TECHNICAL SPECIFICATION

ISO/TS 14907-1

Third edition
2015-09-01

Electronic fee collection — Test procedures for user and fixed equipment —

Part 1: Description of test procedures

Perception du télépéage — Modes opératoires relatifs aux équipements embarqués et aux équipements fixes —

Partie 1: Description des modes opératoires

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 204, *Intelligent transport systems*.

This third edition cancels and replaces the second edition (ISO/TS 14907-1:2010). It also incorporates the Technical Corrigenda ISO/TS 14907-1:2010/Cor.1:2010. The main changes are related to the revision of the references.

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

— *Part 1: Description of test procedures*

— *Part 2: Conformance test for the onboard unit application interface*

Introduction

For an electronic fee collection (EFC) system, approvals and tests are required to determine whether the system (or individual components 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 available, including documentation and approvals, and these could already be in operation in some European countries. This part of ISO/TS 14907 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 previously performed approvals, this part of ISO/TS 14907 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 publication of this part of ISO/TS 14907, the determination of common system requirements for Europe (or any other region) has not been agreed. For this reason, this part of ISO/TS 14907 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 part of ISO/TS 14907 provides that reference. This part of ISO/TS 14907 defines only the test and test procedures, not the benchmark figures that these are to be measured against. Benchmark figures which the systems or components under test can be compared with and validated against might form the subject of a future part of this Technical Specification. Within the framework of the European Electronic Toll System (EETS), this part of ISO/TS 14907 could provide inputs for the work of the notified bodies in view to certify the different systems' part of the EETS in particular to check the suitability for use.

This part of ISO/TS 14907 is furthermore limited to automated (electronic) payment using a standardized dedicated short-range communication (DSRC). The scope of this part of ISO/TS 14907 does not include manual payment, conventional money transaction, nor 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 part of ISO/TS 14907 enables 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 who specified the system can state their 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 standardized test procedures;

— focusing on those tests that 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 part of ISO/TS 14907 is provided by Annex A.

While this part of ISO/TS 14907 relates to general test procedures, certain provisions relate specifically to test procedures for certification purposes. Many features of this part of ISO/TS 14907 are relevant internationally; it is recognized that due to different regulatory requirements outside Europe, extension may be required to make its applicability as comprehensive in non-EU countries, before this International Standard can be reviewed for acceptance as in EU countries.

The ISO/TS 17444 series provides an examination framework for EFC charging performance.

Electronic fee collection — Test procedures for user and fixed equipment —

Part 1: Description of test procedures

1 Scope

This part of ISO/TS 14907 specifies the test procedures of EFC roadside 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 part of ISO/TS 14907 is restricted to systems operating within the radio emission, electromagnetic compatibility (EMC) regulations, traffic, and other regulations of the countries in which they are operated.

This part of ISO/TS 14907 identifies a set of suitable parameters 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 parameters:

— functionality;

— quality;

— referenced pre-tests.

An overview of the tests and parameters provided by this part of ISO/TS 14907 is given in 5.1 and 5.2.

This part of ISO/TS 14907 describes procedures, methods and tools, and a test plan which shows the relation between all tests and the sequence of these tests. It lists all tests that are required to measure the performance of EFC equipment. It describes which EFC equipment is covered by the test procedures; the values of the parameters to be tested are not included. It also describes how the tests are to be performed and which tools and prerequisites are necessary before this series of tests can be undertaken. It is assumed that the security of the system is inherent in the communications and EFC functionality tests, therefore they are not addressed here. All tests in this part of ISO/TS 14907 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 of ISO/TS 14907 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 part of ISO/TS 14907 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 part of ISO/TS 14907.

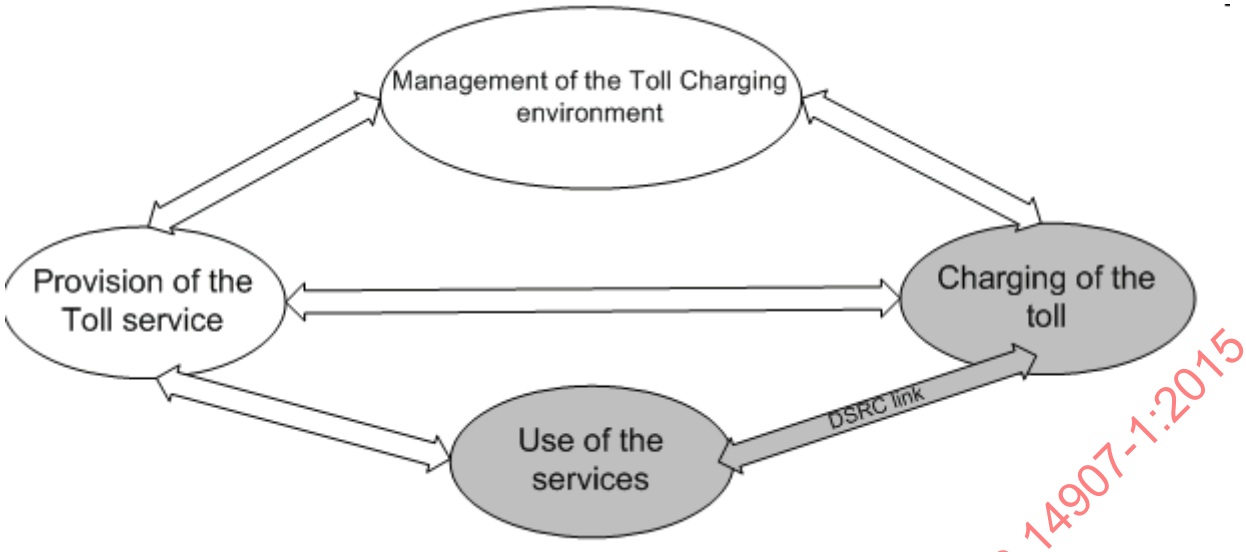

Figure 1 — Conceptual model of EFC

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 of all, or most, of the following:

— OBE within a vehicle;

— OBE 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 RSE containing the communications and computing sub-functions;

— equipment for the enforcement at the roadside;

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

The scope of this part of ISO/TS 14907 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, localization, and registration) and central equipment are outside the scope of this part of ISO/TS 14907.

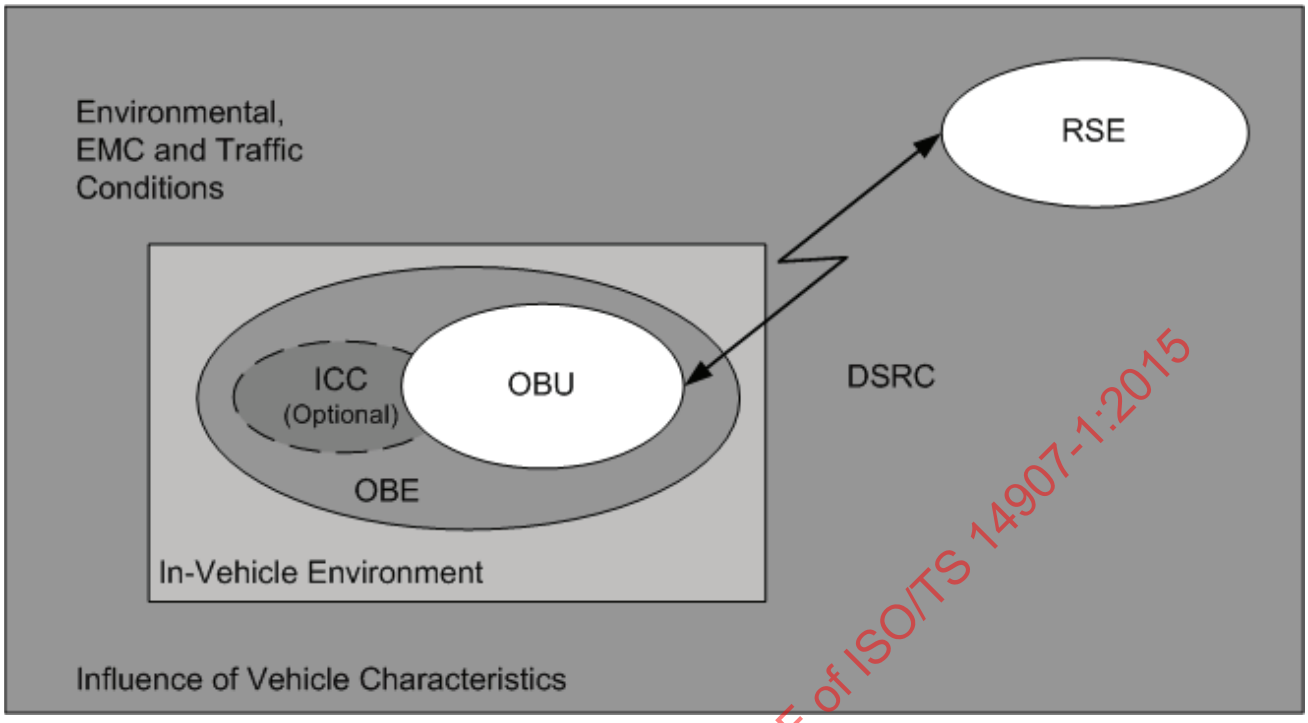

Figure 2 — OBE/RSE interface and associated environments

2 Normative references

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

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO/IEC 17065:2012, *Conformity assessment — Requirements for bodies certifying products, processes and services*

