
Health informatics — Standard communication protocol — Computer- assisted electrocardiography

*Informatique de santé — Protocole de communication standard —
Électrocardiographie assistée par ordinateur*





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Published in Switzerland

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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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by the European Committee for Standardization (CEN) (as EN 1064:2020) and was adopted, without modification other than those given below by Technical Committee ISO/TC 215, *Health informatics*.

- changed "this Standard" or "this technical specification" to "this document" and "the present standard" or "this version of the standard" to respectively "the present document" or "this version of the document";
- changed any "EN ISO xxxx" references to "ISO xxxx" references;
- changed "section" to "clause" in 5.13.6, NOTE 10 and in Clause E.2;
- fixed the corrupted characters in the formula in D.4.8.10;
- corrected the wording in Table 8.

This first edition of ISO 41064 cancels and replaces ISO 11073-91064:2009, which has been technically revised.

The main changes are as follows:

- Deprecated the possibility to use other than UTF-8 language encoding schemes and deprecated former Annex A: Encoding of alphanumeric ECG data in a multilingual environment. Now only UTF-8 encoded text strings are allowed;
- Deprecated the use of beat subtraction and bimodal compression schemes which are no longer supported. But Section 4, formerly used to store QRS locations to allow beat subtraction for computing a “residual signal”, is still mentioned in the present document to support decoding and conversion of legacy SCP-ECG version 1.x and 2.x files into SCP-ECG version V3.0 files;
- Significantly extended the global and per-lead measurements sections. The terminology used and the measurements and annotations provided have been harmonized with ISO/IEEE 11073-10102 Annotated ECG (aECG) and 11073-10101 Nomenclature (Vital signs) standards and with the different recommendations and consensus papers found in the scientific literature;
- Extended Section 11 to include two new ECG interpretation and overreading data coding schemes, based on the categorized AHA statement codes and according to the CDISC (Controlled Terminology. Clinical Data Interchange Standards Consortium) code;
- Introduced Sections 12 to 14 to provide means of storing long-term ECG rhythm data and protocol-based ECG recordings, e.g. stress tests and drug trials procedures;
- Introduced Sections 15 to 17 to allow the storage of different sets of per-lead beat or spike measurements and annotations;
- Introduced Section 18 “Additional ECG annotations” to provide a solution for storing any type of manually or automatically produced annotation which has not been stored in a systematic way in sections 7, 8, 10, 11 and 15 to 17;
- More details on the main changes can be found hereafter at the end of the Introduction and in Annex H, Revision History.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The electrocardiogram (ECG) is a recording of voltage changes transmitted to the body surface by electrical events in the heart muscle, providing direct evidence of cardiac rhythm and conduction, and indirect evidence of certain aspects of myocardial anatomy, blood supply and function. During its propagation to the surface, extracardiac tissues may intervene and influence the ECG morphology.

Electrocardiography has been used for many years, and is increasingly used as a key, non-invasive and low cost method in the diagnosis and early detection of coronary heart disease, which is the leading cause of mortality worldwide [56]¹. Of the 56,9 million global deaths in 2016, 40,5 million (71,3 %) were due to non-communicable diseases (NCDs) and 17,9 million (31 %) were due to cardiovascular diseases (CVDs). Out of these 17,9 million cardiovascular deaths, ischaemic heart disease was responsible for 9,4 million and strokes were responsible for 5,8 million deaths. More than 3 million of these 17,9 million CVD deaths occurred before the age of 60. The percentage of premature deaths from CVDs ranges from 8,8 % in high-income countries to 26 % in low-income countries [56].

In 2018, it was estimated that, worldwide, approximately 3 million ECGs are recorded every day [41]. The Mayo Clinic, for example, nowadays performs about 240 000 standard ECG recordings per year [57]. According to Research And Markets, the Global Electrocardiography Devices (ECG) Market accounted for \$5 122 million in 2018 and is expected to reach \$9 738 million by 2027 [58]. The factors driving this market include the increasing geriatric population, rising incidences of lifestyle diseases, technological advancements in diagnostic ECG devices, and high growth rate in developing countries.

Almost all newer electrocardiographs nowadays use digital recording, interpretation and communication techniques, and there is an increasing number of portable and even wearable (mobile) ECG devices that are now used instead of the traditional ECG cart. These stand-alone, microprocessor based machines and devices can be connected to each other, to a host computer, to the internet or to a hospital information system for reporting, long-term storage in the Medical Electronic Record and serial comparison. To this end, various manufacturers have used different techniques.

It is in the general public interest for users not to be restricted in their options by incompatible technical features and services of different systems and devices. ECG processing is increasingly being integrated with various other types of data processing in health care. This evolution will have considerable impact on the storage and communication of ECG data. There are many different end-users who for different purposes (support of patient care, management, drug trials and/or drug management, research and education) want to obtain a copy of the signal data, of the interpretive report and/or measurement results. Being one of the very first ever developed systems for medical decision support, computerized ECG interpretation stretches from departments of cardiology in hospitals, to general practitioners in primary care and health care centres and to home care. In life-threatening acute myocardial infarction, ECGs are now used in ambulances by paramedical personnel to assess the necessity for administering thrombolytic agents or to alert cathlabs to prepare for a coronary intervention, with long-distance monitoring whenever possible, and in self-care situations to detect ischemia or life threatening arrhythmias as early as possible [31].

To facilitate the exchange of information between various systems, it was of utmost importance that a standard communications protocol for computer-aided electrocardiography (SCP-ECG) was established, as defined in this document. Its aim is to specify a data format for transferring ECG signals, metadata and reports from any vendor's computerized ECG device to any other's vendor central ECG management system. The same standard should also allow standardized transfer of digitised ECG data

¹ Figures in square brackets refer to the Bibliography.

and results between various computer and information systems, Electronic Medical Records, and ECG data repositories.

Under this standard communications protocol (SCP-ECG), the contents and format of the ECG waveform data, metadata and the measurements from ECG devices of different manufacturers are not expected to be identical. As a result, the determination of the suitability of a device and/or system for any particular application remains with the user/purchaser. The following possible uses of ECG records require special attention:

- serial comparison of ECGs and interpretations;
- printout formats of ECGs;
- maintaining an audit trail of edits and annotations;
- integration into an electronic medical record;
- integration into clinical information systems and data repositories.

The users are cautioned to make sure that the data contents and format of the waveform data, metadata, measurements, and the interpretive statements meet their specific needs. If more than one type of ECG device and/or ECG management system is interconnected, the user is also advised to verify with the manufacturers that the data from different systems and devices are compatible with each other and with the user's needs.

In order to understand this document, the reader needs some basic knowledge of electrocardiology, electrocardiography and signal processing.

This document not only relates to the conventional recording of the electrocardiogram, i.e. the so-called standard 12-lead electrocardiogram and the vectorcardiogram (VCG), but also to other types of ECG such as Holter ECG, physiologic monitoring ECG, stress ECG, intracardiac ECG, home care ECG monitoring and wearable self-care ECG devices. Initially, the electric connections used for recording the ECG were made to the limbs only. These connections to the right arm (RA), left arm (LA) and left leg (LL) were introduced by Einthoven. The electrical variations detected by these electrode connections are algebraically combined to form the bipolar leads I, II, and III. Lead I, for example records the difference between the voltages of the electrodes placed on the left arm and the right arm. The unipolar electrocardiographic leads (VR, VL, VF and the precordial leads V1 to V6) were introduced much later, starting in 1933. In these leads, potentials are recorded at one location with respect to a level which does not vary significantly in electrical activity during cardiac contraction. The “augmented” limb lead potentials (aVR, aVL, aVF) are recorded with reference to the average potential of (L+F), (R+F) and (L+R) respectively, where R, L and F refer to the RA, LA and LL electrodes. The unipolar chest leads are recorded with reference to the average potential of $(RA+RL+LL)/3$ which is called the Wilson “central terminal” (CT). In vectorcardiography, recordings are made from three mutually orthogonal leads, running parallel to one of the rectilinear coordinate axes of the body. The axes are the X-axis going right to left, the Y-axis with a top to bottom orientation, and the Z or front to back axis. In 12-Lead stress ECG recordings, the limb electrodes are placed on the torso to reduce limb movement artefacts. The same electrode positions apply to some Holter, emergency and home care recordings, both to limit movement artefacts and undressing.

In some research centres, so-called body surface maps are obtained by placing many (from 24 to 124 or even more) closely spaced electrodes around the torso. This document has not been designed to handle exchange of such recordings, although future extensions could be made to this end. The standard has also not been designed to exchange specialized recordings of intracardiac potentials (electrograms) recorded in the EP (Electrophysiology) laboratories or by cardiac implantable electronic devices (CIED), viz pacemakers, implantable cardioverter-defibrillators (ICDs) and cardiac resynchronization therapy (CRT) devices, although it could also be used to this intent.

ECG computer processing can be reduced to 3 principal stages:

- 1) data acquisition, encoding, transmission and storage;
- 2) pattern recognition and feature extraction, i.e. ECG measurement;
- 3) diagnostic classification.

In each of these stages there are important needs for standardization and quality assurance testing. The scope of this document is confined to the first of these three stages. Quality assurance of ECG measurement and diagnostic classification have been addressed by the CSE Working Party (see [32] and [44] to [50]) and to some extent by IEC 60601-2-25:2011² [4]. The latter also addresses the issue of quality assurance testing of the signal acquisition hardware and filtering.

The various data sections that can be transmitted by means of the standard ECG communications protocol are defined in Clause 5 of this document.

The selection and definition of ECG specific high-level syntaxes and query languages for transfer of messages and data between devices or between devices and hosts or host-to-hosts, using for example Bluetooth, TCP/IP, FTP, USB, Filesystem, HL7, etc., are beyond the scope of this document.

The main goal of the SCP-ECG standard is to address ECG data and related metadata structuring, semantics and syntax, with the objective of facilitating interoperability and thus to support and promote the exchange of the relevant information for ECG diagnosis. Indeed, as recommended by the ACC/AHA/ACP-ASIM task force: “Electrocardiogram readers should understand the importance of comparing a current tracing to previous tracings in order to make correct diagnoses. All abnormal tracings should be compared with available previous tracings. The accuracy of some diagnoses may be considerably enhanced by reviewing previous tracings.” [33]. It is thus of utmost importance to provide a storage format enabling any device or computer program performing the analysis and interpretation of a current ECG to perform a reliable re-analysis of the previous ECGs. For assessing serial changes between ECG measurements it is necessary that the measurements are computed in the same way on each recording in order to avoid any bias.

The binary encoding of ECG data within SCP-ECG and the included content self-control capabilities allow for an efficient encoding, an encapsulation of all ECG-related parameters, and a small memory footprint compliant with mHealth scenarios for an early detection of cardiac diseases, anywhere and anytime [31], [39]. These features not only provide an advantage in data transmission and archiving, but also when the data need to be encrypted (for protecting the data and the confidentiality), or signed (protection against changes).

The present version of the SCP-ECG standard has been significantly amended, with the objective to provide means to support the storage and interchange of almost all existing ECG recording modalities, processing results, annotations and diagnoses, as well as precisely defined metadata enabling the harmonization with other standards in health informatics. The main changes are summarized hereafter.

The ECG data and related metadata addressed in this document are now structured into 18 sections. Sections 0 to 11 already existed in the previous versions of SCP-ECG and, although they have been significantly updated, they remain almost backwards compatible with SCP-ECG V1.x and V2.x, except for other than UTF-8 text strings encoding and beat subtraction or bimodal compression schemes which are no longer supported. Starting with SCP-ECG V3.0, only lossless compression (difference and Huffman encoding) of the long-term rhythm data (section 6) and of the reference beat type 0 data (section 5) are now allowed. In addition, to simplify encoding, the present document recommends to store all ECG signal data uncompressed as a series of fixed length, signed integers and to reserve

2 Impacted by IEC/CD 80601-2-86 under development

difference data calculation and Huffman encoding for mobile and/or wearable devices, when they are intended to be used in poorly served areas with limited wireless connectivity such as GPRS, where significant lossless data reduction strategies are still of importance. Converting legacy SCP-ECG V1.x and V2.x files into SCP-ECG V3.0 compliant files would thus only require to convert non UTF-8 text strings into UTF-8 and to store ECG signal data, if any, uncompressed. Sections 12 to 18, which are new, have been introduced to support the storage of continuous, long-term ECG recordings, of selected sequences of stress tests, drug trials and protocol-based ECG recordings, and the related metadata, measurements and annotations

All over the document, emphasis has been put on cross-referencing and providing a semantic mapping between the terminology and the methodologies used in SCP-ECG and the ISO/IEEE 11073-10102 Annotated ECG (aECG) [9] and 11073-10101 Nomenclature (Vital signs) [8] standards and on leveraging the ambiguities and inaccuracies of some of these other than SCP-ECG standards.

In section 1, SCP-ECG Drugs coding (Tag 10), Medical History codes (Tag 32) and Electrode configuration Codes (Tag 33) have been significantly updated to take account of the evolution of the medical needs, and two new tags have been introduced, respectively aimed at describing Implanted Cardiac Devices (Tag 36, based on the NASPE/BPEG coding systems [28], [29]) and at specifying drugs according to the WHO Anatomical Therapeutic Chemical Classification System (ATC code [43], Tag 37).

Section 4, formerly used to store QRS locations to allow beat subtraction for computing a “residual signal”, has been deprecated. But Section 4 is still mentioned in the present document to support decoding and conversion of legacy SCP-ECG version 1.x and 2.x files into SCP-ECG version V3.0 files.

The global and per-lead measurements sections have been significantly extended. The terminology used and the measurements and annotations provided have been harmonized with the aECG standard [9] and with the different recommendations and consensus papers (viz the need for introducing new measurements describing the early repolarization patterns) found in the scientific literature.

All measurements have been precisely defined, with the aim of unifying the way ECG measurements are performed and of serving as a reference for scientific work. Manufacturers using methods other than those recommended in SCP-ECG Version 3.0 are requested to specify the method they are using in the physician's guide.

Section 11, which aims to contain the most recent interpretation and overreading data, now allows three different coding schemes (in addition to free text): (1) according to the Universal Statement Codes and Coding Rules defined in Annex B; (2) based on the categorized AHA statement codes [21]; (3) according to the CDISC (Controlled Terminology. Clinical Data Interchange Standards Consortium) code [30].

The three different coding schemes may coexist, i.e. an interpretive statement encoded according to the SCP-ECG Universal Statement Codes and Coding Rules may concomitantly also be encoded according to the AHA and/or the CDISC code specifications.

Emphasis has also been put on extending and harmonizing the SCP-ECG Universal Statement Codes defined in Annex A with the AHA and CDISC statement codes and specifications, and with aECG [9] and DICOM [19].

Starting with version V3.0, in addition to the short duration resting ECG (section 6) and the corresponding type 0 reference beat (section 5), the standard now provides means of storing long-term ECG rhythm data in section 12, e.g. up to 40 days continuous recording of 3-Lead ECG signals sampled at 200 samples/sec with a 16 bit resolution, in section 14 several selected short to medium duration ECG sequences, and, in section 13, the related metadata and reference beats (or pointers to selected reference beats). These two additional sections have been included to support protocol-based ECG recordings, viz stress tests and drug trials procedures.

The format of section 12 is very similar to the ISHNE format [26]. In order to preserve random access to the record's segments, no compression or encoding is allowed in this section.

