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Health informatics — Standard communication protocol — Computer-assisted electrocardiography

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

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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).

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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, approximatively 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

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[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 60601-2-25:2011[2] [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

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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 levering 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

Note1 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

Note1 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 Vorausgabe (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.
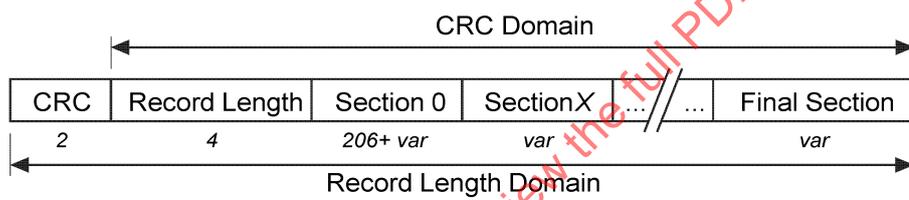
5.2.5 SCP-ECG record overview:

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
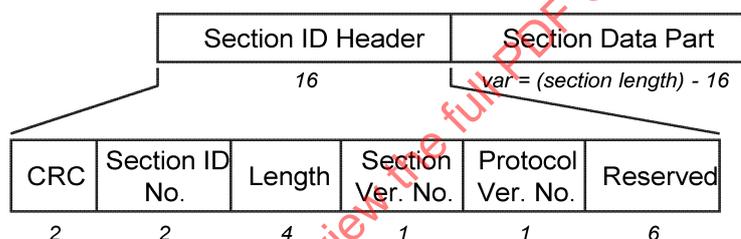
Figure 2 — Section layout overview

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.

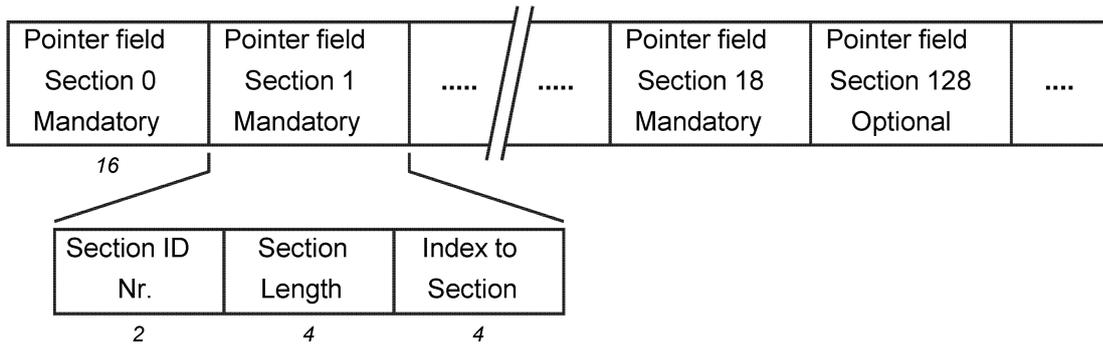**5.3.4** An overview of the pointer section data part is presented in Figure 3.

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	Patient ID (used as primary key in the ECG management database)
2	14	ID of the acquiring device
3	25	Date of acquisition
4	26	Time of acquisition

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	Patient's last name
6	1	Patient's first name
7	5	Patient's date of birth (the date of birth shall in principle be given AD)
8	8	Patient's sex
9	15	ID of the analysing device
10	34	Date time zone

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.
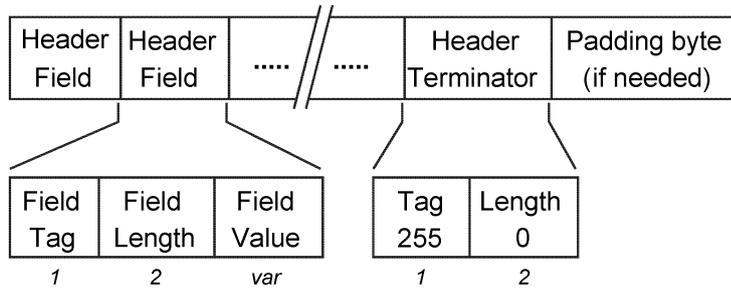
Figure 4 — Overview of the "Header information" section data part

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: Byte Contents 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:
		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]
		If all 3 bytes are zero, then age is not specified.

5	4	**Date of birth** (Binary)
		
		 Semantically equivalent to MDC_ATTR_PT_DOB
		
		 This field has the following format:
		
		   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)
		
		 If all 4 bytes are zero, then date of birth is not specified.

6	3	**Height** (Binary)
		
		 Semantically equivalent to MDC_ATTR_PT_HEIGHT
		
		 This field has the following format:
		
		   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]
		
		 If all 3 bytes are zero, then height is not specified.

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 Male 0 Not Known
		    2 Female 9 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 Byte Contents 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 Byte Contents 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>Byte</td><td>Contents</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>

Value	Type
0	Cart or mobile device
1	System (or Host)
2	Wearable device

<table>
<tr><td>8</td><td>Binary: shall be set equal to 255</td></tr>
</table>

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:

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

<table>
<tr><td>9 to 14</td><td>Text characters: Text model description. Up to 5 bytes of text and NULL terminator.</td></tr>
<tr><td>15</td><td>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.</td></tr>
</table>

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:

<div style="margin-left:6em">

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

</div>

19   Binary: AC Mains Frequency Environment (one byte):

<div style="margin-left:6em">

Value	Meaning
0	Unspecified
1	50 Hz
2	60 Hz

</div>

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.

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) Byte　Contents 1　Binary: Level of emergency of the recording. 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.
25	4	**Date of Acquisition** (Binary) [MDC_DIM_DATE] This field has the following format: 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: 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] 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.
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:

Value	Contents
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

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).
		<u>Byte</u> <u>Contents</u>
		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.
		<u>Value</u> <u>Electrode placement system</u>
		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.
		Byte **Contents**
		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).
		Value **Electrode placement system**
		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.

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.

Value	Meaning
0	Index not used
1 to 1 000	Reserved for future use
1 001 to 32 766	Manufacturer-specific
32 767	Reserved

Byte	Name	Type	Notes
5 to ***	Description	Text String	Time Zone specified by a null-terminated string.

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.