3 Terms and definitions

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

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

3.2
availability
property of being accessible and useable upon demand by an authorized entity

[SOURCE: ISO 7498-2:1989, 3.3.11]

3.3
certification
procedure by which a party gives written assurance that a product, process, or service conforms to specified requirements

3.4
compatibility
suitability of products, processes, or services for use together under specific conditions to fulfil relevant requirements without causing unacceptable interactions

3.5
EFC equipment
equipment comprising roadside equipment (RSE) and on-board equipment (OBE)

3.6
EFC system
system that enables electronic debiting for the use of transport services

3.7
evaluation
systematic process of determining how individuals, procedures, systems, or programs have met formally agreed objectives and requirements

[SOURCE: ISO 10798:2011, 1.90]

3.8
evaluation assurance level
set of assurance requirements, usually involving documentation, analysis and testing, representing a point on a predefined assurance scale, that form an assurance package

[SOURCE: ISO/IEC 15408-1:2009, 3.1.27, modified]

3.9
field test
test that is performed under real-life conditions

3.10
functionality test
assessing the performance of an EFC system, based on specific parameters

Note 1 to entry: Functionality parameters can include communication, application, and vehicle and traffic characteristics.

3.11
inspection
conformity evaluation by observation and judgement accompanied, as appropriate, by measurement, testing, or gauging

3.12
interoperability
ability of systems to exchange information and to make mutual use of the information that has been exchanged

[SOURCE: ISO/IEC/TR 10000-1:1998, 3.2.1, modified]

3.13
laboratory test
test which is performed in a laboratory under specified conditions

3.14
maintainability
ability of a system or subsystem to be maintained or restored to specified conditions within a given period of time

3.15
on-board equipment
OBE
equipment located on-board a vehicle including nomadic devices with the function of exchanging information with external systems

Note 1 to entry: OBE is composed of the on-board unit (OBU) and other sub-units whose presence is considered optional for the execution of the DSRC interface.

[SOURCE: ISO 14906:2011, 3.14]

3.16
quality
degree to which a set of inherent characteristics fulfils requirements

Note 1 to entry: User requirements can include ease of use, safety, availability, reliability, sturdiness, economy, and environmental safety. Such requirements can be explicit or implicit.

[SOURCE: ISO 9000:2005, 3.1.1]

3.176
reliability
ability of a device or a system to perform its intended function under given conditions of use for a specified period of time or number of cycles

3.18
roadside equipment
RSE
equipment located along the road, either fixed or mobile

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

[SOURCE: ISO/IEC 2382-1:1993, definition 01.06.01]

3.20
test
procedure designed to measure characteristics of a component or system in specified conditions

3.21
test parameter
parameter that specifies one or more characteristics of a system to be tested

3.22
test procedure
instructions for the setup, execution, and evaluation of results for a given test case

[SOURCE: ISO/IEC 25051:2014, 4.1.22, modified]

3.23
test status
nature of a test, either basic or conditional

Note 1 to entry: A test labelled “conditional” is performed if, and only if, it is applicable to a feature identified in the specification of the system or component, whereas a test labelled “basic” indicates a highly recommended test as part of a foundation for meaningful evaluation. See 5.2.

3.24
test type
kind of test, such as inspection, simulation, lab test, and field test

3.25
test house
third party that carries out the test

3.26
type approval
approval based on conformity testing on the basis of one or more specimens of a product representative of the production

3.27
validation
confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled

3.28
verification
confirmation by examination and provision of objective evidence that specified requirements have been fulfilled

4 Abbreviated terms

ARIB Association of Radio Industries and Businesses

NOTE A Japanese standards development organisation.

DSRC dedicated short-range communication (ISO 14906)

EAL Evaluation Assurance Level

EFC electronic fee collection (ISO 17573)

EIRP equivalent isotropically radiated power

EMC electromagnetic compatibility

ETSI European Telecommunications Standards Institute

ICC integrated circuit card

IEC International Electrotechnical Commission

IUT implementation under test

MMI man-machine interface

MTBF mean time between failure

MTTF mean time to failure

MTTR mean time to repair

OBE onboard equipment (ISO 14906)

OBU onboard unit

RSE roadside equipment (ISO 14906)

SUT system under test

tbd to be determined

5 Test parameters and test procedures for EFC

5.1 Tests overview

5.1.1 General

The test parameters for EFC systems or components are categorized 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 part of ISO/TS 14907. The test parameters for pre-tests are referenced from sources other than this part of ISO/TS 14907. The specific test parameters that 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 those pre-tests that have already been passed, i.e. for EMC, DSRC, and environment.

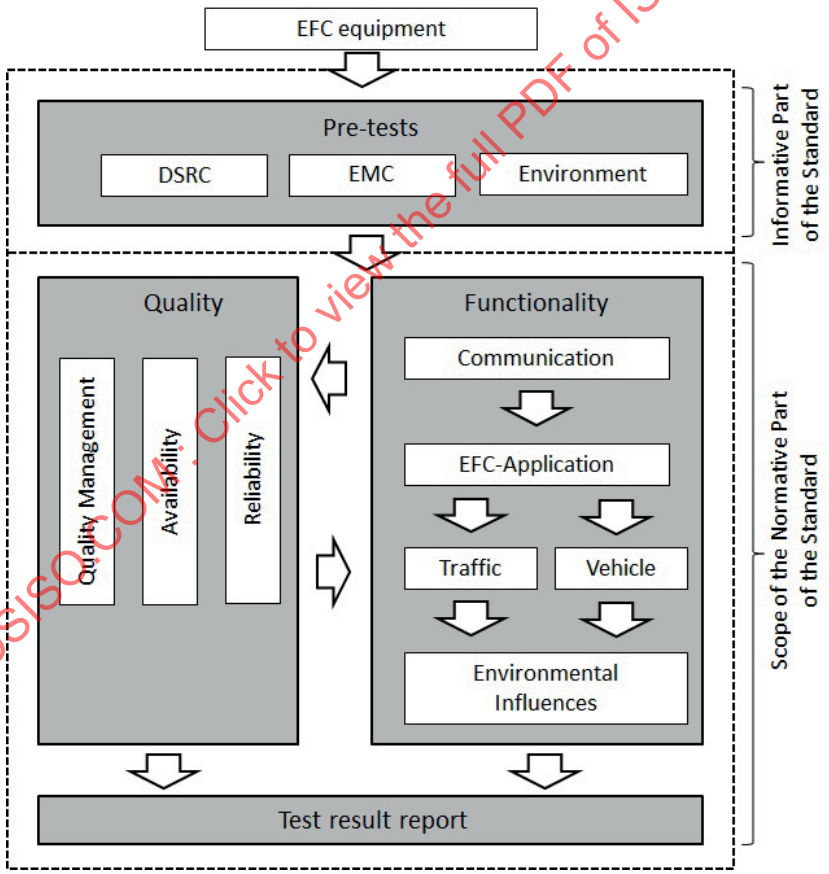

Figure 3 — Test plan — Interdependencies

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 that need to be applied to verify the performance and capability of EFC equipment of different vendors and system operators.