In addition to the full set of global measurements (section 7) and the per-lead measurements (section 10) of the type 0 reference beat, starting with version V3.0 the standard now allows the storage, in section 15, of several pre-defined global and per-lead beat measurements and annotations, for all or for only some computed or selected beats of the analysed signals (long-term and/or long-term ECGs stored in sections 12 and 14 and/or in section 6). The beats may have been selected one by one by a physician or by a beat typing algorithm (reference beats of different types, etc.), or may refer to the entire set of beats from one or more selected time windows within the long-term ECG stored in section 12 or in the long-term ECGs stored in sections 6 or 14.

In another scenario, one may choose to select and store the measurements and annotations for K preselected, not necessarily consecutive beats, in as much Measurement Blocks (MB) as there are selected beats, for thorough QT studies for example. To facilitate comparison with reference beats measurements, the standard also allows saving, in separate MBs, the measurements and annotations performed on the reference beats stored in sections 5 & 13.

Section 16 provides a solution for storing a different set of measurements and annotations than those stored in section 15 and is thus complementary to section 15. Its structure and format are much the same as for section 15, except that there is no provision for specifying analysis time windows and that there are no reserved fields for systematically storing the PP and RR intervals (the latter can nevertheless be stored, if need be, as optional additional measurements).

Section 16 is the preferred section for storing selected ECG beat measurements and annotations, if no beat-by-beat measurements and annotations are required (section 15 is not present).

Section 17 has been designed to include support for pre-defining and storing (much like the way used for storing beat-by-beat ECG measurements in section 15) large sets of global and/or per-lead spike measurements and annotations, spike-by-spike in one or more spike measurements array(s), one measurement array per analyzed ECG sequence (full long-term ECG record, selected ECG sequence) or reference beat.

Section 18 “Additional ECG annotations” provides a solution for storing any type of manually or automatically produced annotation which has not been stored in a systematic way in sections 7, 8, 10, 11 and 15 to 17, viz the onset (and end) of a bigeminal rhythm or atrial fibrillation, the identification of a pacemaker spike that was not listed in section 17, measurements that were not foreseen in sections 15 and 16 (or a few measurements like QT intervals in drug studies in case neither section 15 nor section 16 have been implemented), manual annotation of complex cases with different types of aberrant QRS complexes (LBBB aberrancy, etc.) and P waves (AV dissociation, etc.), noise annotations in a given lead, etc.

Health informatics — Standard communication protocol — Computer-assisted electrocardiography

1 Scope

This document specifies the common conventions required for the interchange of specific patient data (demographic, recording conditions ...), ECG signal data and metadata, ECG measurements and ECG annotations, and ECG interpretation results.

This document specifies the content and structure of the information which may be interchanged between digital ECG electrocardiographs/devices and computer ECG management systems, as well as other computer or information systems (cloud, etc.) where ECG data can be stored.

This document defines the way to describe and encode standard and medium to long-term electrocardiogram waveforms measured in physiological laboratories, hospital wards, clinics and primary care medical check-ups, ambulatory and home care. It covers electrocardiograms such as 12-lead, 15-lead, 18-lead, Cabrera lead, Nehb lead, Frank lead, XYZ lead, Holter ECGs and exercise ECGs that are recorded, measured and analysed by equipment such as electrocardiographs, patient monitors, wearable devices. It also covers intracardiac electrograms recorded by implantable devices as well as the analysis results of ECG analysis and interpretation systems and software that are compatible with SCP-ECG.

ECG waveforms and data that are not in the scope of this document include real-time ECG waveform encoding and analysis used for physiological monitors, and intra-cardiac or extra cardiac ECG mapping.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 10646, *Information technology — Universal coded character set (UCS)*

ISO/IEEE 11073-10101, *Health informatics — Device interoperability — Part 10101: Point-of-care medical device communication — Nomenclature*

ISO/IEEE 11073-10102, *Health informatics — Point-of-care medical device communication — Part 10102: Nomenclature — Annotated ECG*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

3.1

acquiring cardiograph / acquiring device

cardiograph/device recording the original ECG signal

3.2

analysis Time Window

defines the time interval (starting date and time and duration) that will be used to select an ECG excerpt that will be analysed by a computer program and/or by a health professional viz a cardiologist

3.3

confirming

process whereby a trained and experienced health professional signs off the stored interpretation report and/or the stored measurement values and annotations of an ECG in order to confirm the computer-generated (or already overread) interpretation report and/or measurement values and annotations

Note 1 to entry: The confirmed ECG interpretation report is the final clinically acceptable version for diagnosis and treatment

3.4

CSE Project

project supported by DG XII of the European Commission aiming at the development of Common Standards for (Quantitative) Electrocardiography (see references [32] and [44] to [50])

3.5

ECG excerpt

portion of a continuous ECG recording that has been either visually selected by a health professional or by a computer based algorithm or according to a predefined protocol (viz a 10 s excerpt every hour)

3.6

interpretive device

device (cardiograph, wearable equipment, smartphone, computer, cloud, etc.) analysing and interpreting the ECG signal

3.7

message

textual body of information

3.8

overreading

process whereby a fully trained cardiologist, or a physician of equivalent standing with cardiology training, reviews the computer-generated interpretation and/or some of the measurement values and annotations of an ECG in order to detect any obvious errors, including those of omission, and hence makes changes to the text of the report and/or to the measurement values and annotations

Note 1 to entry: In some clinical settings, the process of overreading is performed in two steps. The ECG is first over-read by a less skilled health professional, e.g. a cardiologist trainee, and is then over-read and confirmed by a fully trained cardiologist.

Note 2 to entry: If an over-read of an ECG interpretation report is signed off (i.e. confirmed, see Clause 3.3) by the over-reader, then it should be clinically acceptable for diagnosis and treatment.

Note 3 to entry: It should be remembered that an over-reader provides a personal opinion in either verifying or altering a computer generated interpretation and/or measurement or annotation. One over-reader may disagree with another in the same way as one medical professional may disagree with another in making a clinical diagnosis.

3.9

record

entire data file which is transmitted, including the ECG data and associated information, such as patient identification, demographic and other clinical data, measurements, annotations, interpretation results, etc.

3.10

reference beat

reference/representative ECG cycle computed through any (but not specified) algorithm comprising the P, QRS and the ST-T waves

3.11

rhythm data

full original ECG data, or the decompressed and reconstructed ECG data if lossless compression is used

Note 1 to entry: Rhythm data are typically 10 s in length for a standard 12-Lead ECG (stored in sections 6 and/or 14), but may last several minutes for stress tests, a few hours for drug trials and up to 7 days for Holter recordings (stored in section 12).

3.12

section

aggregate of data elements related to one aspect of the electrocardiographic recording, measurement, annotation or interpretation

3.13

universal statement codes

ECG interpretation codes described in Annex B of this document

Note 1 to entry: See glossary in Annex G for other technical terms related to this part of EN 1064.

4 Symbols and abbreviated terms

AAMI	American Association for the Advancement of Medical Instrumentation
AC	Alternating Current
AHA	American Heart Association
AIM	Advanced Informatics for Medicine Programs of the European Commission Directorate General XIII
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
AVM	Amplitude Value Multiplier (see 5.8.3)
CEN	Comité Européen de Normalisation - European Committee for Standardization
CIED	Cardiac Implantable Electronic Device
CRC	Cyclic Redundancy Check
CRT	Implanted Cardiac Resynchronization Therapy device

CSE	Common Standards for quantitative Electrocardiography
DG	Directorate General (of the European Commission)
EU	European Union
ECG	Electrocardiogram
EN	Europäische Norm (European Standard)
ENV	Europäische Norm Vorauskabe (European Pre-standard)
ICD	Implanted Cardioverter Defibrillator
ID	Identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISO	International Organization for Standardization
LSB	Least significant bit
MSB	Most significant bit
RMS	Root Mean Square
SCP	Standard Communications Protocol
SCP-ECG	Standard Communications Protocol for computerized Electrocardiography
TC	Technical Committee
UTF-8	Universal Coded Character Set + Transformation Format – 8-bit (specified in ISO/IEC 10646)
VCG	Vectorcardiogram

5 Definition of the data contents and format

5.1 General considerations

5.1.1 The data record which is to be interchanged shall be divided into different sections. The contents and format of each of these sections are defined in this document.

5.1.2 All text data (character strings) shall be stored in the 8-bit Universal Character Set Transformation Format of ISO/IEC 10646 (also known as UTF-8)

5.1.3 All character strings shall be encoded in UTF-8 and NULL terminated

5.1.4 For all signed binary values 2's-complement coding shall be applied

5.1.5 All single and multiple byte binary values are regarded as unsigned integers, if not otherwise specified

5.1.6 Endianness: binary values spanning more than 1 byte shall be transmitted and/or stored according to the little endian mode, i.e. in ascending order of significance (the least significant byte is transmitted and/or stored first, the most significant byte last)

5.1.7 Consecutive bytes are numbered from left to right (starting with 1). Bits of a byte are numbered from right to left (0 = LSB, 7 = MSB)

5.1.8 The first byte in the record (i.e. the first byte of the Checksum) is defined as Byte 1

5.1.9 ECG samples are indexed and numbered starting with sample number 1. Sample index 0 is not used in the present document. Sample indexes are stored as ones-based 16-bit or 32-bit unsigned integers. The first sample starts at time 0. The second sample is at time $(0 + 2)$ ms in case of 500 samples/s sampling rate

5.1.10 Sections are numbered starting from 0 (the Pointer Section) to 32 767

5.1.11 The term “Reference Beat” used in this document refers to an ECG complex which is chosen as representative of a class of such complexes. No specific statistical meaning is implied by this term; for example, it may be an averaged beat (obtained by averaging the waveforms of a set of beats of the same type), a “Median Beat” (obtained by computing the median of the waveforms of a set of beats of the same type), a selected or any other representative single cycle taken from the total ECG recording. This “Reference Beat” does include the P-wave if present (not in case of atrial fibrillation), the ST-T segment and the T wave of this beat

An ECG may have multiple reference beats. The term “reference Beat type” used in this document refers to any one of an ordered list of reference beats, starting with reference beat type 0 (zero). Reference beat type 0 (sometimes also called “dominant beat”) is, in general, the primary heart beat excepting extrasystole or artefact. It is used for the calculation of the full set of global measurements and the per-lead measurements stored in sections 7 (Clause 5.10) and 10 (Clause 5.13) and is, by definition, the reference beat used for the so-called contour interpretation of the ECG. The ordering of the list of reference beats does not imply a temporal sequence within the rhythm data.

The term “Rhythm Data” is used to indicate the ECG recording over the entire recording time, usually 10 s in most standard electrocardiographs, but it may take several minutes for stress tests and up to several days for Holter recordings.

Reference Beat type 0 data in 5.8 and the reference beats defined in 5.16 are intended to be used for (re)analysis and for display.

A description of these terms and of the recommended lossless data compression methodology, including numerical examples and the methods for conformance testing are given in Annex C and Annex D.

5.1.12 All indexes or pointers to a field are defined in bytes and are ones-based (start at 1) if not otherwise specified.

5.1.13 1 KiB (kibibyte) = 1 024 bytes; 1 GiB (gibibyte) = 1 073 741 824 bytes

5.2 Specifications for the data structure

5.2.1 All sections shall start on an odd index (even offset) boundary. This implies that all sections shall contain an even number of bytes. A padding byte has to be added to the end of any section otherwise containing an odd number of bytes. Padding bytes shall always be set to NULL (0x00). Blocks of data within a section may contain either odd or even numbers of bytes. Padding occurs only at the end of a section if needed.

5.2.2 All sections are given Identification numbers. Starting with version V3.0, section ID numbers 0 through 18 are currently defined in the SCP-ECG protocol, numbers 19 through 127 as well as numbers above 1 024 are reserved for future use. Numbers 128 to 1 023 are for manufacturer specific sections. The combination of the manufacturer code (see 5.4.5, tag 14) and section numbers 128 to 1 023 uniquely defines the content of the manufacturer-specific sections. There are no specific rules for the layout and format of these sections. However, use of the structure defined in 5.2.7 is recommended.

5.2.3 Inclusion of Sections 2, 5, 7 to 11, 15 to 18 (see section format in 5.2.7 and 5.2.8) is optional. Any SCP-ECG data record shall contain Section 0 (Pointers), Section 1 (Header), Section 3 (ECG Lead Definition) and Section 6 (Short-term ECG Rhythm Data) or Section 12 (Long-term ECG Rhythm Data) or Section 14 (Selected ECG sequences repository). Section 13 (Stress tests, Drug trials and Protocol based ECG recordings Metadata) is compulsory when Section 14 (Selected ECG Sequences Repository) is present. No other consistency checking among the presence of different sections is assumed. Specifically, if any of Sections 8, 9, or 11 is present, it is not assumed that all three shall be present.

5.2.4 The ECG record starts with a 6-byte record header, consisting of a 2-byte CRC followed by a 4-byte record length. These are defined as follows

- 1) The 2-byte cyclic redundancy check (CRC) is calculated as a CRC-CCITT, the algorithm of which is described in C.6, and is calculated over the entire range starting with the first byte following the CRC and ending with the last byte in the record.
- 2) The 4-byte record length denotes the number of bytes in the total record, including the 6 bytes of this record header.

5.2.5 SCP-ECG record overview:

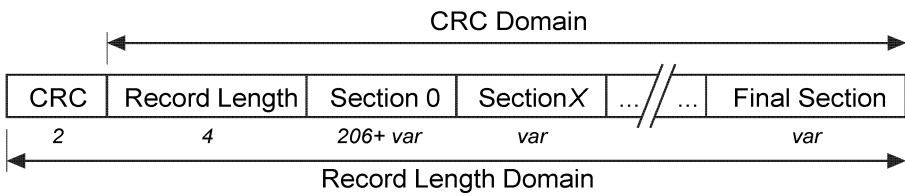


Figure 1 — SCP-ECG record overview

NOTE The length of Section 0 is equal to $(16 + 10(n + 1)) + 10m$, where $n = 18$ is the number of sections currently described in this version of the protocol and m is the number of additional, manufacturer specific sections (if any) contained in the SCP-ECG record.

5.2.6 The sequence order of the sections of a record is free, with the exception of Section 0 (zero) which shall immediately follow the record header. However, a maximum of one instance of any section is allowed in a SCP-ECG data record.

5.2.7 Each section consists of

- 1) a Section Identification Header (Section ID Header)
- 2) a Section Data Part.

Any section shall start with a “Section ID Header” (16 bytes) defined below:

Bytes	Contents
1 to 2	16 bit CRC-CCITT over the entire section except these 2 bytes.
3 to 4	Section ID number as defined in 5.2.2 (see also 5.3.3.1).
5 to 8	Section length in bytes <u>including</u> the “Section ID Header” (5.3.3.2).
9	Version Number of the Section.

10 **Version Number of the Protocol** (see 5.4.5, tag 14, byte 15).

11 to 16 **Reserved** (shall be set to Null (0), except for section 0, see 5.3.2).

Each section shall have a Section Version Number and a Protocol Version Number (see bytes 9 and 10) which may be used to specify different levels of compatibility with the standard when this is updated in the future (see Annex C). For data sections 1 to 18, Section Version Numbers (byte 9) shall be the Protocol Version under which the section was approved. For data sections 128 to 1 023, Section Version shall refer to the manufacturer's version for that section, independent of the Protocol version.

The version number of the protocol described in this document is V3.0. This version number shall be stored as decimal value of 30. For implementation details, see 5.4. 5, Tag 14, byte 15.