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). <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) 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".
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
	Value Content 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
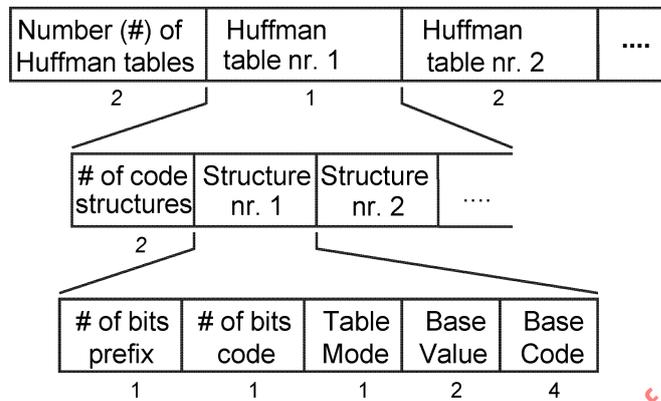
Figure 5 — Overview of the data part of the Huffman tables section

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
dfI	54	Derived lead fI	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.
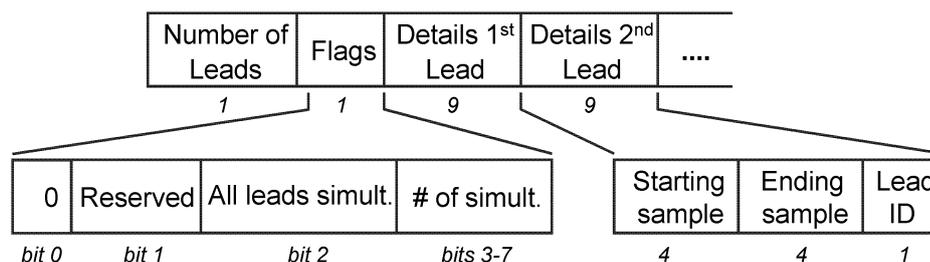
Figure 6 — Overview of the data part of the ECG leads definition section

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 = truncation $[(1\,000\ \mu s/ms \times L)\ /\ STI]$.
	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.
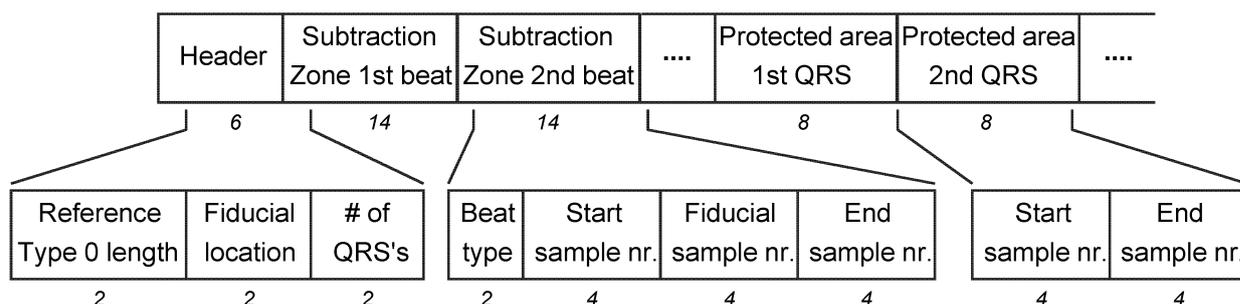
Figure 7 — Overview of the data part of section 4

NOTE   All sample numbers in clause 5.7 refer to the original samples before processing them for decimation and/or compression. The first sample of the original data is numbered 1.

5.8 Encoded type 0 reference beat data – Section 5

5.8.1   This section provides details as for encoding/decoding and storing reference beat type 0 signal data (if the reference beat type 0 is stored).

For a definition of reference beats, reference 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.

In case more than one reference beat and/or more than one selected beat shall be stored, see sections 13 and 14.

5.8.2   If present, the section shall start with a "Section ID Header" as defined in 5.2.7.

5.8.3   The section data part begins with a header that has the following format.

Byte   **Contents**

1 to 2   Multiplier for Amplitude Value (AVM) for this section in nanovolt (1×10^{-9} V).

EXAMPLE: 1 250 - > 1 amplitude quantum = 1,250 µV ; 2 441 - > 1 amplitude quantum = 2,441 µV

3 to 4   Sample Time Interval (STI) for this section in microseconds (1×10^{-6} s).

EXAMPLE: 4 000 - > 250 samples/s. ; 1 250 - > 800 samples/s.

5   Difference encoding specifier (DES)

This value indicates if difference encoding is used for storing the type 0 reference beat sample data as follows:

0 = No difference encoding used. Only original values or Huffman encoded data (see byte 6) used for reference beat data.

1 = First difference data used for reference beat data.

2 = Second difference data used for reference beat data.

6   Huffman encoding specifier (HES) (see Note 5)

This value specifies if Huffman encoding is used for storing the type 0 reference beat sample data as follows:

0 = No Huffman encoding used. Only original data or difference encoded data (DES ≠ 0)

are used. Each sample value is stored as a signed 2-byte integer.

2 = Default Huffman encoding. The default table, defined in D.4.7.6, is used for encoding the type 0 reference beat data. Section 2 is optional (see Note 6)

4 = Huffman encoding used. The appropriate Huffman tables are defined in section 2. Section 2 is mandatory.

7 to 8	Number of samples per lead, assuming that all the recorded leads in this section have the same duration (SPL)
9 to 10	(Unsigned) sample number of the fiducial (QRS trigger point) relative to the beginning of reference beat type 0. This location is abbreviated as fcM in Annex D. The first sample is numbered 1.
	Shall be set to Null (0) if not computed.
	Semantically equivalent to MDC_ECG_BEAT_TOC and to MDC_ECG_WAVC_QRSWAVE_TIME_POINT
11 to 16	Reserved. Shall be set to Null (0)

NOTE 1   Difference data are defined as: [Sample value (difference) for time t] – [Sample value (difference) for time t-1].

The general formula for the first difference calculation is as follows: $D1(n) = X(n) - X(n-1)$.

The general formula for the second difference calculation is as follows: $D2(n) = X(n) - 2*X(n-1) + X(n-2)$.

Decoding of second difference data are performed using the following formula: $X(n) = D2(n) + 2*X(n-1) - X(n-2)$

NOTE 2   For the first two samples in each lead, second differences are not computed in the SCP-ECG Protocol. The original amplitude values of these samples are retained. The first sample value is similarly retained in the encoded data stream using first differences. An example of difference data calculation for the first four samples is given in Table 5.

NOTE 3   An example of the encoded results using second differences is given in Table 6 for a series of eight sample data.

NOTE 4   An example of the encoded results using first differences is given in Table 7 using the same series of eight sample data.

NOTE 5   In SCP-ECG V1.x and V2.x, field HES (byte 6) was "reserved" (supposedly set to "0")

NOTE 6   In case HES=2, no Section 5 specific Huffman table(s) are stored in Section 2, and Section 2 is only compulsory if used to store Huffman tables needed by Section 6.