The following parameters shall be tested:

— communication;

— EFC application;

— influence of vehicle characteristics;

— influence of 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 procedures that aim to determine the quality of the EFC equipment. These are relevant for both operators and users.

The following test parameters shall be tested:

— quality management;

— reliability;

— availability.

For some of these test parameters, there are some 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 parameters which are fundamental for the performance of EFC equipment. The specific parameters and requirements are not within the scope of this part of ISO/TS 14907. The parameters that are relevant can be assigned to the following groups:

— DSRC;

— EMC;

— environment.

5.2 Parameter overview

Tables 1 to 3 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 subjects of 5.1.2, 5.1.3, and 5.1.4, namely functionality, quality, and referenced pre-tests. The subclause in which 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.

As used in Tables 1 to 3,

— "basic" means that the identified tests are highly recommended as part of a foundation for meaningful evaluation, and

— "conditional" means that the test shall be performed if, and only if, it is applicable to a feature identified in the specification of the system or component under evaluation, for example, performing the lane changing test (T6) if the RSE is characterized as multilane.

Table 1 provides an overview of the parameters for which tests are defined in this part of ISO/TS 14907 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 for pre-tests and whose performance and conformance are tested by reference to existing standards or Technical Specifications.

NOTE The tests have been categorized 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 is available to a test house, it is up to the test house to decide which type of test is most appropriate to meet its specific remit.

Where a particular category of test shall be performed to conform to this part of ISO/TS 14907, 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 subclause	Basic/ conditional[a]	Inspection	Laboratory	Simulation	Field test
Category 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 OBEs	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
	T10	Traffic volume	6.1.3, B.2	C	—	—	o	o

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

Table 1 — (*continued*)

Tests			Location	Test status	Applicable test type (p = shall be performed, o = optional)			
Parameter	**Item**	**Name**	**Reference to subclause**	**Basic/ conditional[a]**	**Inspection**	**Laboratory**	**Simulation**	**Field test**
Category 2								
Vehicle characteristics	V1	Length of vehicle	6.1.4, B.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 transporters 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. metallized, coated, heated, or dirty windscreen	6.1.4, B.3	C	—	o	o	o
	V8	Angle of windscreens, horizontal plane cars, small trucks and vans, trucks, buses, and touring coaches	6.1.4, B.3	C	—	o	o	o
	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

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

Table 1 — (*continued*)

Tests			Location	Test status	Applicable test type (p = shall be performed, o = optional)			
Parameter	**Item**	**Name**	**Reference to subclause**	**Basic/ conditional[a]**	**Inspection**	**Laboratory**	**Simulation**	**Field test**
Category 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 daylight	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 subclause**	**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 subclause**	**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 manufacturer or the test house carrying out the type approval or acceptance testing shall devise an individual test plan for each tested EFC system or EFC component, in accordance with Figure 3, taking into account the system-specific characteristics of the EFC application. With respect to *type approval*, the requirements of applicable standards or other normative and referenced documents shall be tested by the manufacturer or by a test house.

With respect to *acceptance tests*, only the features that are specified or implicit in the system specification shall be tested. Where additional features are provided for contingent use at some future date, these shall be tested only if such contingency is included in the system specification. Where additional features are present in products supplied, but are neither used nor included in the system specification or implementation, there is no requirement that they shall be tested unless they have an effect on the operation of the system.

Results of pre-tests that have already been passed shall be compared with the application-specific requirements. If deviations are detected, additional tests will need 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 (see G.5).

Interdependencies between the results of the different tests are anticipated and shall be taken into account by the manufacturer or the test house. An example test protocol form is given in 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 ISO/TS 14907-2. It specifies the tests that verify OBU conformance of implemented communication (transaction) protocols to conform with the specifications given in ISO 14906 to be used for EFC applications.

NOTE ISO/TS 14907-2 can also be used as a source of inspiration for roadside equipment testing in accordance with ISO 14906.

ISO/TS 14907-2 describes general requirements for conformance testing and specific test procedures for the following:

— 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.

6.1.2.2 and 6.1.2.3 describe a set of tests (see also Annex B); which of those tests are relevant and sufficient to prove the performance of an EFC system or its components shall be 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 relationship between the test sections is shown in Figure 4.

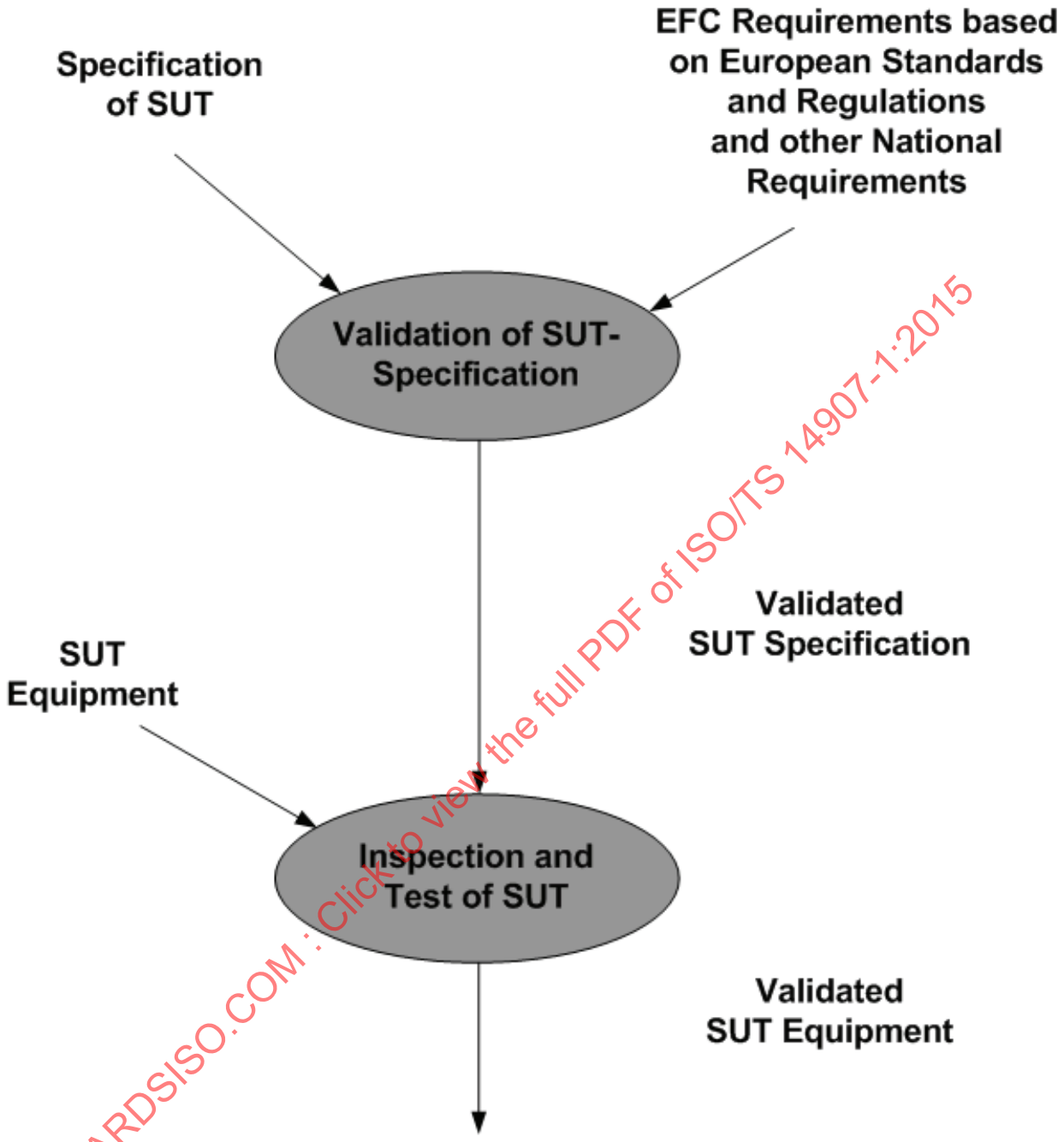

Figure 4 — Structure of application tests

6.1.2.2 addresses the validation of the EFC system specification with respect to the 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 authorized 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.