The section and protocol version numbers must match for all sections containing strings (i.e. sections 1, 8, and 10 to 18). Specifically, mixing old and new version sections could corrupt the interpretation of strings (see also section 1, Clause 5.4.5, Tags 14 and 15, byte 15).

5.2.8 Reserved fields shall always be set to NULL (zero).

5.2.9 A global overview of the layout of an SCP-ECG section is presented in Figure 2

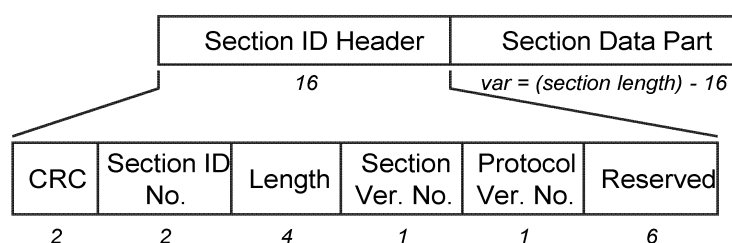


Figure 2 — Section layout overview

5.2.10 The numbers in *italic* in the layout overviews in 5.2.5 and 5.2.9 as well as in all other layout overviews of Clause 5 indicate the length in bytes of the corresponding field or indicated block (var = variable length).

5.2.11 A global overview of the SCP-ECG data structure is presented in Table 1

Table 1 — SCP-ECG data structure

Requirement Status	Content
Required	2 BYTES - CHECKSUM - CRC - CCITT OVER THE ENTIRE RECORD (EXCLUDING THIS WORD)
Required	4 BYTES - (UNSIGNED) SIZE OF THE ENTIRE ECG RECORD (IN BYTES)
Required	(Section 0) POINTERS TO DATA AREAS IN THE RECORD
Required	(Section 1) HEADER INFORMATION - PATIENT DATA/ECG METADATA
Optional	(Section 2) HUFFMAN TABLES USED IN ENCODING OF ECG DATA (IF USED)

Requirement Status	Content
Required	(Section 3) ECG LEADS DEFINITION
Reserved	(Section 4) RESERVED FOR LEGACY SCP-ECG VERSIONS
Optional	(Section 5) ENCODED TYPE 0 REFERENCE BEAT DATA (IF REFERENCE BEAT IS STORED)
Optional * * see 5.2.12	(Section 6) SHORT-TERM ECG RHYTHM DATA
Optional	(Section 7) GLOBAL ECG MEASUREMENTS
Optional	(Section 8) TEXTUAL DIAGNOSIS FROM THE “INTERPRETIVE” DEVICE
Optional	(Section 9) MANUFACTURER SPECIFIC DIAGNOSTIC AND OVERREADING DATA FROM THE “INTERPRETIVE” DEVICE
Optional	(Section 10) PER LEAD ECG MEASUREMENTS
Optional	(Section 11) UNIVERSAL STATEMENT CODES RESULTING FROM THE INTERPRETATION
Optional * * see 5.2.12	(Section 12) LONG-TERM ECG RHYTHM DATA
Optional * * see 5.2.12	(Section 13) STRESS TESTS, DRUG TRIALS AND PROTOCOL-BASED ECG RECORDINGS METADATA
Dependent on Section 13	(Section 14) SELECTED ECG SEQUENCES REPOSITORY
Optional	(Section 15) BEAT-BY-BEAT ECG MEASUREMENTS AND ANNOTATIONS
Optional	(Section 16) SELECTED ECG BEATS MEASUREMENTS AND ANNOTATIONS
Optional	(Section 17) PACEMAKER SPIKES MEASUREMENTS AND ANNOTATIONS
Optional	(Section 18) ADDITIONAL ECG ANNOTATIONS

5.2.12 The following remarks apply to the data sections identified above:

- 0 This section contains pointers to the start to itself and to the start of each of the following sections. This section is required.
- 1 This section contains information of general interest concerning the patient (e.g. patient

- name, patient ID, age, etc.) and the ECG (acquisition date, time, etc.). This section is required.
- 2 This section contains all of the other than default SCP-ECG Huffman tables used in the encoding of Section 6 short-term ECG rhythm (or “residual signal” in SCP-ECG versions prior to 3.0) and type 0 reference beat data (Section 5). The tables shall be referenced by Sections 5 and 6 by their numerical order in this section. Thus, when reference is made in the type 0 reference beat encoding section to Table 2, this shall refer to the second table defined in Section 2. This section is required, dependent upon Huffman encoding being used in the encoding of ECG signals of Section 6 (short-term ECG rhythm) and of Section 5 (type 0 reference beat, if stored). Starting with SCP-ECG V3.0, this section is no longer mandatory if only the default Huffman table defined in D.4.7.6 is used.
 - 3 This section specifies which ECG leads are contained within section 5 (type 0 reference beat) and section 6 (short-term ECG rhythm) ECG records. This section is required.
 - 4 This section was formerly used to store QRS locations to allow beat subtraction for computing a “residual signal”. This section has been deprecated and is now reserved. It shall no longer be used.
 - 5 This section is used to store lead by lead the type 0 reference beat if the originating device or the (re)analysing device has identified or computed a dominant reference beat. This section is optional.
 - 6 Whenever only a short-term ECG is recorded, this section shall be used to store its entire rhythm signal data. The section may also be used to store the rhythm signal data of a standard, short duration baseline ECG in case a long-term ECG or selected ECG sequences are recorded and stored in sections 12 and 14. Section 6 may accommodate rhythm recordings up to a length of 65 536 samples per lead. This section is optional (but required if neither section 12 nor section 14 are present).
 - 7 This section contains global measurements for reference beat type 0. It may also contain a basic set of global measurements for each other than type 0 reference beat or for each QRS contained in the short-term ECG rhythm record and a list of possible pacemaker spikes in the short-term ECG rhythm record. This section is optional.
 - 8 This section contains the latest actual text of the diagnostic interpretation of the recorded ECG data, including all overreadings if performed. Only the text of the most recent interpretation and overreading shall be included in this section. No manufacturer specific codes should be used in the text. Mnemonic codes as listed in Annex B, Universal statement codes and coding rules, may be used if necessary. The data contained in this section shall be consistent with the data in Section 9 and Section 11. This section is optional.
 - 9 This section contains the manufacturer specific diagnostic statements of the analysing device and the manufacturer specific overreading trails of the interpretations. The ID of the analysing device and the name of the latest confirming physician (or device) are defined in the “Header information” section (Section 1). This section is optional.
 - 10 A set of basic per lead measurements and manufacturer specific measurements (if any) for each recorded lead of “the type 0 reference beat” are presented in this section. This section is optional.
 - 11 This section contains the most recent interpretation and overreading data, coded according to the SCP-ECG Universal Statement Codes and Coding rules (Annex B) and/or the categorized AHA statement codes [21] or CDISC code specifications [30]. The data contained in this section shall be consistent with the data in Sections 8 and 9. This section is optional.

- 12 This section contains the signal data of the long-term ECG rhythm recording, if any. It may be used to overcome the 64 KiB per lead maximum storage capacity limit of section 6. The signals are stored uncompressed, up to 32 bits per sample, according to an interleaved format. This section is optional (but required if neither section 6 nor section 14 are present).
- 13 This section contains meta-data describing the different steps and workloads for stress ECGs or drug trials and other protocol based recordings which might have been stored in sections 12 and 14. This section is optional (but required if section 14 is present).
- 14 This Section is complementary to Section 13 and is used, if need be, to store the short duration ECG sequences acquired during the recording of an exercise ECG or a drug trial ECG. This section is optional (but required if neither section 6 nor section 12 are present).
- 15 This Section provides means to store several pre-defined global and per-lead beat measurements and annotations, for all or for only some computed or selected beats of the analysed signals (long-term and/or short-term ECGs stored in sections 12 and 14 and/or in section 6). The beats may have been selected one by one by a physician or by a beat typification algorithm (reference beats of different types, etc.), or refer to the entire set of beats from one or more selected time windows within the long-term ECG stored in section 12 or in the short-term ECGs stored in sections 6 or 14. This section is optional.
- 16 Section 16 provides a solution to store a different set of measurements and annotations than the one stored in section 15 and is thus complementary to section 15. Its structure and format are much the same as for section 15, except that there is no provision for specifying analysis time windows. Section 16 should be the preferred section for storing selected ECG beats measurements and annotations, if no beat-by-beat measurements and annotations are required. This section is optional.
- 17 This Section provides means to store several pre-defined global and/or per-lead spike measurements and annotations, for the entire ECG recording or for only some selected time windows of the analysed signals (long-term ECG and/or selected ECG sequences stored in sections 12 and 14 and/or in section 6).
- 18 This Section provides means to store, in a highly flexible manner, any type of manually or automatically produced annotation which has not been stored in a systematic way in sections 7, 8, 10, 11 and 15 to 17, viz the onset (and end) of different types of arrhythmia, measurements that were not foreseen in sections 15 and 16, manual annotations of complex cases with different type of aberrant QRS complexes and P waves, noise annotations in a given lead, etc.

5.3 Pointer section – Section 0

5.3.1 The purpose of this section is to store pointers to the remaining sections in the record. All sections are given identification numbers, as defined in 5.2.2.

5.3.2 The section starts with a “Section ID Header” as defined in 5.2.7. Bytes 11 to 16 of the Section ID Header shall contain the six-character ASCII string (UTF-8 compliant): “SCPECG”. This string shall not be Null terminated.

5.3.3 To provide a flexible way of section management, the data part of the pointer section is defined as follows

- One pointer field shall be provided in the pointer section for each Section 0 to 18 defined by the SCP-ECG protocol, whether the optional sections are present or not. For any optional section not

included in a SCP-ECG data record, the special coding rules defined in 5.3.3.2 and 5.3.3.3 for the pointer field shall be applied. The same yields for section 4.

- Manufacturer specific sections, if present, shall have a pointer field in Section 0.
- The first pointer field included in this section shall be the field for Section 0 (this section).

Each pointer field contains three parts:

- a) A Section Identification number (see 5.3.3.1).
- b) A Section Length (see 5.3.3.2).
- c) An Index to the Section (see 5.3.3.3).

5.3.3.1 The Section Identification number is stored in two bytes (unsigned integer) containing the section number, as defined in 5.2.2. Section ID numbers 0 through 18 are currently defined in this SCP-ECG protocol, numbers 19 through 127, as well as numbers above 1 023 are reserved for future use, numbers 128 through 1 023 are codes for manufacturer-specific sections.

5.3.3.2 The length, in bytes, of a section (= an even number, see 5.2.1) is presented in this unsigned 4-byte integer “Section length” field part. The length includes the 16 bytes of the “Section ID Header” (see 5.2.7). For data Sections 2 to 18 a pointer field shall be included. If no data are stored for any of these sections, set the section length to 0.

NOTE The 4-byte integer specification limits each section length to be less than 4 GiB. However, the user is advised that the total SCP-ECG record length is itself limited to 4 GiB (see 5.2.4), so the single section limit cannot be reached.

5.3.3.3 An index to the first byte of a section shall be presented in this unsigned 4-byte integer “Index to section” field part. The index is calculated relatively to the start of the record, i.e. byte 1 of the record (first byte of the CRC). For example, if Section 11 begins at an offset of 128 900 bytes from the beginning of the ECG record, the index to Section 11 would be set to 128 901. If a section is not included in the SCP-ECG record the index shall be set to NULL (0). The index to Section 0 shall always be set to 7, since Section 0 is always preceded by the Checksum (2 bytes) and the Record Length (4 bytes).

5.3.3.4 The pointer fields in Section 0 shall be in numerical order. However, the sections themselves do not necessarily have to follow in numerical order.

For instance, the pointer field for Section 11 shall be located as represented in Figure 3 after the one of Section 10 and before the one of Section 12, but Section 11 could actually begin at byte 128 901 and section 12 at byte 26 801.

5.3.4 An overview of the pointer section data part is presented in Figure 3.

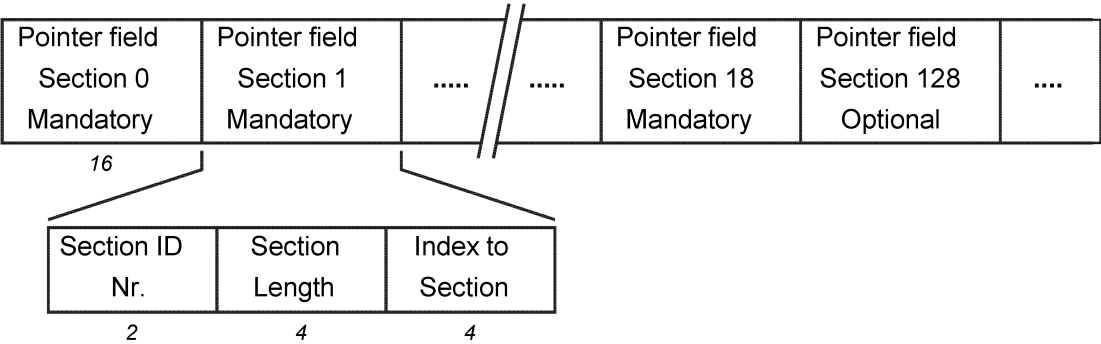


Figure 3 — Section 0 - Pointer section - data part overview

5.4 Header information - Patient data / ECG metadata – Section 1

5.4.1 General

The section shall start with a “Section ID Header” as defined in 5.2.7.

5.4.2 Introduction to the section data part

The following layout details the format that should be used to transmit patient demographic and clinical data and ECG metadata as part of the standard (SCP-ECG) communications protocol for digital ECG data.

5.4.3 Basic methodology

5.4.3.1 It is recognized that, although a large number of parameters may be transmitted, most devices will only send a subset of that number. As a result, it was agreed that the format of the patient data and ECG metadata area should be made flexible.

Each parameter shall be stored in a separate field. Including a field in this section shall be optional, with the single provision that the following parameters (1 to 4) SHALL be present:

Tag	Parameter
1	2
2	14
3	25
4	26

In addition, the SCP-ECG Working Group highly recommends the following parameters for uniquely identifying the patient and time of acquisition.

Tag	Parameter
5	0
6	1
7	5
8	8
9	15
10	34

5.4.3.2 Flexibility is achieved by structuring each “Header information” field (hereafter called “Header” field) in the following way:

- a) Each Header field starts with one leading specification byte, referred to as “tag”, indicating the contents of the parameter field.
- b) The tag is followed by a 2-byte unsigned integer, referred to as “length”, containing the length of the field value in bytes, allowing variable length text entries encoded in UTF-8. The NULL terminator character of a text string shall be included to calculate the field length. For example, for the last name “Menuel” the length shall be listed as 7, the NULL included. A length field value of 0 is allowed, which is equivalent to “not defined”.
- c) The length field is followed by zero or more parameter bytes, referred to as “value”, containing the actual parameter data.

The field tag (1 binary byte) permits a total of 255 different field types to be defined (0 to 254; 255 is used as terminator). Any field identified by a value of 200 to 254 is not defined within the specification of this protocol and permits a manufacturer to define its own set of fields.

The field length (2 binary bytes) shall contain the actual length of the field value. The tag and length bytes (first 3 bytes of any field) are not included in the field length. The maximum possible length of each field value is 65 535 bytes (unsigned 2 bytes). However, for practical reasons, the maximum length of a field shall not exceed 64 bytes, except for the free text items (see 5.4.3.5).

The field value, containing the actual parameter data, can be of any combination of binary bytes and text characters.