It is highly recommended to store the type 0 reference beat data of standard 12-lead and short duration ECGs uncompressed as a series of signed two-byte integers (see 5.8.5) and to reserve 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 only where significant lossless data reduction strategies are still of importance.

Table 5 — Example of difference data calculation for the first four samples

Original data	First differences	Second differences
X(1)	D1(1) = X(1)	D2(1) = X(1)
X(2)	D1(2) = X(2)-X(1)	D2(2) = X(2)

Original data	First differences	Second differences
X(3)	D1(3) = X(3)-X(2)	D2(3) = D1(3)-D1(2) = X(3)-2*X(2)+X(1)
X(4)	D1(4) = X(4)-X(3)	D2(4) = D1(4)-D1(3) = X(4)-2*X(3)+X(2)

Table 6 — Example of encoded results using 2nd differences

Sample Number	n	1	2	3	4	5	6	7	8
Sample Value	X(n)	10	12	13	15	18	22	20	15
2nd Difference	D2(n)	-	-	−1	1	1	1	−6	−3
Encoded data			10	12	−1	1	1	1	−6	−3

Table 7 — Example of encoded results using 1st differences

Sample Number	n	1	2	3	4	5	6	7	8
Sample Value	X(n)	10	12	13	15	18	22	20	15
1st Difference	D1(n)	-	2	1	2	3	4	−2	−5
Encoded data			10	2	1	2	3	4	−2	−5

5.8.4 The section data part contains the byte lengths of the encoded leads. Its format is as follows:

Byte   **Content**

1 to 2   (Unsigned) number of bytes of the "compressed" type 0 reference beat data for the first encoded lead.

3 to 4   (Unsigned) number of bytes of the "compressed" type 0 reference beat data for the second encoded lead etc.

NOTE   Signal data can be stored uncompressed as signed two-byte integers (HES = 0), in different fixed-length formats if a dummy Huffman table is provided, compressed using first and/or second difference encoding (DES = 1 or 2), and/or Huffman encoded, see 5.8.5.

5.8.5 The encoded type 0 reference beat data then follows. If HES = 2 or 4, the data are coded as a series of Huffman codes taken from the default SCP-ECG Huffman table (defined in D.4.7.6) or from Section 2. The leads are encoded in the order specified in Section 3. If HES = 0, ECG data (either differenced or non-differenced) shall be formatted as signed, two-byte integers.

Other fixed length formats (as for example 8, 10, 12 or 24-bit format) may be accommodated by setting HES = 4 and providing a "dummy" Huffman table with one code structure. The number of bits in the prefix shall be set to zero. The number of bits in the entire code shall be set to the desired number of bits per sample.

5.8.6 An overview of the data part of this section is presented in Figure 8.
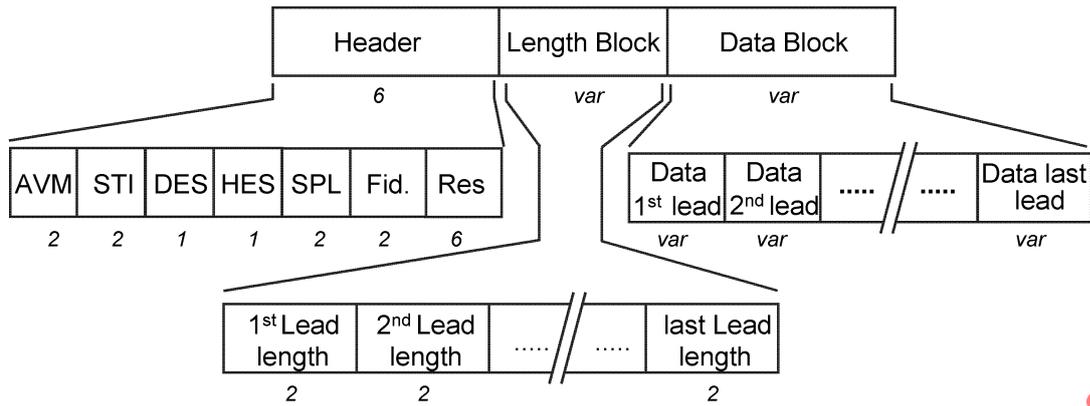
Figure 8 — Overview of the data part of the encoded type 0 reference beat section

5.9 Short-term ECG Rhythm data – Section 6

5.9.1   This section contains the entire encoded short-term ECG rhythm data (i.e. the entire signal data from ECGs such as standard 10-s diagnostic ECGs).

Long-term ECGs such as Holter recordings, stress tests rhythm data or any ECG for which any encoded lead data requires more than 64 KiB, should be stored in section 12 "Long-term ECG rhythm data" (Clause 5.15).

NOTE   In SCP-ECG versions V1.x and V2.x, this section could also be used to store the residual signal after reference beats have been subtracted (see 5.6.3, byte 2, bit 0 = 1). This option is no longer supported.

5.9.2   If present, the section shall start with a "Section ID Header" as defined in 5.2.7.

5.9.3   The section data part begins with a header that has the following format

Byte	Contents
1 to 2	Multiplier for Amplitude Value (AVM) for this section in nanovolt (1×10^{-9} V).
	EXAMPLE: 1 250 - > 1 amplitude quantum = 1,250 µV ; 2 441 - > 1 amplitude quantum = 2,441 µV
3 to 4	Sample Time Interval (STI) for this section in microseconds (1×10^{-6} s).
	EXAMPLE: 4 000 - > 250 samples/s. ; 1 250 - > 800 samples/s.
5	Difference encoding specifier (DES)
	This value indicates if difference encoding is used for storing the sample data as follows:
	0 = No difference encoding used. Only original or Huffman encoded data (see byte 6) used for rhythm data.
	1 = First difference data used for rhythm data.
	2 = Second difference data used for rhythm data.

6	Huffman encoding specifier (HES) (see Note 2)

This value specifies if Huffman encoding is used for storing the rhythm data as follows:

0 = No Huffman encoding used. Only original data or difference encoded data (DES ≠ 0) are used. Each sample value is stored as a signed 2-byte integer.

2 = Default Huffman encoding. The default table, defined in D.4.7.6, is used for encoding the type 0 reference beat data. Section 2 is optional

4 = Huffman encoding used. The appropriate Huffman tables are defined in Section 2. Section 2 is mandatory.

It is highly recommended to store short-term ECG rhythm data uncompressed as a series of signed two-byte integers (see 5.9.5) and to reserve 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 only where significant lossless data reduction strategies are still of importance.

