for each OBE. It is in this scenario assumed that the OBE are operating **independently** from each other.

Let T_i be the operational time for one OBE (number **i**) until its operation is caused by one failure, i.e. its Time To Failure (TTF).

The estimator MTTF* is defined as the sample average:

$$MTTF^* = \frac{1}{N}\sum_{i=1}^{N} T_i$$

The variance is calculated from the individual life times and the sample average, as follows:

$$Var^*(MTTF) = \frac{\sum_{i=1}^{N}(T_i - MTTF^*)^2}{N - 1}$$

Given the mean and the variance, percentile estimates for the MTTF can be obtained, preferably using some known or assumed distribution function. If we have no information at all about the distribution of the lifetimes, the confidence level can be established from the average alone, using the *Markov inequality*:

$$P[X \geq x] \leq \frac{\overline{X}}{x}$$

This yields a rather weak estimate. The *Chebyshev inequality* uses the mean and variance, and is somewhat tighter; it states that for any $x > 0$,

$$P[|X - \overline{X}| \geq x] \leq \frac{\sigma_X^2}{x^2}$$

Estimates based on a (known or assumed) distribution are generally superior.

For example, if the distribution of the MTTF can be approximated by a normal distribution, then the 95 confidence interval lies between MTTF*-1,96s and MTTF* + 1,96s, where s is the standard deviation, the square root of the estimated variance.

The assumption of a normal distribution has to be justified, however; it cannot under all circumstances be taken for granted.

A problem with this approach is that it takes a long time (theoretically until the last OBE has failed) until the above calculations can be made. This method, (which is generally quite useful for measuring population properties from

samples) does not seem to be practical in this case. The determination of MTTF will be discussed at the end of this Annex.

E.2 Statistical considerations when proving low transaction-error rates

In the following some statistical considerations are presented, which demonstrate the statistical relevance of different numbers of test events.

For this example, the probability, that in a number of tested EFC transactions, no failed transaction will occur (100 % success) is calculated depending on the number of test transaction carried out and the actual reliability (which of course usually is not known and shall be determined by the testing).

The calculations presented in the following table are based on the binomial distribution function:

$$p_k = \binom{n}{k} r^k \times (1 - r)^{n-k} \quad 3$$

The following definitions are used:

r	Probability of failure of an EFC transaction (unreliability of the EFC system)
n	Number of tested EFC transactions
k	Number of failed transactions
p	Probability, that k failed transaction are encountered for n tested transactions

For the following table, the following values were chosen:

n	Number of tested EFC transactions: 100, 100 000 and 10 000 000
k	Number of failed transactions: 0 (no failure, 100 % success)
p	Probability, that the EFC system passes the testing with no failure (100 % success)

The formula reduces then to:

$$p_0 = (1-r)^n$$

Table E.1 — Calculations

n (No. of tested transactions)	***R*** (Transaction failure probability)	p_0 (probability of no failure in n transactions)
100	10^{-2}	36,6 %
	10^{-3}	90,4 %
	10^{-4}	99,01 %
	10^{-5}	99,90 %
	10^{-6}	99,99 %
100 000	10^{-2}	0
	10^{-3}	0
	10^{-4}	0,004 5 %
	10^{-5}	36,8 %
	10^{-6}	90,5 %
10 000 000	10^{-2}	0
	10^{-3}	0
	10^{-4}	0
	10^{-5}	0
	10^{-6}	0,005 %
	10^{-7}	36,7 %

p_0 can be interpreted as the probability that a PASS verdict is given to a system with a failure rate given by *r*, and with this interpretation, the results of the testing lead to the following observations:

100 tested transactions:

— With only 100 tested transactions a system with a reliability of 1 failure out of 10 000 will pass the test without failure with almost the same probability as a system with a reliability of 1 failure out of 1 000 000 transactions.

— Clearly 100 tests are insufficient to verify low transaction error rates

100 000 tested transactions:

— with 100.000 tested transaction without a failure, a reliability of better than 1 failure out of 10 000 can be concluded with a very high probability

10 000 000 tested transactions:

— with 10 000 000 tested transaction without a failure, a reliability of better than 1 failure out of 1 000 000 can be concluded with a very high probability

This can be seen directly by using the following approximation:

$$r\,n << 1 \Rightarrow p_0 = (1-r)^n \cong 1-r\,n$$

For very small values of **r** it can be seen immediately that ***r* n** should *not* be small (since then p_0 will be near unity) so **n** should be big (roughly n>1/*r*). Or, if there is a requirement for a reliable PASS verdict for a transaction error rate of 10^{-6}, then a need on the order of a million test transactions is given.

If the desired confidence level is α, then the minimum required sample size is log (1- α)/log(1-*r*).