6.1.2.3 addresses EFC equipment that 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 tests that have been previously performed, for example, quality tests and reference tests, and shall be detailed by a test plan (see 5.3). Annex B contains a list of tests that 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, and other technical and non-technical measures concerning system performance.	
Constraints reference:	None	
Verdict:	**Test result** Authorized and valid system specification of the SUT. Test plan for the performance proof. The system specification does 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 to the DSRC standards and a qualification of the SUT in accordance with other fundamental requirements. 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. — 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 subsystems (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** The results are stating the SUT ability to meet principal requirements under specific conditions. The SUT does not meet the principal requirements.	**Verdict** Pass 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** The results confirm the ability of the SUT to meet functionality, compatibility, and interoperability requirements based on the conditions of all carried-out tests. Not in accordance with the specifications.	**Verdict** Pass Fail
Comments:		

6.1.3 Traffic conditions

Table 4 shows typical traffic conditions, for which individual test case specifications are described in 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)

Conditions T1 to T3 and T5 to T7 are shown in Figure 5.

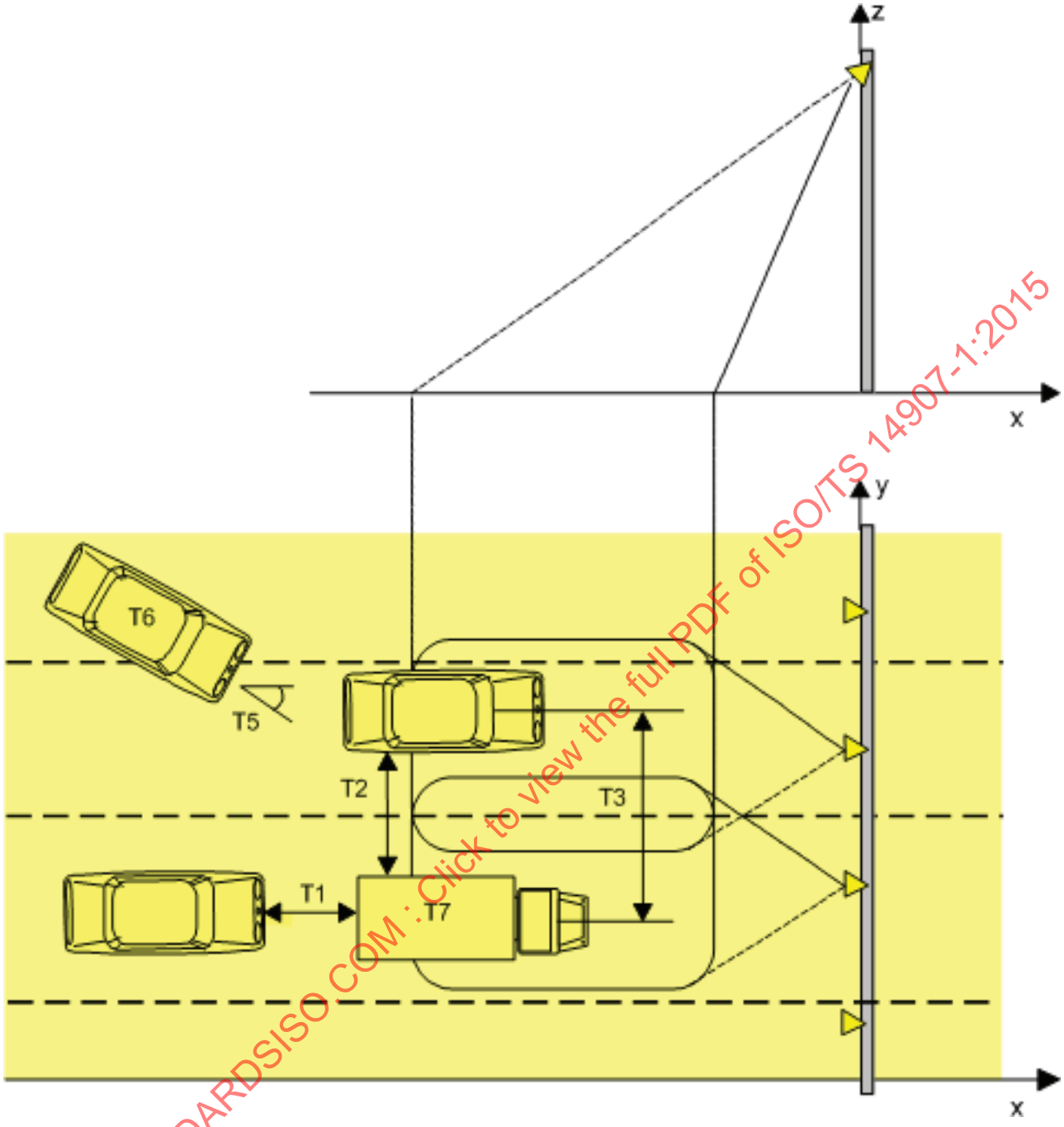

Figure 5 — Traffic conditions

6.1.4 Vehicle characteristics

Table 5 shows typical vehicle characteristics for which individual test case specifications have been described in 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 transporters with projecting loading surface sun roof (open/closed)/roof mountings
V7	attenuation of windscreen, caused by e.g. metallized, coated, heated, dirty windscreen
V8	angle of windscreens, from horizontal plane cars, small trucks and vans, trucks, buses, and touring coaches
V9	angle of windscreens, 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 vehicle characteristics in Table 5 excluding V5 to V7 and V12 are shown in Figure 6.

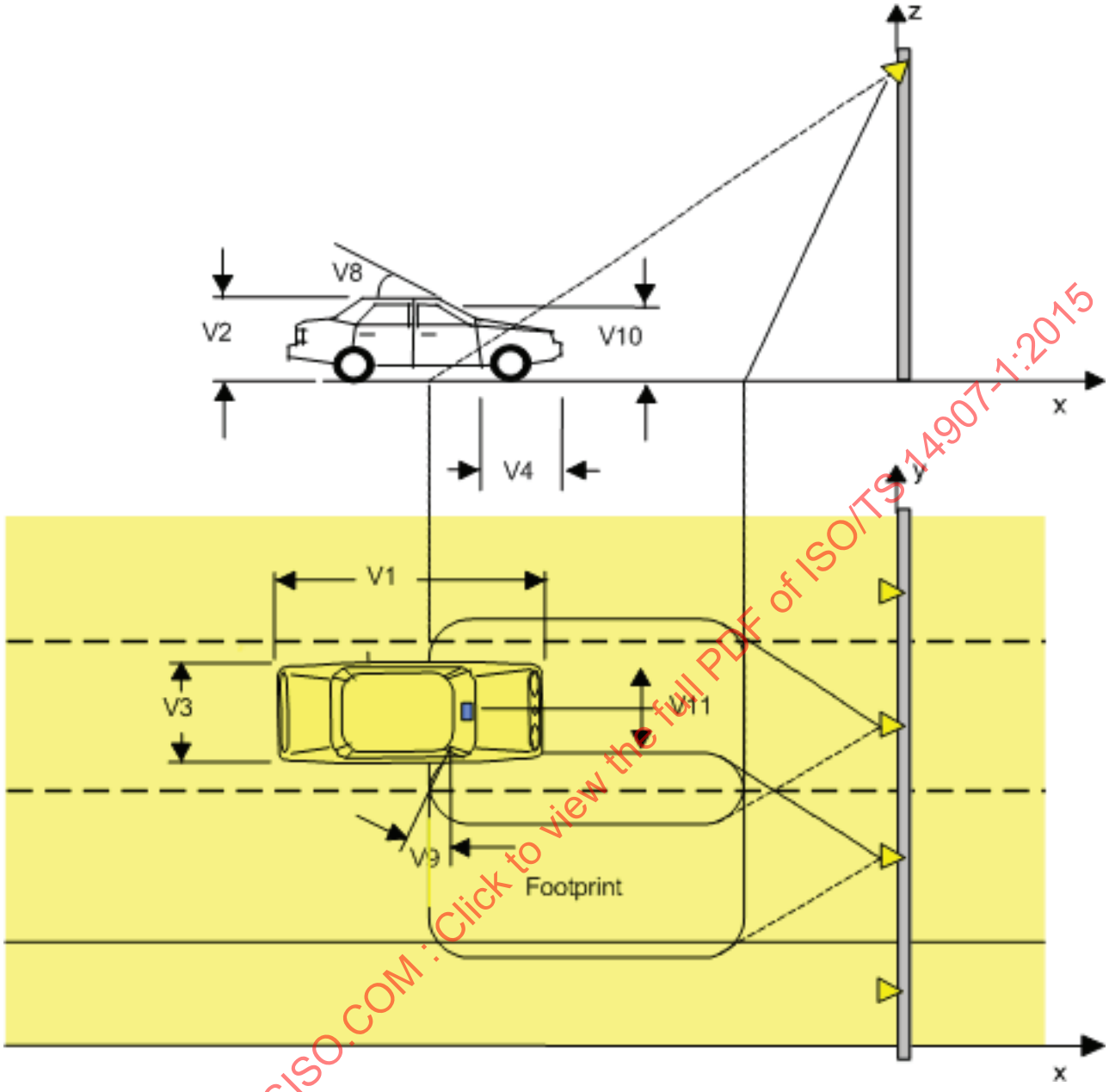

Figure 6 — Vehicle characteristics

6.1.5 Environmental influences

Table 6 lists environmental influences for which individual test case specifications have been described in B.4.