NOTE 1   For the calculation of difference data, see 5.8.3

NOTE 2   In SCP-ECG versions V1.x and V2.x, Byte 6 was used to indicate how rhythm data was compressed (0 = Bimodal compression not used, 1 = Bimodal compression used). This option being no longer supported, starting with SCP-ECG V3.0 byte 6 is used to store HES.

NOTE 3   In case HES = 2, no Section 6 specific Huffman table(s) are stored in Section 2, and Section 2 is only compulsory if used to store Huffman tables needed by Section 5.

5.9.4   The section data part contains the byte lengths of the encoded leads. Its format is as follows:

Byte	Contents
1 to 2	(Unsigned) number of bytes in rhythm signal data for first encoded lead.
3 to 4	(Unsigned) number of bytes in rhythm signal data for second encoded lead etc.

NOTE   Rhythm signal data can be stored uncompressed as signed two-byte integers (HES = 0), in different fixed length formats if a dummy Huffman table is provided, compressed using first and/or second difference encoding (DES = 1 or 2), and/or Huffman encoded, see 5.9.5.

5.9.5   The short-term ECG rhythm signal data then follow. If HES = 2 or 4, the data are coded as a series of Huffman codes taken from the default SCP-ECG Huffman table (defined in D.4.7.6) or from Section 2. The leads are encoded in the order specified in Section 3. If HES = 0, ECG data (either differenced or non-differenced) shall be formatted as signed, two-byte integers.

Other fixed-length formats (as for example 8, 10, 12 or 24-bit format) may be accommodated by setting HES = 4 and providing a "dummy" Huffman table with one code structure. The number of bits in the prefix shall be set to zero. The number of bits in the entire code shall be set to the desired number of bits per sample.

NOTE   The number of samples per lead is obtained by computing the differences [(Ending sample number) - (Starting sample number) + 1] (see Section 3, Clause 5.6.4, bytes 1 to 8). It is assumed that the leads belonging to a same group of leads have the same duration.

5.9.6   An overview of the data part of this section is presented in Figure 9.
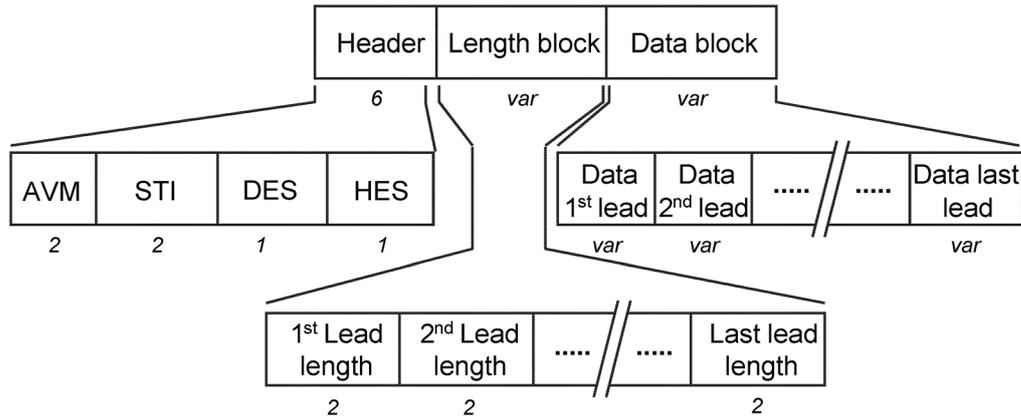
Figure 9 — Overview of the data part of the rhythm data section

5.10 Global ECG measurements – Section 7

5.10.1 General

This section contains the global measurements of the type 0 reference beat, viz the locations of the global onsets and offsets of the P, QRS and T waves, the electrical axes, the QT interval, the amplitude, azimuth and elevation of the spatial P, QRS and T vectors, etc. The term "global" refers to measurements taken across all leads of the ECG, but not necessarily representing more than one individual beat. See 5.1.11 for a discussion of beat types.

For backwards compatibility, the section may also provide, as for SCP-ECG versions V1.x and V2.x, a list of pacemaker spikes (if any) of the short-term ECG rhythm record (section 6), and the global wave onsets and offsets and electrical axes (hereafter referred to as "Main PQRST measurement data") of either the other than type 0 reference beats (if any) or for all beats of the short-term ECG rhythm record (section 6). It is however recommended, starting with SCP-ECG version V3.0, to partially deprecate section 7 by limiting its use to the storage of the global measurements and annotations for reference beat type 0 and to preferably store global beat-by-beat measurements and pacemaker spikes data and annotations in sections 15 to 17.

If the global electrical axes and the wave onset and offset measurements are provided for each PQRST beat, then the first measurement block shall contain global measurements of beat type 0.

The global measurements of the type 0 reference beat stored in this section shall correspond to the measurements performed on the signal data stored in section 5 "Encoded type 0 reference beat data", if present. If section 5 is not present, then the measurements shall have been performed on the type 0 reference beat of section 6 "Short-term ECG rhythm data", if present, or on the type 0 reference beat of section 12 "Long-term ECG rhythm data" if neither section 5 nor section 6 are present.

5.10.2 Section ID Header

If present, the section shall start with a "Section ID Header" as defined 5.2.7.

5.10.3 Global ECG measurement data and pacemaker spike measurement data

5.10.3.1 General

The section data part contains global ECG measurement data and pacemaker spike measurement data, if any.

Special codes, of which three are as defined in the CSE Project, have been reserved to indicate:

29 999 (decimal)	Measurement not computed by the program.
29 998 (decimal)	Measurement result not found due to rejection of the lead by the measurement program.
29 997 (decimal)	Measurement not computable reliably (e.g. Amplitude of the Maximum Vector in one of the orthogonal projection planes if amplitude is very small).
19 999 (decimal)	Measurement not found because wave was not present (e.g. P wave during atrial fibrillation).
999 (decimal)	Angle Measurement result undefined.

These codes shall replace the measurement data when appropriate, unless specified otherwise.

