

Primary batteries —

Part 1: General

The European Standard EN 60086-1:2001 has the status of a British Standard

ICS 29.220.10

National foreword

This British Standard is the official English language version of EN 60086-1:2001. It is identical with IEC 60086-1:2000. It supersedes BS EN 60086-1:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee CPL/33, Primary Cells, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

Attention is drawn to the fact that CEN and CENELEC Standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement these international or European publications may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 June 2001

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 45 and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

© BSI 06-2001

ISBN 0 580 37340 1

English version

Primary batteries
Part 1: General
(IEC 60086-1:2000)

Piles électriques
Partie 1: Généralités
(CEI 60086-1:2000)

Primärbatterien
Teil 1: Allgemeines
(IEC 60086-1:2000)

This European Standard was approved by CENELEC on 2000-12-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 35/1131/FDIS, future edition 9 of IEC 60086-1, prepared by IEC TC 35, Primary cells and batteries, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60086-1 on 2000-12-01.

This European Standard supersedes EN 60086-1:1997 + A1:1999 + A2:1999.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2001-09-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2003-12-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A to E and ZA are normative and annexes F to H are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60086-1:2000 was approved by CENELEC as a European Standard without any modification.

CONTENTS

	Page
INTRODUCTION	4
Clause	
1 Scope	5
2 Normative references.....	5
3 Definitions	5
4 Requirements	8
4.1 General	8
4.2 Performance	13
5 Performance – Testing.....	13
5.1 General	13
5.2 Discharge testing.....	14
5.3 Conformance check to a specified minimum average duration	15
5.4 Calculation method of the specified value of minimum average duration	15
5.5 OCV testing	15
5.6 Battery dimensions	15
5.7 Leakage and deformation	15
6 Performance – Test conditions.....	15
6.1 Pre-discharge conditioning	15
6.2 Commencement of discharge tests after storage	16
6.3 Discharge test conditions.....	16
6.4 Load resistance	16
6.5 Time periods.....	17
6.6 Activation of ‘P’-system batteries	17
6.7 Measuring equipment	17
7 Sampling and quality assurance.....	17
7.1 Sampling	17
7.2 Product quality indices.....	17
8 Battery packaging	18
Annex A (normative) Designation system (nomenclature).....	19
Annex B (normative) Code of practice for packaging, shipment, storage, use and disposal of primary batteries	31
Annex C (normative) Equipment design.....	34
Annex D (normative) Calculation method for the specified value of minimum average duration	35
Annex E (normative) Guidelines for the standardization of batteries	36
Annex F (informative) Preferred dimensions for primary batteries.....	37
Annex G (informative) Standard discharge voltage-definition and method of determination	39
Annex H (informative) Preparation of standard methods of measuring performance (SMMP) of consumer goods.....	43
Annex ZA (normative) Normative references to international publications with their corresponding European publications.....	45
Bibliography	44

INTRODUCTION

The technical content of this part of IEC 60086 provides fundamental requirements and information on primary cells and batteries. In this sense, part 1 is the main component of IEC 60086 and forms the basis for the subsequent parts. For example, this part includes elementary information on definitions, nomenclature, dimensions and marking. While specific requirements are included, the content of this part tends to explain methodology (how) and justification (why).

The objective of IEC 60086-1 is to benefit primary battery users, device designers and battery manufacturers by ensuring that batteries from different manufacturers are interchangeable according to a standard form, fit and function. Furthermore, to ensure compliance with the above, this part specifies standard test methods for testing primary cells and batteries.

Over the years, this part has been changed to improve its content and remains under continual scrutiny to ensure that the publication is kept up to date with the advances in both battery and battery-powered device technologies. This current revision is the result of a reformatting initiative, as well as some content changes, aimed at making it more user-friendly, less ambiguous, and on a cross-reference basis, fully harmonized with other parts of IEC 60086 (such as IEC 60086-2 and IEC 60086-3).

NOTE Safety information has been removed from IEC 60086-1 and is now available in IEC 60086-4 and IEC 60086-5.