Table 6 — Environmental influences

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

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

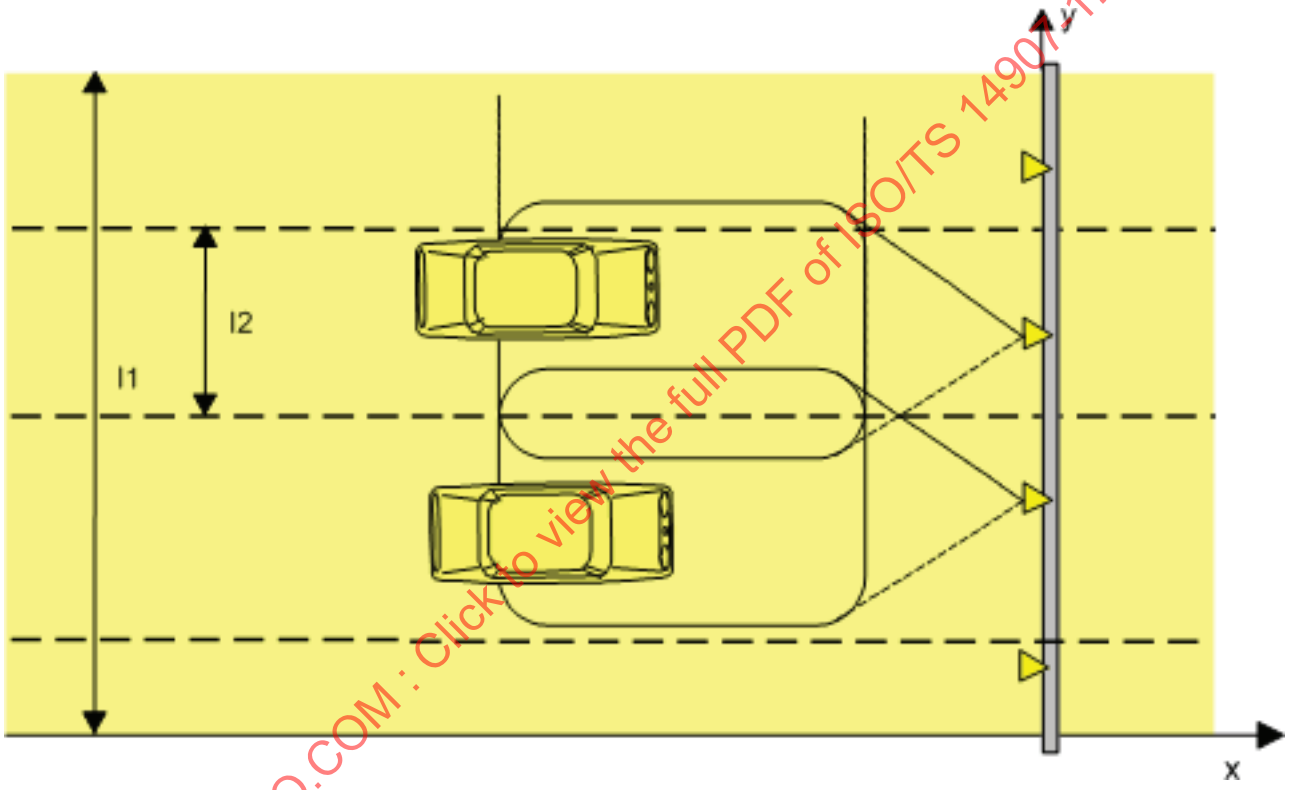

Figure 7 — Environmental influences

6.2 Quality tests

6.2.1 Quality management

6.2.1.1 ISO 9000 series of International Standards

The ISO 9000 series of International Standards are intended to provide a generic core of quality system standards applicable to a broad range of industry and economic sectors. The management system of an organization is influenced by the objectives of the organization, its products, and practices specific to the organization. One of the main objectives of quality management is to improve the systems and processes so that continual improvement of quality can be achieved.

ISO 9000 describes fundamentals of quality management systems and specifies the terminology for quality management systems. 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. ISO 9004 provides

guidelines that consider both the effectiveness and efficiency of the quality management system; its purpose is to improve the performance of the organization and to ensure satisfaction of customers and other interested parties.

6.2.1.2 ISO 9001 compliance requirements

Organizations that manufacture or use EFC equipment and wish to claim compliance with this part of ISO/TS 14907 shall use all the applicable test procedures specified herein. In addition, compliance with ISO 9001 or an equivalent QMS is recommended for manufacturers of EFC equipment, as well as for those who supply products for use in test houses or test laboratories that evaluate EFC equipment.

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 such as the following:

— 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 standalone 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, such as the following:

— 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 shall be considered during the specification of a test plan. Results of previously performed tests and approvals shall be taken into account and shall 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.

Examples of referenced DSRC tests are 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.

Examples of referenced environment tests are listed in F.2.

6.3.3 EMC

The range of the EMC tests shall cover the areas:

— emission;

— immunity.

Examples of referenced environment tests are listed in F.3.

7 Evaluation and certification

7.1 Evaluation

Test houses or test laboratories that evaluate EFC components or complete EFC systems shall comply with ISO/IEC 17025. The objective of the evaluation is to assess a complete EFC system or EFC components regarding compliance with the specified requirements.

The basis of an evaluation is 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 documentation, standards, and regulations that were used is defined unambiguously and completely. The test report forms the basis for the certification. The report shall contain relevant information found in ISO/IEC 17025:2005, 5.10.

NOTE Among the items to include are the following:

— identification of the test report;

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

— name and address of the test house;

— purpose of the evaluation;

— standards and regulations applied;

— test procedures and results;

— summary evaluation result;

— date and signature of the person responsible for the evaluation.

7.2 Certification

Test houses or certification bodies that certify EFC components or complete EFC systems shall comply with ISO/IEC 17065.

The identification of conformity with standards and regulations may be done in the form of a certificate and/or a mark on the components of the system. The certificate shall contain relevant information found in ISO/IEC 17065:2012, 7.7.

NOTE Among the items included are the following:

— 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 of the person responsible for certification.

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 part of ISO/TS 14907.

The principal parties who will use this part of ISO/TS 14907 will be manufacturers, operators, and test houses.

a) Manufacturers (first party) are those designing and producing EFC equipment which has to be in compliance with standards and regulations. Manufacturers should use test procedures of this part of ISO/TS 14907 for prototype testing to demonstrate and ensure a level of performance in accordance with determined EFC requirements. Use of the tests and procedures enables the manufacturer to carry out factory tests which are comparable with tests carried out by independent test houses and with tests carried out after installation of the EFC equipment.

b) 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 part of ISO/TS 14907 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 part of ISO/TS 14907 are designed to enable such comparison.

c) 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 accreditation body for carrying out the assessment activities.

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 part of ISO/TS 14907, ensures that systems meet the claimed performance levels and provides reassurance to users.

This part of ISO/TS 14907 is designed to enable operators and suppliers of EFC systems to measure conformance with system functional requirements. It 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 part of ISO/TS 14907 have been functionally organized into groups which are defined in Clause 5.

A.2 Step-by-step guidance

This subclause describes the expected steps required to execute the procedures in this part of ISO/TS 14907.