5.10.3.2 Global ECG measurement data header

Byte	Contents
1	This byte contains the number #MMB of "Main PQRST Measurements" data Blocks (global onsets and offsets and electrical axes defined in 5.10.3.3) stored in Section 7. If more than one block is stored, then the first block (bytes 7 to 22) always contains the measurements for the type 0 reference beat. If the measurements of all beats are stored, then the value #MMB stored in this byte shall be equal to N+1, the number N of QRS's plus 1 (compare to 5.10.3.6 byte 1 to 2), and blocks 2 to N+1 shall contain the measurements for each individual beat in sequence. If the value #MMB stored in this byte is larger than 1 but less than N+1, then the subsequent blocks contain the main PQRST measurements for the other then type 0 reference beats (a reference beat may itself be a computed, viz a median, or a selected beat, see 5.1.11 for a discussion of beat types) #MMB should be set to 1 if, as recommended, no other global measurements than the measurements of the type 0 reference beat are stored in this section (see recommendations (i) and (ii) at the end of this clause).
2	The number of pacemaker spikes for which location times are sent. Should be set to 0 (zero) if no pacemaker spikes are stored or if they are stored, as recommended, in Section 17
3 to 4	Average RR interval in milliseconds for all QRS's of the analysed ECG sequence. Semantically equivalent to MDC_ECG_TIME_PD_RR_GL_MEAN.
5 to 6	Average PP interval in milliseconds for all P waves of the analysed ECG sequence. Semantically equivalent to MDC_ECG_TIME_PD_PP_GL_MEAN.

As the size of the first two fields in this header has been left unchanged for backwards compatibility with SCP-ECG version 1.x and 2.x, the maximum number of QRSs for which main PQRST measurements can be reported is 254. The same yields for the number of pacemaker spikes. Another limitation is the 16-bit representation of the global wave fiducials measurement results, which prevents storing main PQRST measurements of QRSs located beyond 65 s after the beginning of the ECG record. It is thus recommended, for all ECG sequences of more than 65 s duration:

(i)   To store all global measurements (including the additional global measurements) of the type 0 reference beat in this section 7.

(ii) To store the global measurements of the other reference beats (if any), and of any other (selected or not) QRS complexes in section 15 "Beat-by-Beat ECG measurements and annotations" and/or in section 16 "Selected ECG beats measurements and annotations", and to store the measurements corresponding to pacemaker spikes in section 17 "Pacemaker Spikes measurements and annotations".

5.10.3.3 Global ECG wave delineation and electrical axes measurement data

The global P, QRS and T wave delineation results and the electrical axes of the type 0 reference beat are stored after the header, i.e. starting from byte 7, in the first 16-byte long "main PQRST measurements" data block.

If computed, the global P, QRS and T wave delineation results and the electrical axes of the other than type 0 reference beats or of all beats of the short duration ECG rhythm data record are then stored in sequence, starting from byte 23, in 16-byte long data blocks.

Byte	Contents
7 to 22	Main PQRST measurements block for reference beat type 0.
23 to 38	Main PQRST measurements block for reference beat type 1, or for first PQRST beat (see specification of the content of byte 1) etc.

For each of these #MMB measurement blocks, the same structure repeats. The format of the 16-byte measurement block for each reference beat type or for each individual QRS is outlined as follows:

Byte	Contents	
1 to 2	P onset	[MDC_ECG_TIME_START_P_LEAD_CONFIG]
3 to 4	P offset	[MDC_ECG_TIME_END_P_LEAD_CONFIG]
5 to 6	QRS onset	[MDC_ECG_TIME_START_QRS_LEAD_CONFIG]
7 to 8	QRS offset	[MDC_ECG_TIME_END_QRS_LEAD_CONFIG]
9 to 10	T offset	[MDC_ECG_TIME_END_T_LEAD_CONFIG]
11 to 12	P axis in the frontal plane (angular degrees)	[MDC_ECG_ANGLE_P_FRONT]
13 to 14	QRS axis in the frontal plane (angular degrees)	[MDC_ECG_ANGLE_QRS_FRONT]
15 to 16	T axis in the frontal plane (angular degrees)	[MDC_ECG_ANGLE_T_FRONT]

NOTE 1   If the measurement block contains measurements for a reference beat type, then measurements for onset/offset are given in milliseconds from the beginning of this reference beat. If the measurement block contains measurements for an individual beat, then measurements for onset/offset are given in milliseconds from

the beginning of the ECG record. Wave durations and intervals can be computed from wave or interval offset minus onset.

NOTE 2 For the axes (P, QRS, T) in the frontal plane, the convention shown in Figure 10 is used.
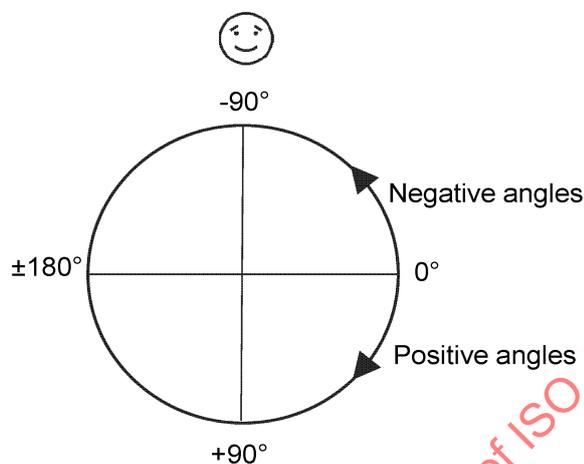
Figure 10 — Angle definition for the electrical axes in the frontal plane

5.10.3.4 Pacemaker spike measurement data (if any)

Byte   Contents

1 to 2   1st spike position in milliseconds from start of the short-term ECG rhythm record (Unsigned integer).

3 to 4   1st spike amplitude in microvolts (1×10^{-6} V) (Signed integer).

5 to 6   2nd spike position in milliseconds from start of the short-term ECG rhythm record (Unsigned integer).

7 to 8   2nd spike amplitude in microvolts (1×10^{-6} V) (Signed integer) etc.

Time and amplitude of these pacemaker spikes shall be given as respectively unsigned and signed quantities, which, correspondingly, give a range of 0 to 65 535 s and ± 32,767 mV.

The time resolution for the pacemaker spikes location shall be less than or equal to one sample time interval.

NOTE   Spike positions stored in this part of the SCP-ECG record are semantically equivalent to MDC_ECG_WAVP_discrim_TIME_POINT, where discrim stands for one of the following terms: PACE, PACE_ATR, PACE_V, ATPACE, AATPACE, VATPACE, depending on the pacing type.

5.10.3.5 Pacemaker Spike Information

For each pacemaker spike identified in 5.10.3.2, byte 2, and in 5.10.3.4, this section shall contain one 6-byte block providing additional information about the pacemaker spike. The order of the blocks corresponds to the order of the spikes identified in 5.10.3.4.