5.4.3.3 A maximum of one instance of any tagged field defined in 5.4.5 is allowed to be included in this “Header” section, except for the following fields listed below:

Tag	Value description	Max. instances
10	Drugs	no limit
13	Diagnosis or referral indication	no limit
30	Free text	no limit
32	History diagnostic codes	no limit
35	Free-text Medical History	no limit
37	ATC drug codes	no limit

5.4.3.4 The first 16 characters of the patient identification number shall be unique.

5.4.3.5 In order to facilitate the implementation of the protocol, the maximum field length of the tags of section 1 has been set to 64 bytes (except for tag 13, tag 30, tag 34 and tag 35, where the limit is 80). Reasonable values for the length of the different free text fields are shown in Annex F, Table F.1.

5.4.4 Overview of the data part of the “Header information” section

An overview of the data part of the “Header information” section is presented in Figure 4.

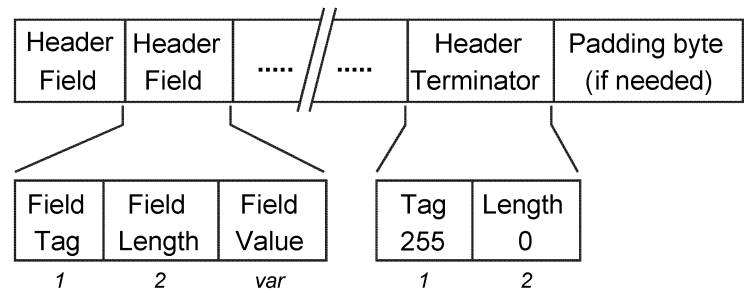


Figure 4 — Overview of the “Header information” section data part

Padding bytes (if any) should be set to zero. This applies to all sections, but will not be shown in all the following diagrams.

5.4.5 Specification of the header information content

For the specification of the defined parameters, see Table 2.

Table 2 — Specification of the defined parameters

Tag	Length	Value (Parameter data)				
0	length	Last name (Text characters) [MDC_ATTR_PT_NAME_FAMILY] ³ This shall also be used to transmit the entire name if the originating unit does not explicitly determine a first name.				
1	length	First name (Text characters) [MDC_ATTR_PT_NAME]				
2	length	Patient ID (Text characters) [MDC_ATTR_PT_ID]				
3	length	Second Last name (Text characters) [MDC_ATTR_PT_NAME_BIRTH] or [MDC_ATTR_PT_NAME_GIVEN] The field value may be defined as appropriate for the country or area where the ECG device is used. For instance in the USA this field may hold the Family member prefix code, in France it may contain the patient's maiden name, and in Portugal as well as in Spain and several Latin American countries, the second last name of the patient.				
4	3	Age (Binary) Semantically equivalent to MDC_ATTR_PT_AGE This field has the following format: <table><tr><td><u>Byte</u></td><td><u>Contents</u></td></tr><tr><td>1 to 2</td><td>Binary: Age in units as indicated in byte 3 [MDC_ATTR_PT_AGE]</td></tr></table>	<u>Byte</u>	<u>Contents</u>	1 to 2	Binary: Age in units as indicated in byte 3 [MDC_ATTR_PT_AGE]
<u>Byte</u>	<u>Contents</u>					
1 to 2	Binary: Age in units as indicated in byte 3 [MDC_ATTR_PT_AGE]					

³ MDC nomenclature codes in square brackets refer to the Reference IDs (REFIDs) defined in ISO 11073-10101 and/or in ISO 11073-10102

Tag	Length	Value (Parameter data)																
		3 Binary: Units of age as defined below: <table><thead><tr><th>Value</th><th>Unit</th></tr></thead><tbody><tr><td>0</td><td>Unspecified [MDC_DIM_NOS]</td></tr><tr><td>1</td><td>Years [MDC_DIM_YR]</td></tr><tr><td>2</td><td>Months [MDC_DIM_MON]</td></tr><tr><td>3</td><td>Weeks [MDC_DIM_WEEKS]</td></tr><tr><td>4</td><td>Days [MDC_DIM_DAY]</td></tr><tr><td>5</td><td>Hours [MDC_DIM_HR]</td></tr></tbody></table> If all 3 bytes are zero, then age is not specified.	Value	Unit	0	Unspecified [MDC_DIM_NOS]	1	Years [MDC_DIM_YR]	2	Months [MDC_DIM_MON]	3	Weeks [MDC_DIM_WEEKS]	4	Days [MDC_DIM_DAY]	5	Hours [MDC_DIM_HR]		
Value	Unit																	
0	Unspecified [MDC_DIM_NOS]																	
1	Years [MDC_DIM_YR]																	
2	Months [MDC_DIM_MON]																	
3	Weeks [MDC_DIM_WEEKS]																	
4	Days [MDC_DIM_DAY]																	
5	Hours [MDC_DIM_HR]																	
5	4	Date of birth (Binary) Semantically equivalent to MDC_ATTR_PT_DOB This field has the following format: <table><thead><tr><th>Byte</th><th>Contents</th></tr></thead><tbody><tr><td>1 to 2</td><td>Binary: Year (full integer notation, as in 2018)</td></tr><tr><td>3</td><td>Binary: Month (range 01 to 12; 01 = January)</td></tr><tr><td>4</td><td>Binary: Day (range 01 to 31)</td></tr></tbody></table> If all 4 bytes are zero, then date of birth is not specified.	Byte	Contents	1 to 2	Binary: Year (full integer notation, as in 2018)	3	Binary: Month (range 01 to 12; 01 = January)	4	Binary: Day (range 01 to 31)								
Byte	Contents																	
1 to 2	Binary: Year (full integer notation, as in 2018)																	
3	Binary: Month (range 01 to 12; 01 = January)																	
4	Binary: Day (range 01 to 31)																	
6	3	Height (Binary) Semantically equivalent to MDC_ATTR_PT_HEIGHT This field has the following format: <table><thead><tr><th>Byte</th><th>Contents</th></tr></thead><tbody><tr><td>1 to 2</td><td>Binary: Height in units as indicated in byte 3 [MDC_ATTR_PT_HEIGHT]</td></tr><tr><td>3</td><td>Binary: Units of height as defined below:</td></tr></tbody></table> <table><thead><tr><th>Value</th><th>Unit</th></tr></thead><tbody><tr><td>0</td><td>Unspecified [MDC_DIM_NOS]</td></tr><tr><td>1</td><td>Centimetres [MDC_DIM_CENTI_M]</td></tr><tr><td>2</td><td>Inches [MDC_DIM_INCH]</td></tr><tr><td>3</td><td>Millimeters [MDC_DIM_MILLI_M]</td></tr></tbody></table> If all 3 bytes are zero, then height is not specified.	Byte	Contents	1 to 2	Binary: Height in units as indicated in byte 3 [MDC_ATTR_PT_HEIGHT]	3	Binary: Units of height as defined below:	Value	Unit	0	Unspecified [MDC_DIM_NOS]	1	Centimetres [MDC_DIM_CENTI_M]	2	Inches [MDC_DIM_INCH]	3	Millimeters [MDC_DIM_MILLI_M]
Byte	Contents																	
1 to 2	Binary: Height in units as indicated in byte 3 [MDC_ATTR_PT_HEIGHT]																	
3	Binary: Units of height as defined below:																	
Value	Unit																	
0	Unspecified [MDC_DIM_NOS]																	
1	Centimetres [MDC_DIM_CENTI_M]																	
2	Inches [MDC_DIM_INCH]																	
3	Millimeters [MDC_DIM_MILLI_M]																	
7	3	Weight (Binary) Semantically equivalent to MDC_ATTR_PT_WEIGHT and ATTR_PT_WEIGHT_LAST This field has the following format:																

Tag	Length	Value (Parameter data)
		Byte Contents 1 to 2 Binary: Weight in units as indicated in byte 3 [MDC_ATTR_PT_WEIGHT] and [ATTR_PT_WEIGHT_LAST] 3 Binary: Units of weight as defined below: Value Unit 0 Unspecified [MDC_DIM_NOS] 1 Kilogram [MDC_DIM_KILO_G] 2 Gram [MDC_DIM_X_G] 3 Pound [MDC_DIM_LB] 4 Ounce [MDC_DIM_OZ] If all 3 bytes are zero, then weight is not specified.
8	1	Sex (Binary) [MDC_ATTR_PT_SEX] This has the following format: Byte Contents 1 Binary: Sex indication defined as: Value Sex Value Sex 1 Male0 Not Known 2 Female9 Unspecified
9	1	Ethnicity (Binary) [MDC_ATTR_PT_RACE] This has the following format: Byte Contents 1 Binary: Race indication defined as: Value Ethnicity 0 Unspecified 1 Caucasian 2 Black 3 Oriental 4 to 9 Reserved 10 to 255 Other (manufacturer specific)
10	length	Drugs (Binary bytes and Text characters) [MDC_DRUG_NAME_TABLE] Each drug entered in this Tag of the patient demographic area shall be described by the following structure: Byte Contents 1 Binary: Drug code table indicator (DCTI)

Tag	Length	Value (Parameter data)
		If DCTI = 0, then the SCP-ECG specific tables defined hereafter and in Annex A apply. 2 Binary: Drug Class code (DCC) [MDC_DRUG_NAME_TYPE] If DCTI = 0, then the SCP-ECG specific DCC drug class codes listed in Annex A, Table A.1 shall be used. Shall be set to 0 if DCTI ≠ 0 3 Binary: Specific drug code (SDC) within the specified class [MDC_DRUG_NAME_POINTER] If DCTI = 0, then the SCP-ECG specific SBC drug sub class codes listed in Annex A, Table A.2 shall be used. Shall be set to 0 if DCTI ≠ 0. 4 to *** Null terminated text string. May contain a textual description of the drug (optional). NOTE 1 If DCTI = 0, a DCC class code of 0 is always followed by a SDC drug code of 0 or 9, indicating that the drug is undefined within this document, and that the text in bytes 4 to *** is the only description available. NOTE 2 If DCTI = 0, a non-zero DCC class code together with a SDC drug code of 0 always indicates that a drug of that particular class has been applied, but that the drug is either unknown (SDC = 0) or not defined within this document (SDC = 9). Even if a non-zero DCC class and SDC drug code are applied, a text description of the drug can also be sent in bytes 4 to ***. No standardized naming conventions have been specified for this textual entry. NOTE 3 This tagged field can have several instances (see 5.4.3.3), one per drug administered to the patient, if any. There is thus no limit on the number of drugs which can be coded. NOTE 4 Using the DCC/SDC drug coding system does not exclude using the ATC drug coding system (see Tag 37), i.e. a same patient's drug can be documented in the SCP-ECG record using two different drug code tags, Tag 10 and Tag 37.
11	2	Systolic blood pressure (Binary) Semantically equivalent to MDC_PRESS_BLD_SYS and to MDC_PRESS_BLD_NONINV_SYS <u>Byte</u> <u>Contents</u> 1 to 2 Binary: Systolic blood pressure in mmHg.
12	2	Diastolic blood pressure (Binary) Semantically equivalent to MDC_PRESS_BLD_DIA and to MDC_PRESS_BLD_NONINV_DIA <u>Byte</u> <u>Contents</u> 1 to 2 Binary: Diastolic blood pressure in mmHg.
13	Length	Diagnosis or Referral indication (Text characters) [MDC_ATTR_DIAGNOSTIC_INFO]

Tag	Length	Value (Parameter data)																																										
		This field contains a text description of the patient's diagnosis or the referral indication.																																										
14	length	Machine ID Acquiring Device (Binary bytes and Text characters) This field uniquely identifies the device that acquired the ECG. It uses the following generic data structure for device characterization, which is also used in tag 15: <table><tr><td><u>Byte</u></td><td><u>Contents</u></td></tr><tr><td>1 to 2</td><td>Binary: Institution number</td></tr><tr><td>3 to 4</td><td>Binary: Department number</td></tr><tr><td>5 to 6</td><td>Binary: Device ID</td></tr><tr><td>7</td><td>Binary: Device type</td></tr></table> <table><tr><td><u>Value</u></td><td><u>Type</u></td></tr><tr><td>0</td><td>Cart or mobile device</td></tr><tr><td>1</td><td>System (or Host)</td></tr><tr><td>2</td><td>Wearable device</td></tr></table> 8 Binary: shall be set equal to 255 SCP-ECG version V1.x used this byte to specify a Manufacturer code. Starting with SCP-ECG version V2.1, this coding system has been discarded and replaced by the use of a "Manufacturer of the Acquiring Device" character string, defined at the end of Tag 14. To support decoding of SCP-ECG V1.x legacy files, these historical, previously assigned codes are recalled hereafter: <table><tr><td>0 – Unknown</td><td>11 – Quinton</td></tr><tr><td>1 – Burdick</td><td>12 – Siemens</td></tr><tr><td>2 – Cambridge</td><td>13 – Spacelabs</td></tr><tr><td>3 – Compumed</td><td>14 – Telemed</td></tr><tr><td>4 – Datamed</td><td>15 – Hellige</td></tr><tr><td>5 – Fukuda</td><td>16 – ESAOTE</td></tr><tr><td>6 – Hewlett-Packard</td><td>17 – Schiller</td></tr><tr><td>7 – Marquette Electronics</td><td>18 – Picker-Schwarzer</td></tr><tr><td>8 – Mortara Instruments</td><td>19 – et medical devices</td></tr><tr><td>9 – Nihon Kohden</td><td>(ex Elettronica Trentina)</td></tr><tr><td>10 – Okin</td><td>20 – Zwönitz</td></tr><tr><td>21 to 99 – Reserved</td><td>100 – Other</td></tr></table> 9 to 14 Text characters: Text model description. Up to 5 bytes of text and NULL terminator. 15 Binary: SCP-ECG protocol revision number (the decimal point shall be deleted; version 3.0 becomes 30, stored as 0x1E; the revisions shall be backward compatible, as far as possible). This number shall exactly refer to the written document describing the actual protocol revision.	<u>Byte</u>	<u>Contents</u>	1 to 2	Binary: Institution number	3 to 4	Binary: Department number	5 to 6	Binary: Device ID	7	Binary: Device type	<u>Value</u>	<u>Type</u>	0	Cart or mobile device	1	System (or Host)	2	Wearable device	0 – Unknown	11 – Quinton	1 – Burdick	12 – Siemens	2 – Cambridge	13 – Spacelabs	3 – Compumed	14 – Telemed	4 – Datamed	15 – Hellige	5 – Fukuda	16 – ESAOTE	6 – Hewlett-Packard	17 – Schiller	7 – Marquette Electronics	18 – Picker-Schwarzer	8 – Mortara Instruments	19 – et medical devices	9 – Nihon Kohden	(ex Elettronica Trentina)	10 – Okin	20 – Zwönitz	21 to 99 – Reserved	100 – Other
<u>Byte</u>	<u>Contents</u>																																											
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21 to 99 – Reserved	100 – Other																																											