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 designated test house used to ensure compliance of any system or equipment with this part of ISO/TS 14907 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 manufacturer's declarations or results of previously performed tests and approvals from a test house that complies with ISO/IEC 17025 are made available. Missing tests are carried out.

Step 3

Where there are general equipment requirements (such as safety, EMC), the appropriate tests are already determined in existing standards. This part of ISO/TS 14907 provides a checklist 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 determines 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 part of ISO/TS 14907. 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 can be different for different implementations as required; in Tables B.1 to B.12 and Tables B.18 to B.20, in cases where no value is specified, this is indicated with “tbd” for the parameter “Default”.

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

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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with test definition — the particular traffic condition will be described and recorded in a database	
Constraints reference:	T1, according to speed class (T4) and traffic scenarios (T8)	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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) with up to five vehicles in accordance with 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 close lateral distance between vehicles	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 vehicle drivers in order to comply with test definition — the particular traffic condition will be described and recorded in a database	
Constraints reference:	T2 according to speed class (T4) and traffic scenarios (T8)	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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 close lateral distance between OBEs	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 vehicle drivers in order to comply with test definition — the particular traffic condition will be described and recorded in a database	
Constraints reference:	T3 according to speed class (T4) and traffic scenarios (T8)	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 vehicle drivers in order to comply with test definition — recording of vehicle speed (e.g. electronic tachograph) — the particular traffic condition will be described and recorded in a database	
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	Verdict
	No failed transaction	Pass
	One or more transactions failed	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 occurs 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with test definition — the particular traffic condition will be described and recorded in a database	
Constraints reference:	T5 according to speed class (T4) and traffic scenarios (T8), one car in a group of 5 to 10 vehicles	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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:	— EFC requirements for DSRC, May 1994, document CEN/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with test definition — the particular traffic condition will be described and recorded in a database	
Constraints reference:	T6 according to speed class (T4) and traffic scenarios (T8), one car in a group of 5 to 10 vehicles	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with test definition — the particular traffic condition will be described and recorded in a database	
Constraints reference:	T7, according to speed class (T4), traffic scenarios (T8)	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 vehicle drivers in order to comply with test definition — recording of vehicle speed (electronic tachograph) — the particular traffic condition will be described and recorded in a database	
Constraints reference:	T8, according to speed class (T4)	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, ...) — 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 with 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 database	
Constraints reference:	T9, duration of staying in the communication zone	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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) Traffic scenarios — restricted flow should be combined with all vehicle classes in a group of up to 10 vehicles and lane changing. d) 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with test definition — continual recording of traffic flow — the particular traffic condition will be described and recorded in a database	
Constraints reference:	T10	
Verdict:	Test result No failed transaction One or more transactions 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with 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 transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 vehicle drivers in order to comply with test definition — the particular vehicle characteristics and constructive elements are described and recorded in central database for evaluation	
Constraints reference:	V6	
Verdict:	Test result	Verdict
	No failed transaction	Pass
	One or more transactions failed	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 occurs 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 "normalized" constructive elements will be defined; it is up to the operator to define his or her 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. metallized, coated, heated, dirty windscreens	
Requirement reference:	— EFC requirements for DSRC, May 1994, document CEN/TC 278 [N318] — EFC application	
Default:	3 dB one way	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, ...) — 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 vehicle drivers in order to comply with 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 transactions 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 occurs 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. NOTE Metallized windscreens without the "DSRC Aperture" shall not be used as criterion of pass/fail.	

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/TC 278 [N318] — EFC application	
Default:	45°	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 vehicle drivers in order to comply with 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 transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	0°	
Test configuration:	— tools: data logger, software tool or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 vehicle drivers in order to comply with 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 transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	0,7 m to 3,0 m	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with 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 transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	0 m	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with 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:	Test result No failed transaction One or more transactions 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 occurs 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 or her 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with 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	Verdict
	No failed transaction	Pass
	One or more transactions failed	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 occurs 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, and 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with test definition — particular environment influences will be listed and recorded in a database	
Constraints reference:	I1, I2, I3 to all traffic conditions	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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/TC 278 [N318] — EFC application	
Default:	tbd (see B.1.3)	
Test configuration:	— tools: data logger, software tool, or equipment for performing EFC transactions — test location: site — interfaces used: RSE access point used to check test outputs (traces of exchanges, transactions log, …) — 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 with test definition — weather conditions recorded automatically and continually — particular environment influences will be listed and recorded in a database	
Constraints reference:	I4, I5, I6	
Verdict:	Test result No failed transaction One or more transactions 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 occurs 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

The concept of reliability comprises both 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 the 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 Annex E.

C.1.2 Availability

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

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

The MTTR is normally obtained from manufacturer guarantees and prescribed repair procedures. The MTBF can be measured statistically, but this is not always feasible. As an alternative, the system failure rate can 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/λ. 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 a "bath tub" curve. The failure rate will decrease to a lower value, which remains fairly constant and defines 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.

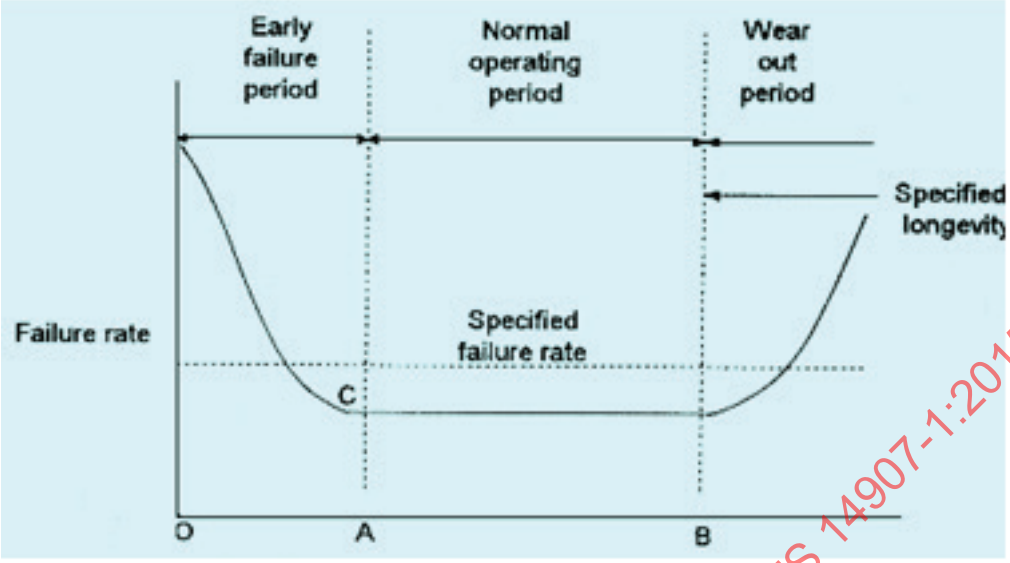

Figure C.1 — Typical failure rate curve

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 can 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 (i.e. it can only provide background information with little quantitative support). Hybrid approaches, where simulation, observation of real traffic and analytical techniques are combined, can be used to obtain reliability results with an acceptable level of confidence. As an alternative, the tests can 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 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 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:	tbd	
Test configuration:	— tools: none — test location: laboratory — interface used: 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:	tbd	
Test configuration:	— tools: software tool or equipment for performing EFC 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 OBEs 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 NOTE Today's battery lifetime in OBEs is 5 to 7 years and operators' expectations are in that range. No operator will accept lower than 5 years or require longer than 7 years when talking about battery lifetime.	

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:	tbd	
Test configuration:	— tools: mechanical smart card manipulator, software tool, or equipment for performing EFC 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. These are given as an example; they are not complete. The purpose of Tables D.1 to D.3 is 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 clause or subclause of this part of ISO/TS 14907. The listed entries of the column "requirement" are incidental; there is no dependency between columns and lines. The tables can be used by operators to specify frame conditions for the intended EFC applications. A set of such selected parameters can form together with the assigned requirements a class of DSRC equipment. The proposed equipment parameters are provided for RSE, OBE, and communication.