Byte	Contents	
1	Spike type of Pacemaker Spike #1	
	0	Unknown
	1	Spike triggers neither P-wave nor QRS
	2	Spike triggers a QRS. Semantically equivalent to [MDC_ECG_WAVP_PACE_V_C] or [MDC_ECG_WAVP_ATPACE_V_C]
	3	Spike triggers a P-wave. Semantically equivalent to [MDC_ECG_WAVP_PACE_ATR_C] or [MDC_ECG_WAVP_ATPACE_ATR_C]
	4 to 127	Reserved
	128 to 254	Manufacturer-specific
	255	No spike type analysis performed
2	Source of Pacemaker Spike #1	
	0	Unknown
	1	Internal
	2	External
	3 to 255	Reserved
3 to 4	Index of triggered QRS Complex for Pacemaker Spike #1	
	0	No link
	1	Link to QRS beat #1 - first QRS complex
	2	Link to QRS beat #2 - second QRS complex, etc.
5 to 6	Pulse width in microseconds – 0 if unknown or uncomputed (unsigned).	

NOTE   The index of triggered QRS complex is only useful if we know the location of the corresponding QRS. This requires that no other than type 0 reference beat data are stored in the "Main QRS measurement" blocks, and that the global onset and/or end of all QRSs of the short-term ECG rhythm record are stored in the "Main QRS measurement" blocks. See also Note in 5.10.3.6.

5.10.3.6 QRS type information

This data structure identifies the reference beat type for each QRS complex in the short-term ECG rhythm data record stored in section 6. Complexes are addressed in order of their appearance in the original ECG record.

In case only reference beat data are stored in the main PQRST measurement data blocks defined in 5.10.3.3, then the Reference beat types stored in this QRS type information block are numbered according to their appearance in the main PQRST measurement data blocks.

Byte   **Contents**

1 to 2   Number of QRS complexes in the short-term ECG rhythm record (section 6).

3   Reference beat type of first QRS complex (0-??).

         Semantically equivalent to MDC_ECG_QRS_MORPH_NUM.

4   Reference beat type of second QRS complex (0-??), etc.

NOTE   In case only reference beats are stored in the main PQRST measurement data blocks (see 5.10.3.3, bytes 23 to 38 and beyond), then the beat type information stored in this QRS type information data block is not very useful because in this use case section 6 does not provide information about the location of the different QRSs. To be fully exploitable, at minimum the onset and/or end of the QRSs of all detected and typified beats are typically stored in the main PQRST measurement data blocks (5.10.3.3), which however excludes also storing the main PQRST measurement for the other than type 0 reference beats.

5.10.3.7 Additional Global measurements

This data structure provides for additional global measurements beyond those defined in 5.10.3.3. Historically, it has been placed here by SCP-ECG V2.1 so as not to render inoperable any implementations of previous versions of the protocol. Starting with SCP-ECG V3.0, it has been markedly expanded to be compliant with ISO/IEE 11073-10102.

Byte   **Contents**

1 to 2   Average Ventricular rate of the analysed ECG sequence, in beats per minute (unsigned integer) [MDC_ECG_VENTRICULAR_RATE_MEAN]

3 to 4   Average Atrial rate of the analysed ECG sequence, in beats per minute (unsigned integer) [MDC_ECG_ATRIAL_RATE_MEAN].

5 to 6   Corrected QT Interval (milliseconds) (unsigned integer).

         The most clinically used QTC value shall be stored here and the correction method used shall be defined in byte 7. If more than one correction method is used or computed, then the other QTc values shall be stored in the tagged fields.

         Semantically equivalent to [MDC_ECG_TIME_PD_QT_NOS_GL], [MDC_ECG_TIME_PD_QTC_BAZETT], etc., depending on the correction method specified in byte 7.

7   Formula type used for HR correction

        0   Unknown or unspecified [MDC_ECG_TIME_PD_QTC_NOS_GL]

        1   Bazett   [MDC_ECG_TIME_PD_QTC_BAZETT]   and [MDC_ECG_TIME_PD_QT_CORR_GL]

        2   Hodges [MDC_ECG_TIME_PD_QTC_HODGES]

        3   Framingham [MDC_ECG_TIME_PD_QTC_FRAMINGHAM]

        4   Fridericia [MDC_ECG_TIME_PD_QTC_FREDERICA]

        5   Linear

        6   User defined [MDC_ECG_TIME_PD_QTC_USER]

        7 to 127   Reserved for future use

        128 to 254   Manufacturer specific

        255   Measurement not available

8 to 9   Number of bytes in tagged fields, which follow (zero if no tagged fields).

10 to   Tagged global measurement data fields, as specified in the following table. Valid tags are 0 to
***   254, tag 255 is a terminator. Each tagged field has at least a one-byte tag identifier and a one-
         byte length specifier (tag 255 length is 0).

Table 8 — Tagged Global ECG Measurements data fields

TAG	LENGTH	VALUE (Parameter data)
0	5	**QTend All-lead Dispersion** (Binary) QT Intervals measured in milliseconds, from QRS onset to T wave offset. All ECG leads are used in measurement. Valid values are 0 to 254 (milliseconds); 255 = measurement not provided. Byte — Contents 1 — Dispersion = maximum QT interval – minimum QT interval. 2 — Heart rate corrected Dispersion: Max–Min. 3 — Dispersion = standard deviation of the QT intervals. 4 — Heart rate corrected Dispersion: standard deviation. 5 — Heart rate correction formula (see 5.10.3.7 definition of byte 7 "Formula type used for HR correction" for valid values). Similar to [MDC_ECG_DISPERSION_QT] and [MDC_ECG_DISPERSION_QTC]. But 11073–10102 neither specifies the measurement method nor the correction method.
1	5	**QTpeak All-lead Dispersion** (Binary) QT Intervals measured in milliseconds, from QRS onset to T wave peak. All ECG leads are used in measurement. Valid values are 0 to 254 (milliseconds); 255 = measurement not provided. Byte — Contents 1 — Dispersion = maximum QTpeak interval – minimum QTpeak interval. 2 — Heart rate corrected Dispersion: Max–Min. 3 — Dispersion = standard deviation of the QTpeak intervals. 4 — Heart rate corrected Dispersion: standard deviation. 5 — Heart rate correction formula (see 5.10.3.7 definition of byte 7 "Formula type used for HR correction" for valid values).
2	5	**QTend Precordial Dispersion** (Binary) QT Intervals measured in milliseconds, from QRS onset to T wave offset. Precordial ECG leads only are used in measurement. Valid values are 0 to 254 (milliseconds); 255 = measurement not provided. Byte — Contents 1 — Dispersion = maximum QT interval – minimum QT interval. 2 — Heart rate corrected Dispersion: Max–Min. 3 — Dispersion = standard deviation of the QT intervals. 4 — Heart rate corrected Dispersion: standard deviation. 5 — Heart rate correction formula (see 5.10.3.7 definition of byte 7 "Formula type used for HR correction" for valid values).