PRIMARY BATTERIES –

Part 1: General

1 Scope

The purpose of this part of IEC 60086 is to standardize primary batteries with respect to their electrochemical system, dimensions, nomenclature, terminal configurations, markings, test methods, typical performance, safety and environmental aspects.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60086. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60086 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60086-2, *Primary batteries – Part 2: Physical and electrical specifications*¹⁾

IEC 60086-3:1995, *Primary batteries – Part 3: Watch batteries*

IEC 60086-4:2000, *Primary batteries – Part 4: Safety of lithium batteries*

IEC 60086-5, *Primary batteries – Part 5: Safety of batteries with aqueous electrolyte*²⁾

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 61429:1995, *Marking of secondary cells and batteries with the international recycling symbol ISO 7000-1135*

ISO 3951:1989, *Sampling procedures and charts for inspection by variables for percent non-conforming*

ISO/IEC Directives – Part 2: 1992

3 Definitions

For the purpose of this part of IEC 60086, the following definitions apply.

3.1

application test

test which simulates the actual use of a battery in a specific application, for example "portable lighting", "tape recorder" or "transistor radio" test

¹⁾ To be published.

3.2

discharge (of a primary battery)

operation during which a battery delivers current to an external circuit

3.3

dry (primary) battery

primary battery in which the liquid electrolyte is immobilized

3.4

effective internal resistance – DC method

resistance of any electrical component determined by calculating the ratio between the voltage drop ΔU across this component and the range of current Δi passing through this component and causing the voltage drop $R = \Delta U / \Delta i$

NOTE As an analogy, the internal d.c. resistance R_i of any electrochemical cell is defined by the the following relation:

$$R_i (\Omega) = \frac{\Delta U (V)}{\Delta i (A)} \quad (1)$$

The internal d.c. resistance is illustrated by the schematic voltage transient as given below:

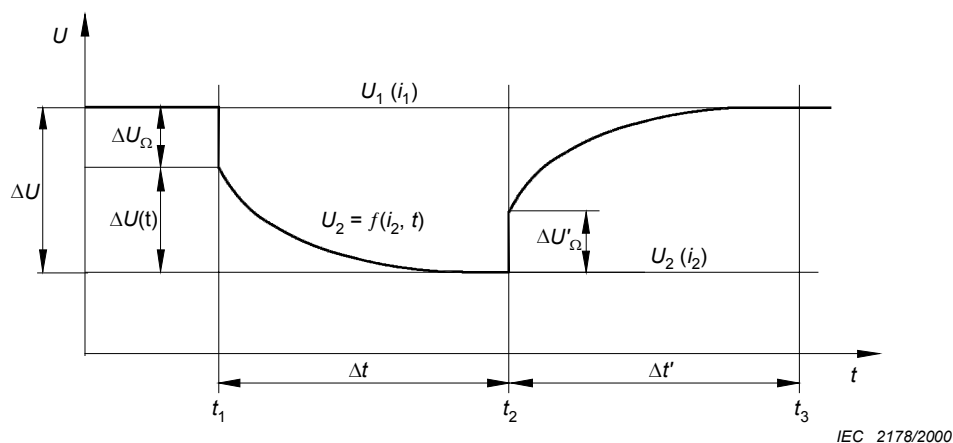


Figure 1 – Schematic voltage transient

As can be seen from this diagram, the voltage drop ΔU of the two components differs in nature, as shown in the following relation:

$$\Delta U = \Delta U_{\Omega} + \Delta U(t) \quad (2)$$

The first component ΔU_{Ω} for $(t = t_1)$ is independent of time, and results from the increase in current Δi according to the relation:

$$\Delta U_{\Omega} = \Delta i \times R_{\Omega} \quad (3)$$

In this relation, R_{Ω} is a pure ohmic resistance. The second component $\Delta U(t)$ is time dependent and is of electrochemical origin.

3.5

end-point voltage

specified closed circuit voltage at which a service output test is terminated

3.6

leakage

unplanned escape of electrolyte, gas or other material from a battery

3.7

minimum average duration (MAD)

minimum average time on discharge which is met by a set of batteries

NOTE The discharge test is carried out according to the specified methods or standards and designed to show conformity with the standard applicable to the battery types.

3.8

nominal voltage of a primary battery

suitable approximate value of voltage used to identify the voltage of a primary battery

3.9

on-load voltage

closed circuit voltage (CCV)

voltage across the terminals of a battery when it is on discharge

3.10

open-circuit voltage (OCV)

off-load voltage

voltage across the terminals of a battery when no external current is flowing

3.11

primary battery

one or more primary cells, including case, terminals and marking

3.12

primary cell

source of electrical energy obtained by the direct conversion of chemical energy not designed to be charged by any other electrical source

3.13

service output (of a primary battery)

service life, or capacity, or energy output of a battery under specified conditions of discharge

3.14

service output test

test designed to measure the service output of a battery

NOTE A service output test may be prescribed, for example, when:

- a) an application test is too complex to replicate;
- b) the duration of an application test would make it impractical for routine testing purposes.