This part of ISO/TS 14907 does not 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/TC 278 [N318]
Security	Defined protection targets		EAL4	EAL5		ISO/IEC 15408-3
Environment	Different conditions	F.2	4K2	4K3		EN 60721
Traffic conditions	Lane configuration	B.2	Single	Multi	3 lanes	CEN/TC 278 [N318]
	Traffic flow/ lane and hour	B.2	<1 800	<2 500	<3 000	CEN/TC 278 [N318]
	Longitudinal distance	B.2	>5 m	2 m to 4 m		CEN/TC 278 [N318]
	Lateral distance	B.2	>1,5 m	1 m to 1,5 m	<1 m	CEN/TC 278 [N318]
Vehicle characteristics	Vehicle speed	B.2	<90 km/h	<160 km/h		CEN/TC 278 [N318]

NOTE 1 EAL4 - methodically designed, tested, and reviewed. EAL4 permits a developer to gain maximum assurance from positive security engineering based on good commercial development practises which, though rigorous, do not require substantial specialist knowledge, skills, and other resources. EAL4 is the highest level at which it is likely to be economically feasible to retrofit to an existing product line. EAL4 is therefore applicable in those circumstances where developers or users require a moderate to high level of independently ensured security in conventional commodity TOEs and are prepared to incur additional security-specific engineering costs.

NOTE 2 EAL5 - semi formally designed and tested. EAL5 permits a developer to gain maximum assurance from security engineering based upon rigorous commercial development practises supported by moderate application of specialist security engineering techniques. Such a TOE will probably be designed and developed with the intent of achieving EAL5 assurance. It is likely that the additional costs attributable to the EAL5 requirements, relative to rigorous development without the application of specialized techniques, will not be large. EAL5 is therefore applicable in those circumstances where developers or users require a high level of independently ensured security in a planned development and require a rigorous development approach without incurring unreasonable costs attributable to specialist security engineering techniques.

Table D.2 — OBE parameters

Parameter of OBE						
Parameter	**Item**	**Test procedure**	**Requirements**			**Reference**
Reliability	λ	C.2	4 years	5 years		CEN/TC 278 [N318]
Security	Different protection targets		EAL4	EAL5		ISO/IEC 15408-3
Environment	Different conditions	F.2	5K2	5K3		EN 60721
Equipment	Type		Tag	OBU	OBU and ICC	CEN/TC 278 [N318]
	MMI		—	Display	Display, keyboard	CEN/TC 278 [N318]
Functionality	Debiting	6.1	Central account	Vehicle account		CEN/TC 278 [N318]
	Receipt	6.1	Central receipt	Vehicle receipt		CEN/TC 278 [N318]
Vehicle characteristics	Vehicle speed	B.2	<90 km/h	<160 km/h		CEN/TC 278 [N318]
	Vertical position OBE	B.3	<0,7 m	0,7 m < h < 1,3 m	<2,5 m	CEN/TC 278 [N318]
	OBU sensitivity	B.3	3 dB	11 dB		CEN/TC 278 [N318]

Table D.3 — Communication parameters

Parameter of communication						
Parameter	**Item**	**Test procedure**	**Requirements**			**Reference**
Communication	EFC communication protocol	6.1.1	Profile 0	Profile 1		ISO 13372
Transaction reliability	λ	C.1	10^{-4}	10^{-5}		CEN/TC 278 [N318]
Security	Different protection targets		EAL4	EAL5		ISO/IEC 15408-3

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. In this scenario, it is assumed that the OBEs are operating *independently* of 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:

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

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

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

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*:

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

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

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

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 is considered in E.3.

E.2 Statistical considerations when proving low transaction error rates

In the following examples, statistical considerations are presented that 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 (i.e. 100 % success) is calculated depending on the number of test transactions carried out and the actual reliability (which of course usually is not known and shall be determined by the testing).

The calculations presented in Table E.1 are based on the binomial distribution function:

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

The following definitions are used:

r is the probability of failure of an EFC transaction (unreliability of the EFC system);

n is the number of tested EFC transactions;

k is the number of failed transactions;

p is the probability that k failed transactions are encountered for n tested transactions.

For the following table, the following values were chosen:

n is the number of tested EFC transactions: 100, 100 000, and 10 000 000;

k is the number of failed transactions: 0 (no failure, 100 % success);

p is the 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 transactions 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 transactions 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 $\log(1 - \alpha)/\log(1 - r)$.

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 can 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 determined in E.2:

$r = T/\mathrm{MTTF}$

The probability for a false "PASS" verdict results in:

$p_0 = (1 - T/\mathrm{MTTF})^n$

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 $T << \mathrm{MTTF}$, the approximation is valid.

Annex F
(informative)

Examples of referenced pre-tests based on European test procedures

F.1 Dedicated short-range communication (DSRC)

This clause contains test items and references to test procedures with regard to the requirements of the European DSRC standards given in References [17] to [20].

F.2 and F.3 give tests that make use of References [21] to [61].

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

Table F.1 — Microwave (5,8 GHz)

Parameter	Test procedure [ref. ETSI EN 300 674–1 V 1.2.1 (2004–08)]
DSRC D	
D.1 Physical layer, 5,8 GHz	
D.1.1 Number and values of carrier frequencies	Carrier frequencies, 5.3
D.1.2 Tolerance of carrier frequencies; RSU	Frequency error, 9.8
D.1.3 RSU transmitter spectrum mask	Transmitter spectrum mask, 9.9
D.1.4 Modulation	Modulation index, 9.1
D.1.5 Subcarrier frequencies (Uplink)	Frequency error (subcarrier), 10.5
D.1.6 OBU transmitter spectrum mask	Transmitter spectrum mask (OBU), 10.6
D.1.7 Maximum single sideband EIRP	Maximum equivalent isotropically radiated power, 10.4
D.1.8 Bit error rate	Contained in: Sensitivity (RSU), 9.2.1 Error behaviour at high wanted input signals (RSU), 9.2.2 Sensitivity (OBU), 10.1.1 Upper power limit for communication (OBU), 10.1.2
D.1.9 Minimum conversion gain (transponder)	Conversion gain (OBU), 10.3
D.1.10 Maximum EIRP	Maximum equivalent isotropically radiated power (RSU), 9.7

Table F.2 — MAC sub-layer

Parameter		Test procedure
Main group	**Sub-group**	[ref. ETSI EN/TS 102 486–1-2 (2008–10)]
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 manages 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 transmits 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**	[ref. ETSI EN/TS 102 486–1-2 (2008–10)]
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 Receiver	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
Initialization kernel element	D.3.2.1 Transmission of BST	Test if the RSE periodically transmits 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 deregistered
	D.3.2.6 Application is ready	Test if the RSE and the OBE react correctly to a ready application-service-primitive
	D.3.2.7 Reception of a release	Test if the RSE and the OBE react correctly to a received release

F.2 Environment

Table F.5 — Basic environment testing with reference tests

Parameter	Test procedure (reference)
Environment V	
Basic testing procedures	IEC 60068–1
ET.1. Climate	
ET.1.1 Cold	IEC 60068–2-1
ET.1.2 Dry heat	IEC 60068–2-2
ET.1.3 Damp heat, steady-state	IEC 60068–2-78
ET.1.4 Damp heat, cyclic	IEC 60068–2-30, IEC 60068–2-3–4
ET.1.5 Temperature changing	IEC 60068–2-14
ET 1.6 Sun radiation	IEC 60068–2-5
ET.2. Mechanical	
ET.2.1 Vibration, sinusoidal (RSE)	IEC 60068–2-6
ET.2.2 Vibration, random (OBE)	IEC 60068–2-64
ET.2.3 Shock	IEC 60068–2-27
ET.2.4 Bump (continuous shocks)	IEC 60068–2-29
ET.2.5 Free fall (OBE)	IEC 60068–2-32
ET.2.6 Housing	IEC 60529, IEC 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	IEC 61000–4-5
ET.4 Chemical/biological	
ET.4 1 Salt mist	IEC 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

NOTE 1 The tests are attached to RSE, OBE, and air interface; usually, they are different for each part.

NOTE 2 The test procedures define whether functional tests are carried out after exposure to test conditions or during the exposure to test conditions.

NOTE 3 For tests that are carried out during exposure to test conditions, a special testing system and testing procedure are defined (distance between the parts, different exposure to test conditions, parameters for RSE, and OBE).

NOTE 4 Combinations of exposure to test conditions (vibration and temperature) can be discussed.

NOTE 5 National regulations are applicable for certain classes of tests like the ones on power supply.