TAG	LENGTH	VALUE (Parameter data)
3	5	**QTpeak Precordial Dispersion** (Binary) QT Intervals measured in milliseconds, from QRS onset to T wave peak. Precordial ECG leads only are used in measurement. Valid values are 0 to 254 (milliseconds); 255 = measurement not provided <u>Byte</u> <u>Contents</u> 1 Dispersion = maximum QTpeak interval – minimum QTpeak interval. 2 Heart rate corrected Dispersion: Max–Min. 3 Dispersion = standard deviation of the QTpeak intervals. 4 Heart rate corrected Dispersion: standard deviation. 5 Heart rate correction formula (see 5.10.3.7 definition of byte 7 "Formula type used for HR correction" for valid values).
4	4	**P Maximum Vector Azimuth and Elevation** (Binary) Azimuth and Elevation of the Maximum Vector of the spatial P wave. Values are in angular degrees (signed integers). Codes defined in 5.10.3.1 apply. <u>Byte</u> <u>Contents</u> 1–2 P vector Azimuth [MDC_ECG_ANGLE_P_AZIM] 3–4 P vector Elevation [MDC_ECG_ANGLE_P_ELEV]
5	4	**QRS Maximum Vector Azimuth and Elevation** (Binary) Azimuth and Elevation of the Maximum Vector of the spatial QRS complex. Values are in angular degrees (signed integers). Codes defined in 5.10.3.1 apply. <u>Byte</u> <u>Contents</u> 1–2 QRS vector Azimuth [MDC_ECG_ANGLE_QRS_AZIM] 3–4 QRS vector Elevation [MDC_ECG_ANGLE_QRS_ELEV]
6	4	**T Maximum Vector Azimuth and Elevation** (Binary) Azimuth and Elevation of the Maximum Vector of the spatial T wave. Values are in angular degrees (signed integers). Codes defined in 5.10.3.1 apply. <u>Byte</u> <u>Contents</u> 1–2 T vector Azimuth [MDC_ECG_ANGLE_T_AZIM] 3–4 T vector Elevation [MDC_ECG_ANGLE_T_ELEV]

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TAG	LENGTH	VALUE (Parameter data)
7	10	**P Maximum Vector Magnitudes** (Binary) Magnitudes of the Maximum Vector of the P wave in the X, Y, Z space and in the Frontal, Horizontal, Sagittal and Einthoven's frontal planes. Values are in µV (unsigned integers). Codes defined in 5.10.3.1 apply. Byte — Contents 1–2 Max Spatial P vector Magnitude, computed as square root of squared scalar magnitudes of X, Y, Z [MDC_ECG_MAG_P_VECT] 3–4 Max Frontal P vector Magnitude, computed as square root of squared scalar magnitudes of X, Y [MDC_ECG_MAG_P_VECT_FRONT] 5–6 Max Horizontal P vector Magnitude, computed as square root of squared scalar magnitudes of X, Z [MDC_ECG_MAG_P_VECT_HORIZ] 7–8 Max Sagittal P vector Magnitude, computed as square root of squared scalar magnitudes of Y, Z [MDC_ECG_MAG_P_VECT_SAGI] 9–10 Length of the vector of the P wave in Einthoven's frontal plane [MDC_ECG_MAG_P_FRONT]
8	10	**QRS Maximum Vector Magnitudes** (Binary) Magnitudes of the Maximum Vector of the QRS complex in the X, Y, Z space and in the Frontal, Horizontal, Sagittal and Einthoven's frontal planes. Values are in µV (unsigned integers). Codes defined in 5.10.3.1 apply. Byte — Contents 1–2 Max Spatial QRS vector Magnitude, computed as square root of squared scalar magnitudes of X, Y, Z [MDC_ECG_MAG_QRS_VECT] 3–4 Max Frontal QRS vector Magnitude, computed as square root of squared scalar magnitudes of X, Y [MDC_ECG_MAG_QRS_VECT_FRONT] 5–6 Max Horizontal QRS vector Magnitude, computed as square root of squared scalar magnitudes of X, Z [MDC_ECG_MAG_QRS_VECT_HORIZ] 7–8 Max Sagittal QRS vector Magnitude, computed as square root of squared scalar magnitudes of Y, Z [MDC_ECG_MAG_QRS_VECT_SAGI] 9–10 Length of the vector of the QRS wave in Einthoven's frontal plane [MDC_ECG_MAG_QRS_FRONT]
9	10	**T Maximum Vector Magnitudes** (Binary) Magnitudes of the Maximum Vector of the T wave in the X, Y, Z space and in the Frontal, Horizontal, Sagittal and Einthoven's frontal planes. Values are in µV (unsigned integers). Codes defined in 5.10.3.1 apply. Byte — Contents 1–2 Max Spatial T vector Magnitude, computed as square root of squared scalar magnitudes of X, Y, Z [MDC_ECG_MAG_T_VECT] 3–4 Max Frontal T vector Magnitude, computed as square root of squared scalar magnitudes of X, Y [MDC_ECG_MAG_T_VECT_FRONT] 5–6 Max Horizontal T vector Magnitude, computed as square root of

TAG	LENGTH	VALUE (Parameter data)
		squared scalar magnitudes of X, Z [MDC_ECG_MAG_T_VECT_HORIZ] 7–8 Max Sagittal T vector Magnitude, computed as square root of squared scalar magnitudes of Y, Z [MDC_ECG_MAG_T_VECT_SAGI] 9–10 Length of the vector of the T wave in Einthoven's frontal plane [MDC_ECG_MAG_T_FRONT]

10	24	**Jyy Azimuth and Elevation** (Binary)
		Azimuth and Elevation of the spatial vector at yy ms after the global end of the QRS complex (J point), where yy = 0, 20, 40, 60, 80 or xx milliseconds.
		Values are in angular degrees (signed integers). Codes defined in 5.10.3.1 apply.
		  Byte Contents
		  1–2 J0 Azimuth [MDC_ECG_ANGLE_J_AZIM]
		  3–4 J0 Elevation [MDC_ECG_ANGLE_J_ELEV]
		  5–6 J20 Azimuth [MDC_ECG_ANGLE_J20_AZIM]
		  7–8 J20 Elevation [MDC_ECG_ANGLE_J20_ELEV]
		  9–10 J40 Azimuth [MDC_ECG_ANGLE_J40_AZIM]
		11–12 J40 Elevation [MDC_ECG_ANGLE_J40_ELEV]
		13–14 J60 Azimuth [MDC_ECG_ANGLE_J60_AZIM]
		15–16 J60 Elevation [MDC_ECG_ANGLE_J60_ELEV]
		17–18 J80 Azimuth [MDC_ECG_ANGLE_J80_AZIM]
		19–20 J80 Elevation [MDC_ECG_ANGLE_J80_ELEV]
		21–22 Jxx Azimuth [MDC_ECG_ANGLE_Jxx_AZIM]
		23–24 Jxx Elevation [MDC_ECG_ANGLE_Jxx_ELEV]
		For the definition of xx see Tag 15.