E.3 MTTF determination

This is to reconsider the MTTF determination problem with which this annex started. It begins with the translation from MTTF to failure rate:

failure rate = 1/MTTF

The failure rate is the expected number of failures per time unit per OBE unit in the sample. Roughly, over a time *T*, one may assume that the probability that an OBE fails during this interval is T/MTTF failures per OBE unit. This is equated to the failure probability in the preceding section:

$$r = T/MTTF$$

The probability for a false PASS verdict results in:

$$p_0 = (1 - T/MTTF)^n$$

and the condition on the minimum number of OBE units that must be involved in the test is:

n should be at least of the order MTTF/T

It can be seen that there is a trade-off between T and n: the shorter the test interval, the more units are required to achieve a good level of confidence.

NOTE Strictly, this is only true for infinitesimal T; however, as long as T<<MTTF, the approximation is good.

Annex F
(informative)

Examples of referenced pre-tests based on European test procedures

F.1 Dedicated Short-Range Communication (DSRC)

The following clauses contain test items and references to test procedures with regard to the requirements of the following European DSRC standards:

EN 12253:2004, *Road transport and traffic telematics – Dedicated short-range communication – Physical layer using microwave at 5,8 GHz.*

EN 12795:2002, *Road transport and traffic telematics – Dedicated Short-Range Communication (DSCR) – Data link layer: Medium access and logical link control.*

EN 12834:2002, *Road transport and traffic telematics – Dedicated Short-Range Communication (DSCR) – Application layer.*

EN 13372:2004, *Road Traffic and Transport Telematics – Dedicated Short-Range Communication (DSCR) – Profiles for RTTT applications.*

Tables F.1 to F.4 are examples for test procedures related to DSRC parameters.

Table F.1 — Microwave (5,8 GHz)

Parameter	Test procedure (ref. Draft ETSI EN 300 674-1 V 0.0.9)
DSRC D	
D.1 Physical layer, 5,8 GHz	
D.1.1 Number and values of carrier frequencies	Carrier frequencies, sub-clause 5.3
D.1.2 Tolerance of Carrier Frequencies; RSU	Frequency error, sub-clause 9.8
D.1.3 RSU Transmitter Spectrum Mask	Transmitter spectrum mask, sub-clause 9.9
D.1.4 Modulation	Modulation index, Clause 9.1
D.1.5 Subcarrier frequencies (Uplink)	Frequency error (Subcarrier), sub-clause 10.5
D.1.6 OBU transmitter spectrum mask	Transmitter spectrum mask (OBU), sub-clause 10.6
D.1.7 Maximum single sideband E.I.R.P.	Maximum equivalent isotropically radiated power, sub-clause 10.4
D.1.8 Bit Error Rate	Contained in : Sensitivity (RSU), sub-clause 9.2.1 Error behaviour at high wanted input signals (RSU), sub-clause 9.2.2 Sensitivity (OBU), sub-clause 10.1.1 Upper power limit for communication (OBU), sub-clause 10.1.2
D.1.9 Minimum Conversion Gain (Transponder)	Conversion gain (OBU), sub-clause 10.3
D.1.10 Maximum E.I.R.P	Maximum equivalent isotropically radiated power (RSU), sub-clause 9.7

Table F.2 — MAC sub layer

Parameter		Test procedure
Main group	**Sub group**	
Control Frame	D.2.1.1 Invalid Flag	Test the behaviour, if the start- or the endflag is not '01111110'B
	D.2.1.2 Invalid Address	Test the behaviour, if the address is invalid
	D.2.1.3 Invalid Control Field	Test the behaviour, if the D- and the X-Bits in the Control Field are invalid
	D.2.1.4 Valid Control Field	Test the values of the Bits of the Control Field in a received frame
	D.2.1.5 Invalid FCS	Test the behaviour, if the Frame Check Sequence is invalid
Window Management	D.2.2.1 Timing	Test the timing behaviour (Parameter T1, T2, T3, T4a, T4b, T5)
	D.2.2.2 Frame length	Test, if the max. layer 2 frame length in a downlink window is N2 octets
	D.2.2.3 Frame length	Test, if the max. layer 2 frame length in a public uplink window is N4 octets
	D.2.2.4 Frame length	Test, if the max. layer 2 frame length in a private uplink window is N3 octets
OBE Management	D.2.3.1	Test, if the RSE manage the variables for each OBE in the communications zone
Access	D.2.4.1 Random	Test the correct implementation of the Random Delay Counter Mechanism (for single- and for multilane scenarios)
	D.2.4.2 Private Uplink Allocation	Test, if the OBE only uses private uplink windows, which are reserved to this OBE
	D.2.4.3 Private Uplink Reallocation	Test, if the RSE reallocates private uplink windows correctly
Data Transfer	D.2.5.1 Transmit	Test, if the OBE transmit the correct LPDU in dependence to the L- and the S-Bit and the V(A) variable
	D.2.5.2 Receive	Test the behaviour, if a correct frame is received
	D.2.5.3 Frame	Test, if the transmitted Frame has the correct format
Private Medium Response Timer	D.2.6.1	Test the correct implementation of the Private Medium Response Timer