F.3 EMC

Table F.6 — EMC tests with reference tests

Parameter	Test procedure (reference)
EMC E	
E.1 EMC General	EN 61000–6-3; EN 61000–6-1
E 1.1 Emission	EN 61000–6-3
E 1.1.1 Radio emission	EN 737; EN 55015; EN 55022 72/245/EEC with modification 95/54/EC
E 1.1.2 EFC specific	none
E 1.2 Immunity	EN 61000–6-1
E 1.2.1 Electrostatic discharge	IEC 61000–4-2
E 1.2.2 Electrical fast transient bursts	IEC 61000–4-4
E 1.2.3 Electromagnetic field	IEC 61000–4-3
E 1.2.4 Surge immunity	IEC 61000–4-5
E 1.2.5 Conducted disturbances inducted by radio frequency fields	IEC 61000–4-6
E 1.2.6 Voltage dips, short interruptions and voltage variations	IEC 61000–4-11
E 1.2.7 Road vehicles	ISO 7637 72/245/EEC with modification 95/54/EC ISO 11451-3 ISO 11451-2 DAM 1
E 1.2.8 GSM	ENV 50204
E 1.2.9 EFC specific	none

NOTE 1 The tests are attached to RSE, OBE, and air interface. Normally, they are different for each part.

NOTE 2 The test procedures define whether functional tests are carried out after exposure to test conditions or during the exposure to test conditions.

NOTE 3 For tests which are carried out during exposure to test conditions, a special testing system and testing procedure are defined (distance between the parts, different exposure to test conditions, parameters for RSE, and OBE).

Annex G
(informative)

Test methods and tools

G.1 General

Different test methods and tools can be applied for the assessment and proof of a complete EFC system or of specific EFC components. The appropriate selection and combination of test methods depends on the object to be tested and the range of the test. The set of tests required to assess a test object will be defined in an individual test plan. 5.2 includes a table which shows the relation between test methods and the set of test parameters and items of this part of ISO/TS 14907.

Table G.1 indicates the fundamental applicability of the test methods with regard to the object being tested or test objective, as applicable.

Table G.1 — Overview of main test methods and test object/objective

	Test methods			
Test object/objective	**Inspection**	**Simulation**	**Laboratory test**	**Field test**
Requirement specification	X			
System documentation	X			
DSRC communication	X	X	X	X
Conformance	X	X	X	
Acceptance (factory and site)	X	X	X	X
Implementation	X		X	X
Functionality	X	X	X	X
Compatibility/interoperability	X	X	X	X

G.2 Inspection

G.2.1 Objective

The following types of inspection are relevant to this part of ISO/TS 14907:

— inspection and analysis of documentation for consistency, completeness, validity, unambiguity, relevance, and clarity;

— inspection of documentation for statements of compliance or for inference of conformance based on analysis or comparison with standards;

— inspection of checklists;

— inspection of equipment for good manufacturing/good workmanship and safety;

— inspection of security (possibly as part of an audit);

— inspection of test results.

G.2.2 Methodology

There are two inherently different kinds of inspection.

a) Formal inspection, which involves a concrete question to which a definite yes/no answer can be given. In order to obtain a definite answer, criteria are set. Examples are checklists or statements of compliance.

b) Inspection for assessment, or review, where the answers are either qualitative or where the result is to be expressed in a figure of merit. Inspection of documentation is an example of this category: the quality aspects of documentation are (to a large degree) subjective, or at least only meaningful relative to the intended readership.

Methodology of inspection differs, depending on the subject matter; the following methods can be distinguished:

— querying for answers to formal questions, and checking the results;

— reading and evaluating text;

— following a checklist and "ticking off" items;

— visual inspection.

G.3 Simulation

G.3.1 Objective

Simulation techniques relevant to this part of ISO/TS 14907 can be used to prove the following:

— DSRC communication reliability;

— conformance to DSRC protocol specifications;

— performance of EFC system characteristics.

G.3.2 Methodology

Simulation tools used to test the performance of EFC system characteristics can consist of the following:

— simulation model representing parts of an EFC system and real EFC components which are integrated in the simulation loop (simulation model with a reference beacon and actual OBEs);

— simulation model implementing a complete EFC system (RSE, OBEs, and the system environment are represented by a simulation model).

The simulation model representing parts of an EFC system supports the conformance testing of protocol and application implementations by comparing output of the simulation with output of real equipment. The DSRC protocol stack specified in a formal description language (SDL) forms the basis of the simulation tool which is adapted with an application specific implementation. The simulation tool coupled with hardware builds a reference beacon and communicates with real equipment (see Figure G.1 of laboratory tests).

The test of a complete EFC system or of components with a simulation tool provides test results such as testing capability and reliability which cannot be easily performed with real equipment. The tests are able to provide interesting conditions that can be subsequently tested with EFC equipment under real-life conditions. Simulation provides cost-efficient testing in a realistically modelled environment. The combination of using results from simulations and from field tests provides reliable proof of performance.

G.3.3 Requirements

G.3.3.1 General

Simulation models used for the testing of EFC systems shall meet the requirements of G.3.3.2 to G.3.3.7.

G.3.3.2 Basic components

The simulation model of a DSRC-based EFC system shall incorporate the following:

— a vehicle mobility model, which produces a realistic traffic flow including vehicle behaviour within the communication zone of an EFC system;

— a channel model, which takes into account the dynamically changing physical link characteristics of a specific EFC system;

— vehicle models including their interception and radiation possibilities;

— an implementation of the communication architecture conforming to the DSRC, as well as ISO 14906, taking into account system-specific characteristics.

G.3.3.3 Simulation method

The simulation shall be based on randomly generated values of the relevant variables using appropriately defined probability distributions describing the characteristics of the system (stochastic simulation).

G.3.3.4 Statistical evaluation of simulation results

The simulation results shall be presented including statistical evaluation based on standard methods, such as statistical evaluation leading to acceptance or rejection within defined confidence intervals. Confidence intervals are specified by either the test house or service provider.

G.3.3.5 Validation of simulation models

The implemented simulation models shall be operationally proven and shall be validated by comparing data produced by the simulation tool with data, which has been measured in a real environment (e.g. inter-arrival times' distribution produced by the traffic model or characteristics of the channel footprint depending on different traffic situations).

G.3.3.6 Input scenarios

The simulation model shall allow various test scenarios (traffic, vehicle, and environment) modelled with the required accuracy.

G.3.3.7 Documentation and quality assurance

Together with the simulation test results, a detailed description of the input parameters, a detailed description of the applied models and the results of the validation tests regarding the simulation models shall be provided.

G.4 Laboratory tests

G.4.1 Objective

The objective of laboratory tests is mainly related to verify the conformance of the equipment and to assess if the equipment fulfils the specified requirements in a controlled environment. Laboratory tests are applied to a complete EFC system, as well as to components, with regard to the following:

— DSRC communication;

— conformance to DSRC protocol specifications;

— EMC;

— environmental conditions.

G.4.2 Methodology

The sensitivity of the equipment due to position or disturbance can be evaluated in the controlled environment of a laboratory. The laboratory tests can be classified into two groups:

— DSRC communication;

— environment.

The methodology to test the DSRC communication is defined in ISO/TS 14907-2.

The environment tests are related to tests which are referenced in 5.1 as pre-tests. Special explanations are provided in References [15] to [59]; see also 6.3 and F.1 to F.3.

G.4.3 Requirements

The DSRC equipment under test shall be installed and used according to the manufacturer's documentation. The used tests' equipment and tools shall meet the requirements specified in the test procedures. The simulation tools and reference beacon shall comply with the requirement specification of the EFC system to be tested. The tests to be carried out and the test conditions applied shall be specified in a test plan in accordance with 5.3. All results of the carried-out laboratory tests shall be stored.

G.5 Field tests

G.5.1 Objective

The objective of field tests is to assess the performance of the real EFC equipment under test with regard to the following aspects:

— fulfilment of requirements of technical standards and regulations;

— functionality as specified by the manufacturer;

— fulfilment of requirements according to the specified application;

— fulfilment of requirements of environmental influences;

— fulfilment of user requirements.

Field tests can be carried out on test tracks and on normal roads and motorways under real-life conditions.

G.5.2 Methodology

Field tests are applied to test a complete EFC system or its components. The tests are carried out at test sites that provide an infrastructure that satisfies the requirements of G.5.3. Before starting