Tag	Length	Value (Parameter data)																																
		16 Binary: SCP-ECG Protocol Compatibility Level (one byte). Legacy field, shall be set to 0xFF. See also Annex C.4. 17 Binary: Language Support Code (one byte). Starting with version V3.0, this byte shall be set to 0x37 to indicate that now only UTF-8 text string encoding is allowed. SCP-ECG versions V1.x and V2.x used this byte to specify other language encodings than UTF-8. The assigned codes are listed in Annex A, Table A.3 for historical purposes. These codes shall no longer be used except for decoding legacy SCP-ECG files. Mixing sections encoded according to versions V1.x / V2.x and newer sections encoded according to version V3.0 could corrupt the interpretation of strings (see also byte 15 above in Tag 14 and hereafter in Tag 15). 18 Binary: Capabilities of the ECG Device (one byte bit map). This bit map indicates the supported functions: <table><tr><th>Bit</th><th colspan="2">Contents</th></tr><tr><td></td><td>Reset (0)</td><td>Set (1)</td></tr><tr><td>0 to 2</td><td>Reserved</td><td>Reserved (Shall be set to 0)</td></tr><tr><td>3</td><td>No analysis</td><td>Can analyse ECG</td></tr><tr><td>4</td><td>No printing</td><td>Can print ECG reports</td></tr><tr><td>5</td><td>No interpretation</td><td>Can interpret ECG</td></tr><tr><td>6</td><td>No storage</td><td>Can store ECG records</td></tr><tr><td>7(MSB)</td><td>No acquisition</td><td>Can acquire ECG data</td></tr></table> 19 Binary: AC Mains Frequency Environment (one byte): <table><tr><th>Value</th><th>Meaning</th></tr><tr><td>0</td><td>Unspecified</td></tr><tr><td>1</td><td>50 Hz</td></tr><tr><td>2</td><td>60 Hz</td></tr></table> 20 to 35 Reserved for future use. Shall be set to Null (0). 36 Binary: Length of the string for Analysing Program Revision Number. Byte 36 shall be equal to or greater than 1. The character strings following byte 36 are required. If a particular character string is empty, a single NULL is required to be present. 37 to *** Character String: Analysing Program Revision Number. The string shall be NULL terminated. *** to *** Character string: Serial number of the Acquisition Device. The character string shall be NULL terminated. *** to *** Character string: Acquisition device system software identifier. The character string shall be NULL terminated.	Bit	Contents			Reset (0)	Set (1)	0 to 2	Reserved	Reserved (Shall be set to 0)	3	No analysis	Can analyse ECG	4	No printing	Can print ECG reports	5	No interpretation	Can interpret ECG	6	No storage	Can store ECG records	7(MSB)	No acquisition	Can acquire ECG data	Value	Meaning	0	Unspecified	1	50 Hz	2	60 Hz
Bit	Contents																																	
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Value	Meaning																																	
0	Unspecified																																	
1	50 Hz																																	
2	60 Hz																																	

Tag	Length	Value (Parameter data)				
		*** to *** Character string: Acquisition device SCP-ECG implementation software identifier (maximum 24 characters plus NULL terminator). The character string shall be NULL terminated. *** to *** Character string: Manufacturer of the Acquisition Device. Contains the Manufacturer's registered trade name. The character string shall be NULL terminated. NOTE 5 If all five character strings are empty, then the content of byte 36 is 1 and the length of tag 14 is (36+5) = 41.				
15	length	Machine ID Analysing Device (Binary bytes and Text characters) This field uniquely identifies the device that analysed the ECG (if other than the acquiring device). The format of this field is identical to that utilized by tag 14 above.				
16	length	Acquiring Institution Description (Text characters) This field provides a text description of the Institution where the ECG was acquired.				
17	length	Analysing Institution Description (Text characters) This field provides a text description of the Institution where the ECG was analysed.				
18	length	Acquiring Department Description (Text characters) This field provides a text description of the Department where the ECG was acquired.				
19	length	Analysing Department Description (Text characters) This field provides a text description of the Department where the ECG was analysed.				
20	length	Referring Physician (Text characters) This field provides a text description of the referring physician.				
21	length	Latest Confirming Physician (Text characters) This field provides a text description of the latest confirming physician.				
22	length	Technician Description (Text characters) This field provides a text description of the technician that has recorded the ECG.				
23	length	Room Description (Text characters) This field provides a text description of the room where the ECG was recorded.				
24	1	Stat Code (Binary) <table><thead><tr><th>Byte</th><th>Contents</th></tr></thead><tbody><tr><td>1</td><td>Binary: Level of emergency of the recording.</td></tr></tbody></table> Value 0 refers to “routine” and higher values to increasing levels of emergency as defined by the user. For this code, values in the range of 1 to 10 are recommended.	Byte	Contents	1	Binary: Level of emergency of the recording.
Byte	Contents					
1	Binary: Level of emergency of the recording.					
25	4	Date of Acquisition (Binary) [MDC_DIM_DATE] This field has the following format: <table><thead><tr><th>Byte</th><th>Contents</th></tr></thead></table>	Byte	Contents		
Byte	Contents					

Tag	Length	Value (Parameter data)								
		1 to 2 Binary: Year (full integer notation, as in 2018) [MDC_DIM_YR] 3 Binary: Month (range 01 to 12; 01 = January) [MDC_DIM_MON] 4 Binary: Day (range 01 to 31) [MDC_DIM_DAY]								
26	3	Time of Acquisition (Binary) [MDC_DIM_TOD] This field has the following format: <table><tr><th>Byte</th><th>Contents</th></tr><tr><td>1</td><td>Binary: Hours (range 0 to 23) [MDC_DIM_HR]</td></tr><tr><td>2</td><td>Binary: Minutes (range 0 to 59) [MDC_DIM_MIN]</td></tr><tr><td>3</td><td>Binary: Seconds (range 0 to 59) [MDC_DIM_SEC]</td></tr></table> This field shall store the time of acquisition of the first sample of the short-term ECG rhythm signals stored in Section 6 (if any) and shall be expressed as local time in the Time Zone of acquisition (see tag 34). Systems and devices shall store 60 and 61 leap seconds as 59.	Byte	Contents	1	Binary: Hours (range 0 to 23) [MDC_DIM_HR]	2	Binary: Minutes (range 0 to 59) [MDC_DIM_MIN]	3	Binary: Seconds (range 0 to 59) [MDC_DIM_SEC]
Byte	Contents									
1	Binary: Hours (range 0 to 23) [MDC_DIM_HR]									
2	Binary: Minutes (range 0 to 59) [MDC_DIM_MIN]									
3	Binary: Seconds (range 0 to 59) [MDC_DIM_SEC]									
27	2	Baseline Filter (Binary) [MDC_ECG_CTL_VBL_ATTR_FILTER_HIGH_PASS] This field contains the “cut-off” frequency (–3 dB) of the analogue or digital high-pass baseline filter used for processing the stored ECG signals, in units of (1/100) Hertz. Systems recording and storing DC-coupled signals without any high-pass filtering shall set the data content of tag 27 to “0”.								
28	2	Low-pass Filter (Binary) [MDC_ECG_CTL_VBL_ATTR_FILTER_CUTOFF_FREQ] This field contains the “cut-off” frequency (–3 dB) of the analogue or digital low-pass filter used for processing the stored ECG signals, in units of Hertz. Systems storing the raw ECG signals without any further processing shall store the cut-off frequency of the anti-aliasing filter.								
29	1	Filter Bit Map (FBM) (Binary) This field indicates if other filters, which were not defined within tag 27 and 28, have been used for processing the stored ECG signals. The definition of the different bits of the FBM bit map are detailed in Annex A, Table A.6. If FBM = 0, no additional filtering than those implicitly defined by tags 27 and 28 was used. If FBM = 255, then the FBM filter setting was not specified.								
30	length	Free Text Field (Text characters) This field permits free text comments to be carried along with the ECG.								
31	length	ECG Sequence Number (Text characters) This field may be used to store the internal ECG record ID from the acquiring device. It would thus allow to retrieve, if needed, the original ECG from the acquiring device. It may also be used to identify to which ECG record an ECG sequence belongs to, in case the signals corresponding to different time windows from a long duration ECG record have been stored as separate SCP-ECG records that include in Section 6 the signals of these								

Tag	Length	Value (Parameter data)																																														
		specific ECG sequences/extracts from the whole ECG record.																																														
32	length	Medical History Codes (Binary) This field contains a description of the patient's clinical problems and diagnoses. There is no limit on the number of diagnoses. This tagged field may have several instances (see 5.4.3.3). In every instance, Byte 1 is used to designate the Medical History Code Table which is applied in this instance. If the content of Byte 1 is equal to zero (0), then the SCP-ECG codes defined hereafter apply. If the Byte 1 content is not equal to zero, then another Medical History Code Table and another coding system shall be used. However, as in the present version of SCP-ECG, no other such table has been referenced yet, the content of bytes 2 and above would be undefined. In case byte 1 is equal to zero (0), then each diagnosis shall be represented by one byte, starting with byte 2. The following set of codes apply: <table><tr><th><u>Value</u></th><th><u>Contents</u></th></tr><tr><td>0</td><td>Diagnoses or clinical problems not specified</td></tr><tr><td>1</td><td>Apparently healthy</td></tr><tr><td>10</td><td>Acute myocardial infarction</td></tr><tr><td>11</td><td>Myocardial infarction</td></tr><tr><td>12</td><td>Previous myocardial infarction</td></tr><tr><td>13</td><td>Heart Failure</td></tr><tr><td>15</td><td>Ischaemic heart disease</td></tr><tr><td>16</td><td>Arterial Stenosis</td></tr><tr><td>18</td><td>Peripheral vascular disease</td></tr><tr><td>20</td><td>Cyanotic congenital heart disease</td></tr><tr><td>21</td><td>Acyanotic congenital heart disease</td></tr><tr><td>22</td><td>Valvular heart disease</td></tr><tr><td>23</td><td>Ventricular Hypertrophy</td></tr><tr><td>25</td><td>Hypertension</td></tr><tr><td>27</td><td>Cerebrovascular accident</td></tr><tr><td>30</td><td>Cardiomyopathy</td></tr><tr><td>31</td><td>Arrhythmogenic cardiomyopathy</td></tr><tr><td>32</td><td>Congenital heart disease</td></tr><tr><td>35</td><td>Pericarditis</td></tr><tr><td>36</td><td>Myocarditis</td></tr><tr><td>40</td><td>Post-operative cardiac surgery</td></tr><tr><td>42</td><td>Implanted cardiac pacemaker</td></tr></table>	<u>Value</u>	<u>Contents</u>	0	Diagnoses or clinical problems not specified	1	Apparently healthy	10	Acute myocardial infarction	11	Myocardial infarction	12	Previous myocardial infarction	13	Heart Failure	15	Ischaemic heart disease	16	Arterial Stenosis	18	Peripheral vascular disease	20	Cyanotic congenital heart disease	21	Acyanotic congenital heart disease	22	Valvular heart disease	23	Ventricular Hypertrophy	25	Hypertension	27	Cerebrovascular accident	30	Cardiomyopathy	31	Arrhythmogenic cardiomyopathy	32	Congenital heart disease	35	Pericarditis	36	Myocarditis	40	Post-operative cardiac surgery	42	Implanted cardiac pacemaker
<u>Value</u>	<u>Contents</u>																																															
0	Diagnoses or clinical problems not specified																																															
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16	Arterial Stenosis																																															
18	Peripheral vascular disease																																															
20	Cyanotic congenital heart disease																																															
21	Acyanotic congenital heart disease																																															
22	Valvular heart disease																																															
23	Ventricular Hypertrophy																																															
25	Hypertension																																															
27	Cerebrovascular accident																																															
30	Cardiomyopathy																																															
31	Arrhythmogenic cardiomyopathy																																															
32	Congenital heart disease																																															
35	Pericarditis																																															
36	Myocarditis																																															
40	Post-operative cardiac surgery																																															
42	Implanted cardiac pacemaker																																															

Tag	Length	Value (Parameter data)
		43 Implanted cardioverter defibrillator (ICD) 44 Implanted cardiac resynchronization therapy (CRT) device 45 Pulmonary embolism 50 Respiratory disease 55 Endocrine disease 60 Neurological disease 65 Alimentary disease 70 Renal disease 80 Pre-operative general surgery 81 Post-operative general surgery 90 General medical 100 Other 128 to 255 Manufacturer specific NOTE 6 The missing numbers in the series from 1 to 100 have been reserved for future extension of some categories. NOTE 7 There are two different ways to encode multiple diagnosis statements. For example, two different statements can be encoded as one tagged field containing the codes of the two diagnoses (the length of the field will equal (1+2) = 3 bytes). Another option is to represent these two diagnoses as two tagged fields, each containing only one diagnosis code (the length of each field will equal (1+1) = 2 bytes). Starting with version V3.0, it is strongly recommended to use this second option, i.e. only one diagnosis code per tagged field, to facilitate interoperability with the Electronic Health Record and other diagnosis encoding standards.
33	2	Electrode Configuration Code (Binary) This field is used to further specify the placement and system of electrodes that has been used to record standard or variants of the standard 12-lead ECG and/or of 3-lead or XYZ leads (byte 2). Byte Contents 1 Binary: Code representing the definitions for system of electrode placements for 12-lead ECG (standard, Mason-Likar, Omnitrode, etc.), 3-lead ECG (NEHB, CC5-CM5-M, CM5-CC5-CH5), 15-lead ECG and standard 12-lead ECG with extra leads to the right and/or left sides. Value Electrode placement system 0 Unspecified 12-lead System. [MDC_ECG_LDSYS_12L_UNSPECIFIED] Devices that record a 12-lead ECG but do not record the electrode placement information or devices that record XYZ leads without recording 12-lead ECGs and use this tag to specify the XYZ electrode placements in byte 2, should use this value. 1 Standard 12-lead positions: RA, RL, LA, and LL are placed at limb extremities. V1 to V6 at standard positions on the chest. All electrodes are placed individually. [MDC_ECG_LDSYS_12LD_STD]

Tag	Length	Value (Parameter data)
		2 RA, RL, LA, and LL are placed on the torso (Mason-Likar positions). V1 to V6 are placed at standard positions on the chest. All electrodes are placed individually. [MDC_ECG_LDSYS_12LD_MASON_LIKAR] 3 RA, RL, LA, and LL are placed on the torso (Mason-Likar positions). These limb electrodes are individually placed. V1 to V6 are placed on the chest as part of a single electrode pad (V1 to V6 are NOT placed individually). [MDC_ECG_LDSYS_12LD_VPAD] 4 RA, RL, LA, LL, and V1 to V6 (all electrodes) are placed on the chest in a single electrode pad (such as Omnitrode). (None of the electrodes are placed individually). [MDC_ECG_LDSYS_12LD_PAD] 5 12-lead ECG is derived from Frank XYZ leads. [MDC_ECG_LDSYS_12LD_FROM_FRANK] 6 12-lead ECG is derived from non-standard leads. [MDC_ECG_LDSYS_12LD_NON_STANDARD] 7 12-lead ECG is derived from Frank (X, Y, Z) leads by Dower transformation. [MDC_ECG_LDSYS_12LD_FROM_DOWER] 8 12-lead ECG is derived from EASI leads (ES, AS, AI) by Dower/EASI transformation. [MDC_ECG_LDSYS_12LD_FROM_EASI] 9 12-lead ECG is derived from Limb Leads (I, II) and one or more V leads. [MDC_ECG_LDSYS_12LD_FROM_LIMB] 10 Standard 12-lead ECG is recorded with the precordial electrodes shifted one intercostal space higher. The limb electrodes remain on their position. I, II, ... aVF, V1', V2', ... V6'. [MDC_ECG_LDSYS_12LD_RAISED_INTERCOSTAL] 11 Standard 12-leads for bicycle exercise testing in Europe (Germany, Finland, etc.) where bicycle tests in upright position are performed. The limb leads are often positioned not on the chest (Mason-Likar) but on the back (shoulder and on the hips) of the patient. Doing this has a practical reason because the patient bows his back during bicycling and the limb lead electrodes applied on the chest would be disturbed. [MDC_ECG_LDSYS_12LD_BICYCLE] 12 Bipolar 3-lead ECG according to NEHB lead system (see Annex BB and CC of IEC 60601-2-25:2011 [4]). [MDC_ECG_LDSYS_3LD_NEHB] 13 Bipolar 3-lead ECG. First electrode at mid-sternum at the second intercostal space and second electrode in the fifth intercostal space in the anterior axillary line (V5R/C5R). [MDC_ECG_LDSYS_3LD_CC5_CM5_ML] 14 Bipolar 3-lead ECG. First electrode at mid-sternum at the second intercostal space; second electrode in the fifth intercostal space in the anterior axillary line (V5R/C5R) and third electrode on either side of neck above shoulders. [MDC_ECG_LDSYS_3LD_CM5_CC5_CH5] 15 Standard 12-lead ECG and XYZ. [MDC_ECG_LDSYS_12LD_STD_AND_XYZ]