Table F.3 — LLC sub layer

Parameter		Test procedure
Main group	**Sub group**	
Control Frame	D.2.7.1 Invalid Address	Test the behaviour, if the address is invalid
	D.2.7.2 Invalid Control Field	Test the behaviour, if the Control Field is invalid
	D.2.7.3 Invalid Length	Test the behaviour, if the LPDU has an invalid length
Type 1 Protocol	D.2.8.1	Test the Type 1 Component State Transition Table in the DSRC-Standard
Type 3 Protocol	D.2.9.1 Receive	Test the Type 3 Receiver Component State Transition Table in the DSRC-Standard
	D.2.9.2 Sender	Test the Type 3 Sender Component State Transition Table in the DSRC-Standard

Table F.4 — Application layer

Parameter		Test procedure
Main group	**Sub group**	
Transfer Kernel Element	D.3.1.1 Encoding	Test the correct encoding of the PDUs according to ASN.1-BASIC-PER
	D.3.1.2 Decoding	Test the correct decoding of the T-APDUs according to ASN.1-BASIC-PER
	D.3.1.3 Fragmentation	Test the correct fragmentation of the encoded PDUs according to ASN.1-BASIC-PER
	D.3.1.4 Defragmentation	Test the correct defragmentation of the T-APDUs according to ASN.1-BASIC-PER
	D.3.1.5 Octet Alignment	Test the correct octet alignment
	D.3.1.6 Multiplexing	Test the correct multiplexing of the T-APDUs
	D.3.1.8 Demultiplexing	Test the correct demultiplexing of the T-APDUs
	D.3.1.9 Concatenation	Test the correct mapping of multiple consecutive T-APDUs on one LLC-service
	D.3.1.10 Access to LLC	Test the correct use of the FlowControl Parameter
Initialisation Kernel Element	D.3.2.1 Transmission of BST	Test if the RSE transmit periodical a correct BST
	D.3.2.2 Reception of BST	Test if the OBE reacts correctly to a received BST
	D.3.2.3 Answer to VST	Test if the RSE reacts correctly to a received VST
	D.3.2.4 Registration	Test if a new Application is correctly registered
	D.3.2.5 Deregistration	Test if an Application is correctly de-registered
	D.3.2.6 Application is ready	Test if the RSE and the OBE reacts correctly to a Ready Application-Service-Primitive
	D.3.2.7 Reception of a Release	Test if the RSE and the OBE reacts correctly to a received Release

F.2 Environment

Table F.5 — Basic environment testing with reference tests

Parameter	Test procedure (reference)
Environment V (Part 1)	
Basic testing procedures	EN 60068-1
ET.1. Climate	
ET.1.1 Cold	EN 60068-2-1
ET.1.2 Dry heat	EN 60068-2-2
ET.1.3 Damp heat, steady state	EN 60068-2-78
ET.1.4 Damp heat, cyclic	EN 60068-2-30, EN 60068-2-3-4
ET.1.5 Temperature changing	EN 60068-2-14
ET 1.6 Sun radiation	EN 60068-2-5
ET 1.7 Light, brightness	to be defined
ET 1.8 Rain, Fog, Snow	to be defined
ET.2. Mechanical	
ET.2.1 Vibration, Sinusoidal (RSE)	EN 60068-2-6
ET.2.2 Vibration, Random (OBE)	EN 60068-2-64
ET.2.3 Shock	EN 60068-2-27
ET.2.4 Bump (continuous shocks)	EN 60068-2-29
ET.2.5 Free fall (OBE)	EN 60068-2-32
ET.2.6 Wind	to be defined
ET.2.7 Housing	EN 60529, EN 60068-2-17 (sealing)
ET.3 Electrical	
ET.3.1 Supply, Roadside	national requirements
ET.3.2 Supply, OBE	national requirements and partly to EMC (ISO 7637)
ET.3.3 Lightning	to EMC (EN 61000-4-5)
ET.4 Chemical/Biological	
ET.4 1 Salt mist	EN 60068-2-11 or -52
ET.4.2 Gas (SO2, H2S)	IEC 60068-2-42, -43, -46, -49
ET.4.3 Smoke, OBE	to be defined
ET.4.4 Mould	IEC 60068-2-10