3.15

storage life

duration, under specified conditions, at the end of which a battery retains its ability to perform a specified service output

3.16

terminals (of a primary battery)

conductive parts provided for the connection of a battery to external conductors

4 Requirements

4.1 General

4.1.1 Design

Primary batteries are sold mainly in consumer markets. In recent years, they have become more sophisticated in both chemistry and construction, for example both capacity and rate capability have increased to meet the growing demands from new, battery-powered equipment technology.

When designing primary batteries, the aforementioned considerations shall be taken into account. Specifically, their dimensional conformity and stability, their physical and electrical performance and their safe operation under normal use and foreseeable misuse conditions shall be assured.

4.1.2 Battery dimensions

The dimensions for individual types of batteries are given in IEC 60086-2 and IEC 60086-3.

4.1.3 Terminals

Terminals shall be in accordance with clause 7 of IEC 60086-2.

Their physical shape shall be designed in such a way that they ensure that the batteries make and maintain good electrical contact at all times.

They shall be made of materials that provide adequate electrical conductivity and corrosion protection.

4.1.3.1 Contact pressure resistance

When mentioned in the battery specification tables or the individual specification sheets in IEC 60086-2, the following applies:

- a force of 10 N applied through a steel ball of 1 mm diameter at the centre of each contact area for a period of 10 s shall not cause any apparent deformation which might prevent satisfactory operation of the battery.

NOTE See also IEC 60086-3 for exceptions.

4.1.3.2 Cap and base

This type of terminal is used for batteries which have their dimensions specified according to figures 1, 2, 3 or 4 of IEC 60086-2, and which have the cylindrical side of the battery insulated from the terminals.

4.1.3.3 Cap and case

This type of terminal is used for batteries which have their dimensions specified according to figures 2, 3 or 4 of IEC 60086-2, but in which the cylindrical side of the battery forms part of the positive terminal.

4.1.3.4 Screw terminals

This contact consists of a threaded rod in combination with either a metal or insulated metal nut.

4.1.3.5 Flat contacts

These are essentially flat metal surfaces adapted to make electrical contact by suitable contact mechanisms bearing against them.

4.1.3.6 Flat or spiral springs

These contacts comprise flat metal strips or spirally wound wire which are in a form that provides pressure contact.

4.1.3.7 Plug-in sockets

These are made up of a suitable assembly of metal contacts, mounted in an insulated housing or holding device and adapted to receive corresponding pins of a mating plug.

4.1.3.8 Snap-fasteners

These contacts are composed of a combination comprising a stud (non-resilient) for the positive terminal and a socket (resilient) for the negative terminal.

They shall be of suitable metal so as to provide efficient electrical connection when joined to the corresponding parts of an external circuit.

4.1.3.8.1 Spacing of contacts

The spacing between the stud and socket is given in the following table, and applies from centre to centre. The stud always forms the positive connection and the socket the negative connection on the battery.

Table 1 – Spacing of contacts

Nominal voltage V	Standard mm	Miniature mm
9	$35 \pm 0,4$	$12,7 \pm 0,25$

4.1.3.8.2 Non-resilient snap-fastener connectors (studs)

Dimensions are given in millimetres.

All dimensions not specified are free. The shape of the stud shall be chosen so that the dimensions specified are conformed to.