Tag	Length	Value (Parameter data)
		16 Standard 12-lead ECG and NEHB. [MDC_ECG_LDSYS_12LD_STD_AND_NEHB] 17 Standard 12-lead ECG and CC5-CM5-ML. [MDC_ECG_LDSYS_12LD_STD_AND_CC5_CM5_ML] 18 Standard 12-lead ECG and CM5-CC5-CH5. [MDC_ECG_LDSYS_12LD_STD_AND_CM5_CC5_CH5] 19 Standard 12-lead ECG with extra leads to the right and/or left sides, specified by their lead labels. [MDC_ECG_LDSYS_12LD_STD_EXTD] 20 Standard 12-lead ECG extended to the right by V5R, V4R, V3R (see Annex CC of IEC 60601-2-25:2011 [4]). [MDC_ECG_LDSYS_12LD_STD_EXTD_RIGHT] 21 Standard 12-lead ECG extended to the left by V7, V8, V9 (see Annex CC of IEC 60601-2-25:2011[4]). [MDC_ECG_LDSYS_12LD_STD_EXTD_LEFT] 22 to 255 Undefined now. Reserved for later use. <u>Byte</u> <u>Contents</u> 2 Binary: Code representing the definitions for systems of electrode placements used for the XYZ leads stored in this SCP-ECG record, if any, such as Frank, Cube, McFee-Parungao, Bipolar, etc. (see chapter 1 of Vectorcardiography by Alberto Benchimol (Williams and Wilkins, Baltimore, 1973) for location of electrodes on the torso and weighting resistors). <u>Value</u> <u>Electrode placement system</u> 0 Unspecified XYZ lead system. [MDC_ECG_LDSYS_XYZ_UNSPECIFIED] Devices that record X, Y and Z leads but do not record the XYZ electrode configuration information or devices that do not record XYZ leads and use tag 33 to specify the 12-lead ECG electrode configuration in byte 1, should use this value. 1 Frank lead system (Frank, 1956; 13:737). [MDC_ECG_LDSYS_XYZ_FRANK] 2 McFee-Parungao lead system (see Benchimol, Vectorcardiography, Williams and Wilkins, Baltimore, 1973, Figure 1.6 on page 6). [MDC_ECG_LDSYS_XYZ_MCFEE_PARUNAGO] 3 Cube lead system (Grishman et al., Amer Heart J 1951; 41:483). [MDC_ECG_LDSYS_XYZ_CUBE] 4 Bipolar uncorrected XYZ lead system. [MDC_ECG_LDSYS_XYZ_BIPOLAR] 5 Pseudo-orthogonal XYZ lead system (as used in Holter recording). [MDC_ECG_LDSYS_XYZ_PSEUDO_ORTH] 6 XYZ leads derived from standard 12-lead ECG. [MDC_ECG_LDSYS_XYZ_FROM_12LD] 7 to 255 Undefined now. Reserved for later use.

Tag	Length	Value (Parameter data)																														
34	length	Date Time Zone (Binary bytes and Text characters) The contents of this tag identify the global time zone in which the ECG data were acquired, thus allowing the local date/time value(s) specified by tags 25 and 26 and/or in Sections 12 and 13 to be converted to any Time Zone (e.g. UTC). The following parameter bytes of this tag provide three ways to indicate Time Zone. It is however strongly recommended to preferably use the first way to specify the Time Zone and to always document the UTC offset in minutes (bytes 1 to 2), whatever the other ways of specifying the Time Zone have been used or not. <table><tr><th>Byte</th><th>Name</th><th>Type</th><th>Notes</th></tr><tr><td>1 to 2</td><td>UTC Offset</td><td>signed binary</td><td>Time Zone specified as an offset from UTC in minutes. Semantically equivalent to MDC_ATTR_TIME_ZONE</td></tr><tr><td>3 to 4</td><td>Index</td><td>unsigned binary</td><td>Time Zone specified by a manufacturer-defined mapping (until a consensus mapping is defined using values 1 to 1 000) using this value as a lookup-table index.</td></tr><tr><td></td><td></td><td></td><td><table><tr><th>Value</th><th>Meaning</th></tr><tr><td>0</td><td>Index not used</td></tr><tr><td>1 to 1 000</td><td>Reserved for future use</td></tr><tr><td>1 001 to 32 766</td><td>Manufacturer-specific</td></tr><tr><td>32 767</td><td>Reserved</td></tr></table></td></tr><tr><td>5 to ***</td><td>Description Text String</td><td></td><td>Time Zone specified by a null-terminated string.</td></tr></table> Allowable values for UTC Offset are −780 through 780 (i.e. ± 13 h) and hexadecimal 0x7FFF. 0x7FFF either indicates that the Time Zone of the acquiring device is unknown, or that the field UTC Offset is unused and one needs to check the values of the Index and Description fields. If the Offset field contains an allowed value other than 0x7FFF, the Index and Description fields are considered redundant and may be ignored. The Index value specifies Time Zone only if the UTC Offset value is 0x7FFF. An Index value of zero either indicates that the field is not used or not initialized or that the Time Zone of the acquiring device is unknown. Use of bytes 3 to 4 as presently defined is manufacturer specific. The Description field specifies Time Zone only if the UTC Offset value is 0x7FFF. This string should be in the format of the TZ environment variable as standardized by Posix (Unix). Reference: 'C/C++' language subroutine name tzset(), environment variable “TZ”, and associated data structures. The Description field must be 1 byte at a minimum (i.e. the null terminator). NOTE 8 If the Time Zone of the acquiring device is not defined or unknown, Tag 34 can be omitted from the data record. Similarly, an instance of Tag 34 containing values for the UTC Offset = 0x7FFF, Index = 0, and Description = null terminator means that the Time Zone is not defined or unknown.	Byte	Name	Type	Notes	1 to 2	UTC Offset	signed binary	Time Zone specified as an offset from UTC in minutes. Semantically equivalent to MDC_ATTR_TIME_ZONE	3 to 4	Index	unsigned binary	Time Zone specified by a manufacturer-defined mapping (until a consensus mapping is defined using values 1 to 1 000) using this value as a lookup-table index.				<table><tr><th>Value</th><th>Meaning</th></tr><tr><td>0</td><td>Index not used</td></tr><tr><td>1 to 1 000</td><td>Reserved for future use</td></tr><tr><td>1 001 to 32 766</td><td>Manufacturer-specific</td></tr><tr><td>32 767</td><td>Reserved</td></tr></table>	Value	Meaning	0	Index not used	1 to 1 000	Reserved for future use	1 001 to 32 766	Manufacturer-specific	32 767	Reserved	5 to ***	Description Text String		Time Zone specified by a null-terminated string.
Byte	Name	Type	Notes																													
1 to 2	UTC Offset	signed binary	Time Zone specified as an offset from UTC in minutes. Semantically equivalent to MDC_ATTR_TIME_ZONE																													
3 to 4	Index	unsigned binary	Time Zone specified by a manufacturer-defined mapping (until a consensus mapping is defined using values 1 to 1 000) using this value as a lookup-table index.																													
			<table><tr><th>Value</th><th>Meaning</th></tr><tr><td>0</td><td>Index not used</td></tr><tr><td>1 to 1 000</td><td>Reserved for future use</td></tr><tr><td>1 001 to 32 766</td><td>Manufacturer-specific</td></tr><tr><td>32 767</td><td>Reserved</td></tr></table>	Value	Meaning	0	Index not used	1 to 1 000	Reserved for future use	1 001 to 32 766	Manufacturer-specific	32 767	Reserved																			
Value	Meaning																															
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1 001 to 32 766	Manufacturer-specific																															
32 767	Reserved																															
5 to ***	Description Text String		Time Zone specified by a null-terminated string.																													

Tag	Length	Value (Parameter data)														
35	length	Free Text Medical History (Text characters) This field permits free text for entering the medical history.														
36	length	Implanted cardiac device description (Binary byte and Text string) This field is used to identify the functionalities of the implanted cardiac device (pacemaker, ICD, pacing ICD, CRT). <table><tr><td><u>Byte</u></td><td><u>Contents</u></td></tr><tr><td>1</td><td>Binary: Implanted cardiac device (CIED) code table indicator.</td></tr></table> <table><tr><td><u>Value</u></td><td><u>Code table</u></td></tr><tr><td>0</td><td>None (text string in bytes 2 to *** is free text)</td></tr><tr><td>1</td><td>NBG/NBD code</td></tr><tr><td>2 to 9</td><td>Reserved for future use</td></tr><tr><td>10 to 255</td><td>Other (manufacturer specific)</td></tr></table> 2 to *** Null terminated text string. Byte 1 defines the code table that shall be used to specify the functionalities of the patient's CIED. If byte 1 is set to 0, then no coded form is used and text string in bytes 2 to *** shall be free text. If byte 1 is set to 1, then the text string in bytes 2 to *** shall contain either the 5-letter NBG code [29] for a pacemaker or the 4-letter NBD code [28] for an ICD. The meaning of these coding letters are summarized in Annex A, Table A.4, for the NBG code and in Annex A, Table A.5, for the NBD code. Complex pacing ICDs may be identified by their NBD code followed by the NBG code describing the corresponding pacing section, as for example "VVE-DDDRV".	<u>Byte</u>	<u>Contents</u>	1	Binary: Implanted cardiac device (CIED) code table indicator.	<u>Value</u>	<u>Code table</u>	0	None (text string in bytes 2 to *** is free text)	1	NBG/NBD code	2 to 9	Reserved for future use	10 to 255	Other (manufacturer specific)
<u>Byte</u>	<u>Contents</u>															
1	Binary: Implanted cardiac device (CIED) code table indicator.															
<u>Value</u>	<u>Code table</u>															
0	None (text string in bytes 2 to *** is free text)															
1	NBG/NBD code															
2 to 9	Reserved for future use															
10 to 255	Other (manufacturer specific)															
37	length	ATC Drug code (Text string) The tag is used to store the patient's drugs according to the WHO Anatomical Therapeutic Chemical Classification System (ATC). This tagged field may have several instances (see 5.4.3.3), one per drug administered to the patient, if any. However, to facilitate parsing, only one null terminated ATC code is permitted per instance. NOTE 9 In the ATC classification system, each drug is identified by a unique, 7 ASCII character long, textual string. Drugs are divided into different groups according to the organ or system on which they act and their therapeutic, pharmacological and chemical properties. They are classified at five different levels, each identified by a capital letter and/or a two-digit decimal code. See http://www.whocc.no/ [43]. NOTE 10 There is no limit on the number of instances of tag 37 and thus on the number of drugs which can be coded. NOTE 11 Using the ATC coding system does not exclude using the SCP-ECG drug coding system (see above Tag 10), i.e. a same patient's drug can be documented in the SCP-ECG record using two different drug code tags, Tag 10 and Tag 37.														

Tag	Length	Value (Parameter data)
38 - 199	(none)	Reserved for future use
200 - 254	length	Manufacturer specific
255	0	None (demographic section terminator)

5.5 Huffman tables – Section 2

5.5.1 If present, the section shall start with a “Section ID Header” as defined in 5.2.7.

5.5.2 Starting with SCP-ECG V3.0, only lossless data compression for encoding the signals stored in section 5 “Encoded type 0 Reference Beat data” and in section 6 “Short-term ECG Rhythm data” is allowed. Thus, the only supported data compression method, if any, is data redundancy reduction based on signal differentiation and variable length Huffman encoding, presented hereafter and in Annex D.4.7.5.

5.5.3 This section of the ECG record contains the definition of the other than the default SCP-ECG Huffman Code Tables that were used to encode the ECG. The provision of a number of tables permits optimum encoding of the data (e.g. the type 0 reference beat and the short-term ECG rhythm data will probably use different tables). It shall be assumed that the encoded data within each entity shall be encoded using table # 1 (i.e. the first table defined within this Section 2). Escape codes should be provided within each table to enable a change to another table (see 5.5.6).

5.5.4 Data part content and format

The following basic values are used:

- i) The Sample Time Interval (STI), as defined in the sections containing the coded data (i.e. Section 5 “Encoded type 0 Reference Beat data” and Section 6 “Short-term ECG Rhythm data”).
- ii) The Amplitude Value Multiplier (AVM), i.e. the amplitude quantum represented by one least significant bit (LSB) as defined in the sections containing the coded data (i.e. Section 5 “Encoded type 0 Reference Beat data” and Section 6 “Short-term ECG Rhythm data”).

The structure of the data part of this Section is then as follows:

Byte	Contents
1 to 2	Number NHT of Huffman Tables defined (if 19 999 then the default table, defined in D.4.7.6, is used and no Huffman table is stored).
3 to 4	Number of code structures in table # 1.
5 to ***	The structures defining each code in table # 1. Each structure has the following layout: 1 byte - Number of bits in prefix 1 byte - Number of bits in entire code 1 byte - Table mode switch

Byte	Contents												
	<table> <tr> <th><u>Value</u></th><th><u>Content</u></th></tr> <tr> <td>0</td><td>Switch to another Huffman Table</td></tr> <tr> <td>1</td><td>Huffman coding if # of bits in prefix = # of bits in entire code</td></tr> <tr> <td>1</td><td>Original data if # of bits in prefix < # of bits in entire code</td></tr> <tr> <td>2 bytes</td><td>- Base value represented by base code (in AVM units).</td></tr> <tr> <td>4 bytes</td><td>- Base code - 1st bit in code represented by least significant bit of the 4 byte area</td></tr> </table>	<u>Value</u>	<u>Content</u>	0	Switch to another Huffman Table	1	Huffman coding if # of bits in prefix = # of bits in entire code	1	Original data if # of bits in prefix < # of bits in entire code	2 bytes	- Base value represented by base code (in AVM units).	4 bytes	- Base code - 1st bit in code represented by least significant bit of the 4 byte area
<u>Value</u>	<u>Content</u>												
0	Switch to another Huffman Table												
1	Huffman coding if # of bits in prefix = # of bits in entire code												
1	Original data if # of bits in prefix < # of bits in entire code												
2 bytes	- Base value represented by base code (in AVM units).												
4 bytes	- Base code - 1st bit in code represented by least significant bit of the 4 byte area												
***+1 to ***+2	Number of code structures in table # 2.												
+3 to *	The structures defining each code in table # 2, etc., up to Huffman table # NHT.												

5.5.5 The Huffman codes have been defined to permit a single structure described above to specify a series of consecutive amplitude values. The “prefix” mentioned above is common to all of the codes describing the consecutive values - the remaining bit field changes by 1 LSB in incrementing through the indicated range.

Structures that define the Huffman code for just one value shall have no remainder and hence the prefix length shall equal the total code length.

An example of a typical Huffman code byte structure is displayed in Table 3.