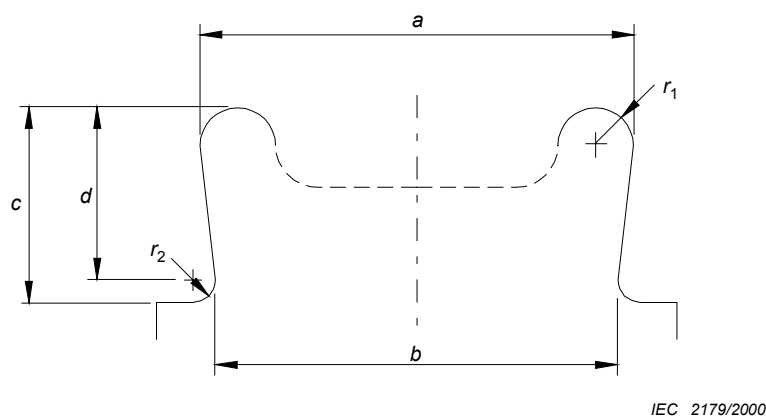


Figure 2 – Standard stud

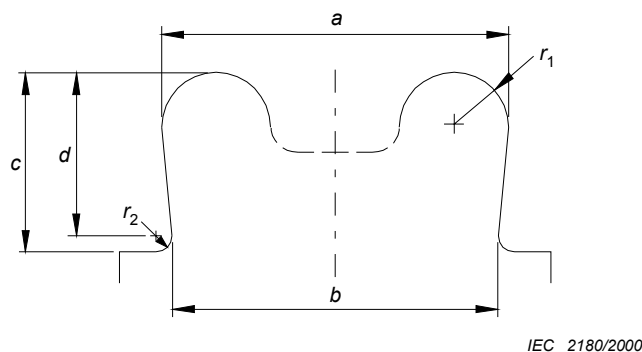


Figure 3 – Miniature stud

Table 2 – Snap-fastener connectors

	Standard mm	Miniature mm
<i>a</i>	$7,16 \pm 0,05$	$5,72 \pm 0,05$
<i>b</i>	$6,65^{+0,07}_{-0,05}$	$5,38 \pm 0,05$
<i>c</i>	$3,20 \pm 0,1$	$3,00 \pm 0,1$
<i>d</i>	$2,67 \pm 0,05$	$2,54 \pm 0,05$
<i>r₁</i>	$0,61^{+0,05}_{-0,08}$	$0,9^{+0,1}_{-0,3}$
<i>r₂</i>	$0,4^{+0,3}_0$	$0,3^{+0,2}_0$

4.1.3.8.3 Resilient snap-fastener connectors (sockets)

Dimensions and requirements:

The dimensions of the resilient (socket) parts of snap-fastener connectors are not specified as such. The properties shall be such that:

- a) the resiliency ensures that the standardized studs can be properly mated;
- b) good electrical contact is maintained.

4.1.3.9 Wire

Wire leads shall be single- or multi-strand flexible insulated tinned copper. The insulation may be cotton braid or suitable plastic. The positive terminal wire covering shall be red and the negative black.

4.1.3.10 Spring clips

Spring clips are generally used on batteries not readily available to the consumer, when the corresponding parts of the external circuit are not precisely known. They shall be of spring brass or of other material having similar properties.

4.1.4 Classification (electrochemical system)

Primary batteries are classified according to their electrochemical system.

Each system, with the exception of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, has been allocated a letter denoting the particular system.

The electrochemical systems that have been standardized up to now are given in table 3.

Table 3 – Standardized electrochemical systems

Letter	Negative electrode	Electrolyte	Positive electrode	Nominal voltage V	Maximum open circuit voltage V
–	Zinc	Ammonium chloride, Zinc chloride	Manganese dioxide	1,5	1,725
A	Zinc	Ammonium chloride, Zinc chloride	Oxygen	1,4	1,55
B	Lithium	Organic electrolyte	Carbon monofluoride	3	3,7
C	Lithium	Organic electrolyte	Manganese dioxide	3	3,7
E	Lithium	Non-aqueous inorganic	Thionyl chloride (SOCl ₂)	3,6	3,9
F	Lithium	Organic electrolyte	Iron disulfide (FeS ₂)	1,5	1,83
G	Lithium	Organic electrolyte	Copper (II) oxide (CuO)	1,5	2,3
L	Zinc	Alkali metal hydroxide	Manganese dioxide	1,5	1,65
P	Zinc	Alkali metal hydroxide	Oxygen	1,4	1,68
S	Zinc	Alkali metal hydroxide	Silver oxide (Ag ₂ O)	1,55	1,63
NOTE 1 The value of the nominal voltage is not verifiable, therefore it is only given as a reference.					
NOTE 2 The maximum open-circuit voltage is measured as defined in 5.4 and 6.7.1.					
NOTE 3 When referring to an electrochemical system, common protocol is to list negative electrode first, followed by positive electrode, i.e. lithium-iron disulfide.					

4.1.5 Designation

The designation of primary batteries is based on their physical parameters, their electrochemical system as well as modifiers, if needed.

A comprehensive explanation of the designation system (nomenclature) can be found in annex A.

4.1.6 Marking

4.1.6.1 General

With the exception of batteries designated as small, each battery shall be marked with the following information:

- designation;
- year and month or week of manufacture, which may be in code, or the expiration of a guarantee period, in clear;
- polarity of terminals (when applicable);
- nominal voltage;
- name or trade mark of the manufacturer or supplier.

4.1.6.2 Small batteries

- a) When this subclause is invoked in IEC 60086-2, 4.1.6.1a) and 4.1.6.1c) shall be marked on the battery. Subclauses 4.1.6.1b), 4.1.6.1d) and 4.1.6.1e) may be given on the immediate package instead of on the battery.
- b) For P-system batteries, 4.1.6.1a) may be on the battery, the sealing tab or the package, 4.1.6.1c) may be marked on the sealing tab of the battery and/or on the battery. Subclauses 4.1.6.1b), 4.1.6.1d) and 4.1.6.1e) may be given on the immediate package instead of on the battery.
- c) Caution for ingestion of small batteries shall be taken. Refer to IEC 60086-4 and IEC 60086-5 for details.

4.1.6.3 Marking of batteries regarding method of disposal

Marking of batteries with respect to the method of disposal shall be in accordance with local legal requirements. Where required, refer to IEC 61429.

4.1.7 Interchangeability: battery voltage

Primary batteries as presently standardized in IEC 60086 can be categorized by their standard discharge voltage U_s ²⁾. For a new battery system, its interchangeability by voltage is assessed for compliance with the following formula:

$$n \times (U_r - 15 \%) \leq m \times U_s \leq n \times (U_r + 15 \%)$$

where

n is the number of cells connected in series, based on reference voltage U_r ;

m is the number of cells connected in series, based on standard discharge voltage U_s .

Currently, two voltage ranges that conform to the above formula have been identified. They are identified by reference voltage U_r , which is the midpoint of the relevant voltage range.

Voltage range 1, $U_r = 1,4$ (V): Batteries having a standard discharge voltage $m \times U_s$ equal to or within the range of $n \times 1,19$ (V) to $n \times 1,61$ (V).

Voltage range 2, $U_r = 3,2$ (V): Batteries having a standard discharge voltage $m \times U_s$ equal to or within the range of $n \times 2,72$ (V) to $n \times 3,68$ (V).

The term standard discharge voltage and related quantities, as well as the methods of their determination, are given in annex G.

NOTE For single-cell batteries and for multi-cell batteries assembled with cells of the same voltage range, m and n will be identical; m and n will be different for multi-cell batteries if assembled with cells from a different voltage range than those of an already standardized battery.

Voltage range 1 encompasses all presently standardized batteries with a nominal voltage of about 1,5 (V), i.e. "no-letter" system, systems A, F, G, L, P and S.

Voltage range 2 encompasses all presently standardized batteries with a nominal voltage of about 3 (V), i.e. systems B, C and E.

²⁾ The standard discharge voltage U_s was introduced to comply with the principle of experimental verifiability. Neither the nominal voltage nor the maximum off-load voltage complies with this requirement.

Because batteries from voltage range 1 and voltage range 2 show significantly different discharge voltages, they shall be designed to be physically non-interchangeable. Before standardizing a new electrochemical system, its standard discharge voltage shall be determined in accordance with the procedure given in annex G to resolve its interchangeability by voltage.

WARNING

Failure to comply with this requirement can present safety hazards to the user, such as fire, explosion, leakage and/or device damage.

This requirement is necessary for safety and operational reasons.

4.2 Performance

4.2.1 Discharge performance

Discharge performance of primary batteries is specified in IEC 60086-2 and IEC 60086-3.

4.2.2 Dimensional stability

The dimensions of batteries shall conform with the relevant specified dimensions as given in IEC 60086-2 and IEC 60086-3 at all times during testing under the standard conditions given in this specification.

NOTE 1 An increase in battery height of 0,25 mm can occur with button cells of the B, C, G, L and P systems, if discharged below end-point voltage.

NOTE 2 For certain button cells (coin cells) of the C and B systems, a decrease in battery height may occur as discharge continues.

4.2.3 Leakage

When batteries are stored and discharged under the standard conditions given in this specification, no leakage shall occur.

4.2.4 Open-circuit voltage limits

The maximum open-circuit voltage of batteries shall not exceed the values given in 4.1.4.

4.2.5 Service output

Discharge durations, initial and delayed, of batteries shall meet the requirements given in IEC 60086-2 and IEC 60086-3.

4.2.6 Safety

When designing primary batteries, safety under conditions of intended use and foreseeable misuse as prescribed in IEC 60086-4 and IEC 60086-5 shall be considered.

5 Performance – Testing

5.1 General

For the preparation of standard methods of measuring performance (SMMP) of consumer goods, refer to annex H.