It shall be seen that the “picking” of bits in a given byte shall proceed from the most significant bit to the least significant bit and that the bytes shall be processed in the order received.

Table 3 — Example byte structure (Huffman code)

	MSB							LSB
Received Byte 1	P1	P2	P3	P4	C1	C2	C3	C4
Received Byte 2	C5	C6	P5	P6	P7	C7	C8	C9
Received Byte 3	C10	C11	P8	P9	P10	C12	C13	C14
etc.	...	...	...	...	...	...	...	...

NOTE 1 The content of Table 3 represents the following coded values:

P1 P2 P3 P4 C1 C2 C3 C4 C5 C6

— 4 bit prefix with total code length of 10.

P5 P6 P7 C7 C8 C9 C10 C11

— 3 bit prefix with total code length of 8.

P8 P9 P10 C12 C13 C14

— 3 bit prefix with total code length of 6.

NOTE 2 Additional examples of Huffman encoding are presented in Annexes D.4.7 and D.5

5.5.6 Escape codes - i.e. “base codes” that shall dictate a change of Huffman table - shall include a zero (0) value for the “Table mode switch”. The “Base Value” shall then contain the number of the table to which a switch is desired (see examples in Annex D.4.7).

5.5.7 An overview of the data part of this section is presented in Figure 5

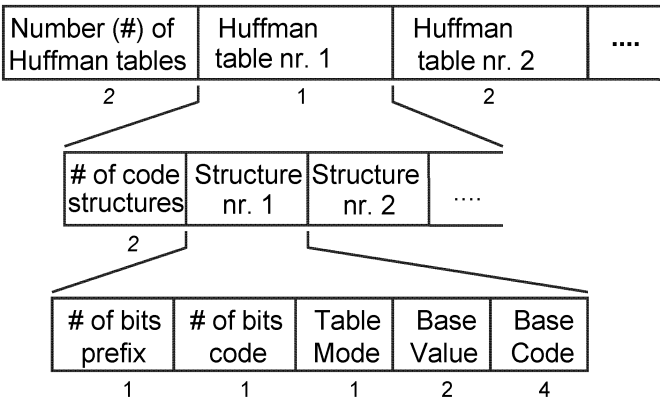


Figure 5 — Overview of the data part of the Huffman tables section

5.6 ECG leads definition – Section 3

5.6.1 This section defines the leads that are recorded in sections 5 and/or 6, together with some metadata about the recorded leads.

5.6.2 If present, the section shall start with a “Section ID Header” as defined in 5.2.7.

5.6.3 The section data part is defined below

Byte	Contents
1	Number of leads enclosed in sections 5 and/or 6 (if present)
2	Flag byte
	Bit 0 (LSB) Shall always be reset (bit 0 = 0)
	Bit 1 Reserved. Shall be set to 0
	Bit 2 Set = Leads all simultaneously recorded
	Reset = Leads not all simultaneously recorded
	Bits 3 to 7 The number of simultaneously recorded leads
3 to 11	Details for first lead (see 5.6.4)
12 to 20	Details for second lead (see 5.6.4)
etc.	

NOTE SCP-ECG versions V1.x and V2.x used Flag byte bit 0 to specify if reference beat subtraction was used for signal compression (bit 0 = 1: Reference beat subtraction used for compression; bit 0 = 0: Reference beat subtraction not used for compression). Starting with SCP-ECG V3.0, reference beat subtraction is no longer supported and bit 0 is thus set to zero.

In case not all leads are recorded simultaneously, the lead details shall be organized so that simultaneously acquired lead details are grouped in adjacent bytes.

EXAMPLE Three leads are recorded simultaneously: e.g. first leads I, aVF, V2 are simultaneously recorded; then leads X, Y, Z are simultaneously recorded, etc. Lead details should thus be stored in the above listed order: Lead I in the first segment (bytes 3 to 11), Lead aVF in the second segment (bytes 12 to 20), Lead V2 in the third segment (bytes 21 to 29), Lead X in the fourth segment (bytes 30 to 38), etc.

5.6.4 The detailed information for each lead is as follows:

Byte Contents

- 1 to 4 (Unsigned) Starting sample number of lead “L” in the short-term ECG rhythm record
- 5 to 8 (Unsigned) Ending sample number of lead “L” in the short-term ECG rhythm record
- 9 Lead “L” identification. The numbering scheme shown in Table 4 shall be used.

NOTE The SCP-ECG code stored in byte 9 is identical to the CODE10 value corresponding to MDC_ECG_LEAD_xxx, where xxx stands for the Lead discriminator.

Table 4 — Lead Identification Codes

SCP-ECG Name	SCP-ECG code	Description	aECG [9] Ref ID MDC_ECG_LEAD_xxx
NOS	0	Unspecified lead (see Note 1)	MDC_ECG_LEAD
I	1	Lead I (see Note 2)	MDC_ECG_LEAD_I
II	2	Lead II	MDC_ECG_LEAD_II
V1	3	V1	MDC_ECG_LEAD_V1
V2	4	V2	MDC_ECG_LEAD_V2
V3	5	V3	MDC_ECG_LEAD_V3
V4	6	V4	MDC_ECG_LEAD_V4
V5	7	V5	MDC_ECG_LEAD_V5
V6	8	V6	MDC_ECG_LEAD_V6
V7	9	V7	MDC_ECG_LEAD_V7
V2R	10	V2R (see Note 3)	MDC_ECG_LEAD_V2R
V3R	11	V3R	MDC_ECG_LEAD_V3R
V4R	12	V4R	MDC_ECG_LEAD_V4R
V5R	13	V5R	MDC_ECG_LEAD_V5R
V6R	14	V6R	MDC_ECG_LEAD_V6R
V7R	15	V7R	MDC_ECG_LEAD_V7R
X	16	X (see Note 4)	MDC_ECG_LEAD_X
Y	17	Y (see Note 4)	MDC_ECG_LEAD_Y
Z	18	Z (see Note 4)	MDC_ECG_LEAD_Z

SCP-ECG Name	SCP-ECG code	Description	aECG [9] Ref ID MDC_ECG_LEAD_XXX
CC5	19	CC5, per V5 and V5R placement (see Note 5)	MDC_ECG_LEAD_CC5
CM5	20	CM5, per V5 placement (see Note 5)	MDC_ECG_LEAD_CM5
LA	21	Left Arm	MDC_ECG_LEAD_LA
RA	22	Right Arm	MDC_ECG_LEAD_RA
LL	23	Left Leg	MDC_ECG_LEAD_LL
fI	24	fI (see Note 6)	MDC_ECG_LEAD_fI
fE	25	fE (see Note 6)	MDC_ECG_LEAD_fE
fC	26	fC (see Note 6)	MDC_ECG_LEAD_fC
fA	27	fA (see Note 6)	MDC_ECG_LEAD_fA
fM	28	fM (see Note 6)	MDC_ECG_LEAD_fM
fF	29	fF (see Note 6)	MDC_ECG_LEAD_fF
fH	30	fH (see Note 6)	MDC_ECG_LEAD_fH
dI	31	Derived lead I	MDC_ECG_LEAD_dI
dII	32	Derived lead II	MDC_ECG_LEAD_dII
dV1	33	Derived lead V1	MDC_ECG_LEAD_dV1
dV2	34	Derived lead V2	MDC_ECG_LEAD_dV2
dV3	35	Derived lead V3	MDC_ECG_LEAD_dV3
dV4	36	Derived lead V4	MDC_ECG_LEAD_dV4
dV5	37	Derived lead V5	MDC_ECG_LEAD_dV5
dV6	38	Derived lead V6	MDC_ECG_LEAD_dV6
dV7	39	Derived lead V7	MDC_ECG_LEAD_dV7
dV2R	40	Derived lead V2R	MDC_ECG_LEAD_dV2R
dV3R	41	Derived lead V3R	MDC_ECG_LEAD_dV3R
dV4R	42	Derived lead V4R	MDC_ECG_LEAD_dV4R
dV5R	43	Derived lead V5R	MDC_ECG_LEAD_dV5R
dV6R	44	Derived lead V6R	MDC_ECG_LEAD_dV6R
dV7R	45	Derived lead V7R	MDC_ECG_LEAD_dV7R
dX	46	Derived lead X	MDC_ECG_LEAD_dX
dY	47	Derived lead Y	MDC_ECG_LEAD_dY
dZ	48	Derived lead Z	MDC_ECG_LEAD_dZ
dCC5	49	Derived lead CC5	MDC_ECG_LEAD_dCC5
dCM5	50	Derived lead CM5	MDC_ECG_LEAD_dCM5

SCP-ECG Name	SCP-ECG code	Description	aECG [9] Ref ID MDC_ECG_LEAD_xxx
dLA	51	Derived lead LA	MDC_ECG_LEAD_dLA
dRA	52	Derived lead RA	MDC_ECG_LEAD_dRA
dLL	53	Derived lead LL	MDC_ECG_LEAD_dLL
dfl	54	Derived lead fl	MDC_ECG_LEAD_dfi
dfE	55	Derived lead fE	MDC_ECG_LEAD_dfe
dfC	56	Derived lead fC	MDC_ECG_LEAD_dfc
dfA	57	Derived lead fA	MDC_ECG_LEAD_dfa
dfM	58	Derived lead fM	MDC_ECG_LEAD_dfm
dfF	59	Derived lead fF	MDC_ECG_LEAD_dff
dfH	60	Derived lead fH	MDC_ECG_LEAD_dfh
III	61	Lead III	MDC_ECG_LEAD_III
aVR	62	aVR, augmented voltage, right	MDC_ECG_LEAD_AVR
aVL	63	aVL, augmented voltage, left	MDC_ECG_LEAD_AVL
aVF	64	aVF, augmented voltage, foot	MDC_ECG_LEAD_AVF
aVRneg	65	aVRneg (see Note 7)	MDC_ECG_LEAD_AVRneg
V8	66	V8	MDC_ECG_LEAD_V8
V9	67	V9	MDC_ECG_LEAD_V9
V8R	68	V8R	MDC_ECG_LEAD_V8R
V9R	69	V9R	MDC_ECG_LEAD_V9R
D	70	D (Nehb – Dorsal)	MDC_ECG_LEAD_D
A	71	A (Nehb – Anterior)	MDC_ECG_LEAD_A
J	72	J (Nehb – Inferior)	MDC_ECG_LEAD_J
Defib	73	Defibrillator lead: anterior-lateral	MDC_ECG_LEAD_DEFIB
Extern	74	External pacing lead: anterior-posterior	MDC_ECG_LEAD_EXTERN
A1	75	A1 (Auxiliary unipolar lead #1)	MDC_ECG_LEAD_A1
A2	76	A2 (Auxiliary unipolar lead #2)	MDC_ECG_LEAD_A2
A3	77	A3 (Auxiliary unipolar lead #3)	MDC_ECG_LEAD_A3
A4	78	A4 (Auxiliary unipolar lead #4)	MDC_ECG_LEAD_A4
dV8	79	Derived lead V8	MDC_ECG_LEAD_dV8
dV9	80	Derived lead V9	MDC_ECG_LEAD_dV9
dV8R	81	Derived lead V8R	MDC_ECG_LEAD_dV8R
dV9R	82	Derived lead V9R	MDC_ECG_LEAD_dV9R
dD	83	Derived lead D (Nehb – Dorsal)	MDC_ECG_LEAD_dD

SCP-ECG Name	SCP-ECG code	Description	aECG [9] Ref ID MDC_ECG_LEAD_XXX
dA	84	Derived lead A (Nehb – Anterior)	MDC_ECG_LEAD_dA
dJ	85	Derived lead J (Nehb – Inferior)	MDC_ECG_LEAD_dJ
Chest	86	Chest lead	MDC_ECG_LEAD_C
V	87	Precordial lead	MDC_ECG_LEAD_V
VR	88	VR, nonaugmented voltage, vector of RA	MDC_ECG_LEAD_VR
VL	89	VL, nonaugmented voltage, vector of LA	MDC_ECG_LEAD_VL
VF	90	VF, nonaugmented voltage, vector of LL	MDC_ECG_LEAD_VF
MCL	91	Modified chest lead (left arm indifferent)	MDC_ECG_LEAD_MCL
MCL1	92	MCL, per V1 placement	MDC_ECG_LEAD_MCL1
MCL2	93	MCL, per V2 placement	MDC_ECG_LEAD_MCL2
MCL3	94	MCL, per V3 placement	MDC_ECG_LEAD_MCL3
MCL4	95	MCL, per V4 placement	MDC_ECG_LEAD_MCL4
MCL5	96	MCL, per V5 placement	MDC_ECG_LEAD_MCL5
MCL6	97	MCL, per V6 placement	MDC_ECG_LEAD_MCL6
CC	98	Chest lead (symmetric placement)	MDC_ECG_LEAD_CC
CC1	99	CC1, per V1 and V1R placement	MDC_ECG_LEAD_CC1
CC2	100	CC2, per V2 and V2R placement	MDC_ECG_LEAD_CC2
CC3	101	CC3, per V3 and V3R placement	MDC_ECG_LEAD_CC3
CC4	102	CC4, per V4 and V4R placement	MDC_ECG_LEAD_CC4
CC6	103	CC6, per V6 and V6R placement	MDC_ECG_LEAD_CC6
CC7	104	CC7, per V7 and V8R placement	MDC_ECG_LEAD_CC7
CM	105	Chest-manubrium	MDC_ECG_LEAD_CM
CM1	106	CM1, per V1 placement	MDC_ECG_LEAD_CM1
CM2	107	CM2, per V2 placement	MDC_ECG_LEAD_CM2
CM3	108	CM3, per V3 placement	MDC_ECG_LEAD_CM3
CM4	109	CM4, per V4 placement	MDC_ECG_LEAD_CM4
CM6	110	CM6, per V6 placement	MDC_ECG_LEAD_CM6
dIII	111	Derived lead III	MDC_ECG_LEAD_dIII
daVR	112	Derived lead aVR	MDC_ECG_LEAD_daVR
daVL	113	Derived lead aVL	MDC_ECG_LEAD_daVL
daVF	114	Derived lead aVF	MDC_ECG_LEAD_daVF
daVRneg	115	Derived lead aVRneg	MDC_ECG_LEAD_daVRneg
dChest	116	Derived lead Chest	MDC_ECG_LEAD_dC

SCP-ECG Name	SCP-ECG code	Description	aECG [9] Ref ID MDC_ECG_LEAD_xxx
dV	117	Derived lead V	MDC_ECG_LEAD_dV
dVR	118	Derived lead VR	MDC_ECG_LEAD_dVR
dVL	119	Derived lead VL	MDC_ECG_LEAD_dVL
dVF	120	Derived lead VF	MDC_ECG_LEAD_dVF
CM7	121	CM7, per V7 placement	MDC_ECG_LEAD_CM7
CH5	122	CH5 (see Note 5)	MDC_ECG_LEAD_CH5
CS5	123	Negative: right infraclavicular fossa (see Note 5)	MDC_ECG_LEAD_CS5
CB5	124	Negative: low right scapula (see Note 5)	MDC_ECG_LEAD_CB5
CR5	125	CR5 (see Note 5)	MDC_ECG_LEAD_CR5
ML	126	ML, modified limb lead, approximately Lead II	MDC_ECG_LEAD_ML
AB1	127	AB1 (auxiliary bipolar lead #1)	MDC_ECG_LEAD_AB1
AB2	128	AB2 (auxiliary bipolar lead #2)	MDC_ECG_LEAD_AB2
AB3	129	AB3 (auxiliary bipolar lead #3)	MDC_ECG_LEAD_AB3
AB4	130	AB4 (auxiliary bipolar lead #4)	MDC_ECG_LEAD_AB4
ES	131	EASI™ ES (see Note 8)	MDC_ECG_LEAD_ES
AS	132	EASI AS (see Note 8)	MDC_ECG_LEAD_AS
AI	133	EASI AI (see Note 8)	MDC_ECG_LEAD_AI
S	134	EASI upper sternum lead (see Note 8)	MDC_ECG_LEAD_S
dDefib	135	Derived lead Defib: Defibrillator lead: anterior-lateral	MDC_ECG_LEAD_dDEFIB
dExtern	136	Derived lead Extern: External pacing lead: anterior-posterior	MDC_ECG_LEAD_dEXTERN
dA1	137	Derived lead A1 (Auxiliary unipolar lead #1)	MDC_ECG_LEAD_dA1
dA2	138	Derived lead A2 (Auxiliary unipolar lead #2)	MDC_ECG_LEAD_dA2
dA3	139	Derived lead A3 (Auxiliary unipolar lead #3)	MDC_ECG_LEAD_dA3
dA4	140	Derived lead A4 (Auxiliary unipolar lead #4)	MDC_ECG_LEAD_dA4
dMCL1	141	Derived lead MCL1: MCL, per V1 placement	MDC_ECG_LEAD_dMCL1
dMCL2	142	Derived lead MCL2: MCL, per V2 placement	MDC_ECG_LEAD_dMCL2
dMCL3	143	Derived lead MCL3: MCL, per V3 placement	MDC_ECG_LEAD_dMCL3

SCP-ECG Name	SCP-ECG code	Description	aECG [9] Ref ID MDC_ECG_LEAD_XXX
dMCL4	144	Derived lead MCL4: MCL, per V4 placement	MDC_ECG_LEAD_dMCL4
dMCL5	145	Derived lead MCL5: MCL, per V5 placement	MDC_ECG_LEAD_dMCL5
dMCL6	146	Derived lead MCL6: MCL, per V6 placement	MDC_ECG_LEAD_dMCL6
RL	147	Right leg	MDC_ECG_LEAD_RL
CV5RL	148	Canine, fifth right intercostal space near the edge of the sternum at the most curved part of the costal cartilage (see Note 9)	MDC_ECG_LEAD_CV5RL
CV6LL	149	Canine, sixth left intercostal space near the edge of the sternum at the most curved part of the costal cartilage (see Note 9)	MDC_ECG_LEAD_CV6LL
CV6LU	150	Canine, sixth left intercostal space at the costochondral junction (see Note 9)	MDC_ECG_LEAD_CV6LU
V10	151	Canine, over dorsal spinous process of the seventh thoracic vertebra (see Note 9)	MDC_ECG_LEAD_V10
dMCL	152	Derived lead MCL: Modified chest lead (left arm indifferent)	MDC_ECG_LEAD_dMCL
dCC	153	Derived lead CC: Chest lead (symmetric placement)	MDC_ECG_LEAD_dCC
dCC1	154	Derived lead CC1, per V1 and V1R placement	MDC_ECG_LEAD_dCC1
dCC2	155	Derived lead CC2, per V2 and V2R placement	MDC_ECG_LEAD_dCC2
dCC3	156	Derived lead CC3, per V3 and V3R placement	MDC_ECG_LEAD_dCC3
dCC4	157	Derived lead CC4, per V4 and V4R placement	MDC_ECG_LEAD_dCC4
dCC6	158	Derived lead CC6, per V6 and V6R placement	MDC_ECG_LEAD_dCC6
dCC7	159	Derived lead CC7, per V7 and V8R placement	MDC_ECG_LEAD_dCC7
dCM	160	Derived lead CM Chest-manubrium	MDC_ECG_LEAD_dCM
dCM1	161	Derived lead CM1, per V1 placement	MDC_ECG_LEAD_dCM1
dCM2	162	Derived lead CM2, per V2 placement	MDC_ECG_LEAD_dCM2
dCM3	163	Derived lead CM3, per V3 placement	MDC_ECG_LEAD_dCM3
dCM4	164	Derived lead CM4, per V4 placement	MDC_ECG_LEAD_dCM4
dCM6	165	Derived lead CM6, per V6 placement	MDC_ECG_LEAD_dCM6
dCM7	166	Derived lead CM7, per V7 placement	MDC_ECG_LEAD_dCM7

SCP-ECG Name	SCP-ECG code	Description	aECG [9] Ref ID MDC_ECG_LEAD_xxx
dCH5	167	Derived lead CH5	MDC_ECG_LEAD_dCH5
dCS5	168	Derived lead CS5: negative: right infraclavicular fossa	MDC_ECG_LEAD_dCS5
dCB5	169	Derived lead CB5: negative: low right scapula	MDC_ECG_LEAD_dCB5
dCR5	170	Derived lead CR5	MDC_ECG_LEAD_dCR5
dML	171	Derived lead ML, modified limb lead, approximately Lead II	MDC_ECG_LEAD_dML
dAB1	172	Derived lead AB1 (auxiliary bipolar lead #1)	MDC_ECG_LEAD_dAB1
dAB2	173	Derived lead AB2 (auxiliary bipolar lead #2)	MDC_ECG_LEAD_dAB2
dAB3	174	Derived lead AB3 (auxiliary bipolar lead #3)	MDC_ECG_LEAD_dAB3
dAB4	175	Derived lead AB4 (auxiliary bipolar lead #4)	MDC_ECG_LEAD_dAB4
dES	176	Derived lead ES: EASI™ ES	MDC_ECG_LEAD_dES
dAS	177	Derived lead AS: EASI AS	MDC_ECG_LEAD_dAS
dAI	178	Derived lead AI: EASI AI	MDC_ECG_LEAD_dAI
dS	179	Derived lead S: EASI upper sternum lead	MDC_ECG_LEAD_dS
dRL	180	Derived lead RL: right leg	MDC_ECG_LEAD_dRL
dCV5RL	181	Derived lead CV5RL: Canine, fifth right intercostal space near the edge of the sternum at the most curved part of the costal cartilage	MDC_ECG_LEAD_dCV5RL
dCV6LL	182	Derived lead CV6LL: Canine, sixth left intercostal space near the edge of the sternum at the most curved part of the costal cartilage	MDC_ECG_LEAD_dCV6LL
dCV6LU	183	Derived lead CV6LU: Canine, sixth left intercostal space at the costochondral junction	MDC_ECG_LEAD_dCV6LU
dV10	184	Derived lead V10: Canine, over dorsal spinous process of the seventh thoracic vertebra	MDC_ECG_LEAD_dV10
	185 to 198	Reserved for future expansion (see Note 10)	
VIRT	199	Global, virtual lead (see Note 1 and Note 11)	MDC_ECG_LEAD_CONFIG

SCP-ECG Name	SCP-ECG code	Description	aECG [9] Ref ID MDC_ECG_LEAD_XXX
	200 to 255	Reserved for Manufacturer Specific codes	
NOTE 1 In the current version of aECG (ISO/IEEE 11073-10102:2014 [9]), CODE10 = 0 (CF_CODE10 = 0) corresponds to two different REFIDs, i.e. MDC_ECG_LEAD and MDC_ECG_LEAD_CONFIG, and has two different meanings: (1) as for SCP-ECG, both MDC_ECG_LEAD and MDC_ECG_LEAD_CONFIG can be used to indicate that the lead of the recorded ECG signal is an “Unspecified lead”; (2) in case of use in combination with a per-lead ECG numeric form, MDC_ECG_LEAD_CONFIG can be used to specify that the measurement has been evaluated over all leads, viz the global P wave onset which can be encoded by means of REFID MDC_ECG_TIME_START_P_LEAD_CONFIG. NOTE 2 The Einthoven lead one (coded with the Roman I; lead IDs 1 and 31) is not to be confused with the Frank electrode I (eye; lead IDs 24 and 54). NOTE 3 V2R is identical to lead V1. Similarly, lead V1R, not listed in the lead table, is identical to lead V2. NOTE 4 Leads X, Y and Z can be recorded by an orthogonal system, such as Frank or McFee lead systems, etc; NOTE 5 CM5, CH5, CS5, CC5, CB5, and CR5 are bipolar leads used in conjunction with stress testing (Macfarlane [35], Volume 1, page 387). NOTE 6 The unipolar Frank leads are prefixed by ‘f’ for clarity and label uniqueness. NOTE 7 The term “-aVR” is replaced with the more programming-friendly term “aVRneg.” NOTE 8 EASI™ is a trademark owned by Philips, invented by Dr. Gordon Dower. Leads: S, upper sternum; E, lower sternum (Frank lead fE); A, under left arm, above V6 (Frank lead fA); I, under right arm, above V6R (Frank lead fI). NOTE 9 The canine leads are summarized in Macfarlane [35], Volume 2, pp. 1865–1867. The abbreviations used in the left and right-most columns are based on Lannek [34] modified for use with a Wilson central terminal. The subscripted terms used in the “+” column were proposed by the Committee of the American Academy of Veterinary Cardiology, and they are roughly similar to those used for humans. NOTE 10 Codes 185 to 198 can be used for extending the lead numbering scheme in future revisions of this document. NOTE 11 Code 199 has been introduced to support, if need be, the use of the _LEAD_CONFIG discriminator and to specify that a given per-lead measurement, e.g. the global P onset (see Note 1 above), has been computed by taking into account a group of leads or the entire set of leads. NOTE 12 Users of this document are advised to refer to documents [8], [9], [16] and other current standards in the ISO/IEEE Nomenclature series to avoid unintended duplication in these code ranges.			

5.6.5 The sample numbering shall start with sample number 1 and refers to all leads recorded simultaneously. In order to convert these values to time, the sample time interval (STI) of the proper data section (see 5.9.3) should be consulted.

For example, if 8 leads (I, II, V1 to V6) are recorded simultaneously over 10 s at 500 samples/s and stored this way, then each lead begins with sample number 1 and ends with sample number 5 000.

If the standard 12 leads are recorded in groups of three, for example over 2,5 s at 500 samples/s, then leads I, II, and III begin with sample number 1 to sample 1 250, and leads aVR, aVL, and aVF begin with sample number 1 251.

5.6.6 An overview of the data part of this section is presented in Figure 6.

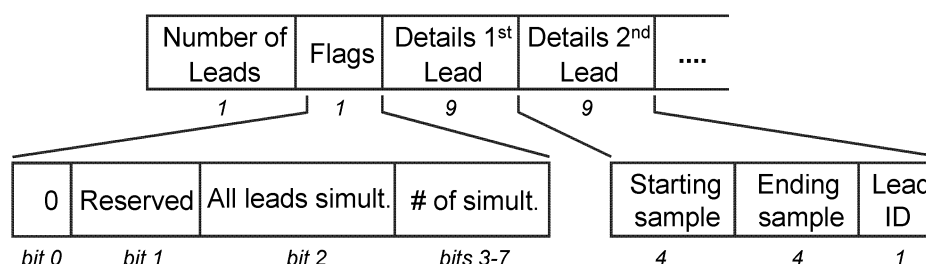


Figure 6 — Overview of the data part of the ECG leads definition section

5.7 Reserved for legacy SCP-ECG versions – Section 4

5.7.1 This section has been deprecated and shall not be implemented in SCP-ECG version V3.

Section 4 is still mentioned in the present document to support decoding and conversion of legacy SCP-ECG version 1.x and 2.x files into SCP-ECG version V3.0 files. The section was included in the previous SCP-ECG versions to support implementation of lossless high redundancy reduction and lossy bimodal compression schemes.

If present in a legacy SCP-ECG record, this section defines the QRS locations, the reference beat subtraction zones and the width of the various QRS complexes (used to protect QRS areas against sample decimation and filtering).

For a definition of reference beats, beat types, and the significance of reference beat type 0, see 5.1.11. For a detailed description of the overall process, see Annex D.

5.7.2 If present in a legacy record, the section starts with a “Section ID Header” as defined in 5.2.7.

5.7.3 The header area of the Section data part defines certain quantities that are common to the type 0 reference beat for all leads. The remaining data indicates the reference beat type and location of each QRS relative to the “residual” signal. The Section data part header area has the following contents

Byte	Contents
1 to 2	Length of reference beat type 0 data in milliseconds. The number of samples N is obtained by dividing the length L of the reference beat (in milliseconds) by the sample time interval STI (in microseconds, see 5.9.3, bytes 3 to 4) using the following equation: $N = \text{truncation} [(1\ 000\ \mu\text{s}/\text{ms} \times L) / STI]$. The manufacturer shall assign a length (in bytes 1 to 2) such that, when this equation is used, the intended number of samples in the reference beat is obtained. For example, 1 000 ms of data at 2 000 μs per sample results in an N equal to 500 samples.
3 to 4	Sample number of the fiducial point (QRS trigger point) with respect to the beginning of reference beat type 0. This location is abbreviated as fcM in Annex D. The first sample is numbered 1.
5 to 6	Total number of QRS complexes within the entire short-term ECG rhythm record.

5.7.4 The following information on location of reference beat subtraction zones is stored, consisting of one block of 14 bytes for each QRS complex. The total number of blocks is equal to the number of QRSs stored in 5.7.3 bytes 5 to 6.

Byte	Contents
1 to 2	Beat type of 1st QRS (see 5.1.11 for definition of “Beat type”)
3 to 6	Sample number on residual data for the start of subtraction/addition of reference beat 0 for 1st QRS, if the QRS is of type 0, otherwise a value of 0 (zero).
7 to 10	Sample number on residual data for location of fiducial point for 1st QRS (see Note 3). This location is abbreviated as $fc(1)$ in Annex D.
11 to 14	Sample number on residual data for end of subtraction/addition of reference beat 0 for 1st QRS, if the QRS is of type 0, otherwise a value of 0 (zero).
15 to 16	Beat type of 2nd QRS etc.

NOTE 1 If bytes 1 to 2 indicate reference beat type 0, then bytes 3 to 6 and 11 to 14 bound the area around the QRS for reference beat type 0 subtraction or addition, as specified and illustrated in Annex D. These locations are abbreviated in Annex D as $SB(k)$ and $SE(k)$, respectively.

NOTE 2 If bytes 1 to 2 indicate a reference beat type other than 0, then reference beat subtraction is not used, in which case bytes 3 to 6 and 11 to 14 contain 0 (zero).

NOTE 3 Manufacturers could also use the information stored in 5.7.4 and 5.7.5 to indicate the locations of the protected zones in case the legacy SCP-ECG record is based on bimodal compression without reference beat subtraction. In this case, bytes 3 to 6 and 11 to 14 in 5.7.4 are set to zero.

5.7.5 The following information on location of protected areas (QRS complexes) is stored, consisting of one block of 8 bytes for each QRS complex. The total number of blocks is equal to the number of QRSs stored in 5.7.3 bytes 5 to 6 (see 5.7.4, Note 3).

Byte	Contents
1 to 4	Sample number on residual data for the start of the protected area of the 1st QRS. This location is abbreviated as $QB(1)$ in Annex D.
5 to-8	Sample number on residual data for the end of the protected area of the 1st QRS. This location is abbreviated as $QE(1)$ in Annex D.
9 to 12	Sample number on residual data for the protected area of the start of the 2nd QRS. This location is abbreviated as $QB(2)$ in Annex D.
13 to 16	Sample number on residual data for the end of the protected area of the 2nd QRS. This location is abbreviated as $QE(2)$ in Annex D etc.

5.7.6 An overview of the data part of this section is presented in Figure 7.