11	12	**Jyy Vector Magnitude** (Binary)
		Magnitude of the spatial vector at yy ms after the global end of the QRS complex (J point), where yy = 0, 20, 40, 60, 80 or xx milliseconds.
		Magnitudes are computed as square root of squared scalar magnitudes of X, Y, Z. Values are in µV (unsigned integers). Codes defined in 5.10.3.1 apply.
		  Byte Contents
		  1–2 J Vector Magnitude [MDC_ECG_MAG_J_VECT]
		  3–4 J20 Vector Magnitude [MDC_ECG_MAG_J20_VECT]
		  5–6 J40 Vector Magnitude [MDC_ECG_MAG_J40_VECT]
		  7–8 J60 Vector Magnitude [MDC_ECG_MAG_J60_VECT]
		  9–10 J80 Vector Magnitude [MDC_ECG_MAG_J80_VECT]
		11–12 Jxx Vector Magnitude [MDC_ECG_MAG_Jxx_VECT]
		For the definition of xx see Tag 15.

12	14	**Additional QTC measurements (if any)** (Binary) This Tag shall only be used if more than one corrected QT Interval needs to be stored, in addition to the one already reported in bytes 5–6 of this additional global measurements block. All values are in ms (unsigned integers)

TAG	LENGTH	VALUE (Parameter data)
		Byte Contents 1–2 QTc (ms) (Corrected QT interval, correction method unknown or unspecified) [MDC_ECG_TIME_PD_QTC_NOS_GL] 3–4 QTcB (ms) (Corrected QT interval, Bazett formula. [MDC_ECG_TIME_PD_QTC_BAZETT] and [MDC_ECG_TIME_PD_QT_CORR_GL] 5–6 QTcH (ms) (Corrected QT interval, Hodges formula) [MDC_ECG_TIME_PD_QTC_HODGES] 7–8 QTcFR (ms) (Corrected QT interval, Framingham formula) [MDC_ECG_TIME_PD_QTC_FRAMINGHAM] 9–10 QTcF (ms) (Corrected QT interval, Fridericia formula) [MDC_ECG_TIME_PD_QTC_FREDERICA] 11–12 QTcL (ms) (Corrected QT interval, Linear formula) 13–14 QTcU (ms) (Corrected QT interval, User defined) [MDC_ECG_TIME_PD_QTC_USER]

13	19	**Editable Intervals and durations** (Binary)
		
		All interval and duration values are stored in milliseconds (unsigned integer)
		
		Byte Contents
		
		1 Binary: Confirmed / Nonconfirmed measurements
		
		    Value Type
		    0 Original measurements (not overread).
		    1 Confirmed measurements.
		    2 Overread measurements, but not confirmed.
		
		2–3 PP interval, from actual P wave to P wave of preceding beat [MDC_ECG_TIME_PD_PP_GL]
		
		4–5 RR interval, from actual QRS to preceding beat [MDC_ECG_TIME_PD_RR_GL] and [MDC_ECG_RR]
		
		6–7 RR for QTC, RR interval used for computing corrected QT intervals (usually the mean RR interval of the analysed ECG sequence). Semantically equivalent to [MDC_ECG_TIME_PD_RR_GL] and to [MDC_ECG_TIME_PD_RR_GL_MEAN], depending on the method used for computing RR
		
		8–9 PQ interval (also called PR interval) duration: P onset to QRS onset [MDC_ECG_TIME_PD_PQ_GL]
		
		10–11 P wave duration: P onset to P offset [MDC_ECG_TIME_PD_P_GL]
		
		12–13 PQ segment (also called PR segment) duration: P offset to QRS onset [MDC_ECG_TIME_PD_PQ_SEG_GL]
		
		14–15 QRS complex duration: QRS onset to QRS end [MDC_ECG_TIME_PD_QRS_GL]
		
		16–17 QT interval duration: QRS onset to T offset (not corrected for heart rate) [MDC_ECG_TIME_PD_QT_GL]
		
		18–19 QTU interval duration: QRS onset to U wave offset, used when T and U waves are fused and T offset can thus not be determined [MDC_ECG_TIME_PD_QTU_GL]
		
		This editable interval and duration measurements block shall be protected

TAG	LENGTH	VALUE (Parameter data)
		against automatic update by computer measurement programs if already confirmed or overread. NOTE 1 The PP an RR measurements stored in this measurement block are different from the average PP an RR intervals stored in 5.10.3.2, bytes 3 to 6, and make sense only if the analysed complex is a selected one. NOTE 2 RR for QTC is usually identical to the average RR interval stored in 5.10.3.2, bytes 3 to 4, but can be different in case the heart rate is unstable.
14	2	**Global T wave onset** (Binary) Global onset of the T wave, in milliseconds (unsigned integer) Byte Contents 1–2 T onset [MDC_ECG_TIME_START_T_LEAD_CONFIG] NOTE 3 T onset is given as for QRS onset and offset in milliseconds from either the beginning of the reference beat or from the beginning of the ECG record (see 5.10.3.3, NOTE 1). It is typically computed as the earliest T onset of each individual lead or determined from the spatial loop using spatiotemporal criteria.
15	2	**Jxx Time Point definition for ST-Jxx lead-by-lead ST measurements and Jxx Vector Magnitude, Azimuth and Elevation measurements** (Binary) Definition of a reference time point xx ms after the global end of the QRS complex for lead-by-lead potential measurements in ST segment and Jxx vector measurements. Byte Contents 1–2 xx in milliseconds (unsigned integer) [MDC_ECG_TIME_ST_Jxx] NOTE 4 The REFID of the corresponding lead-by-lead ST-Jxx measurement is MDC_ECG_AMPL_ST, see 5.13.6, bytes 69 to 70.
16	2	**Heart rate** (Binary) Heart rate, method of calculation unspecified Byte Contents 1–2 Heart rate, in beats/minute (unsigned integer) [MDC_ECG_HEART_RATE]
17 to 254	(none)	**Reserved** for future use
255	0	**None (section terminator).**

For the angles of the vectors in the (X, Y, Z) space, the conventions shown in Figure 11 shall be used.
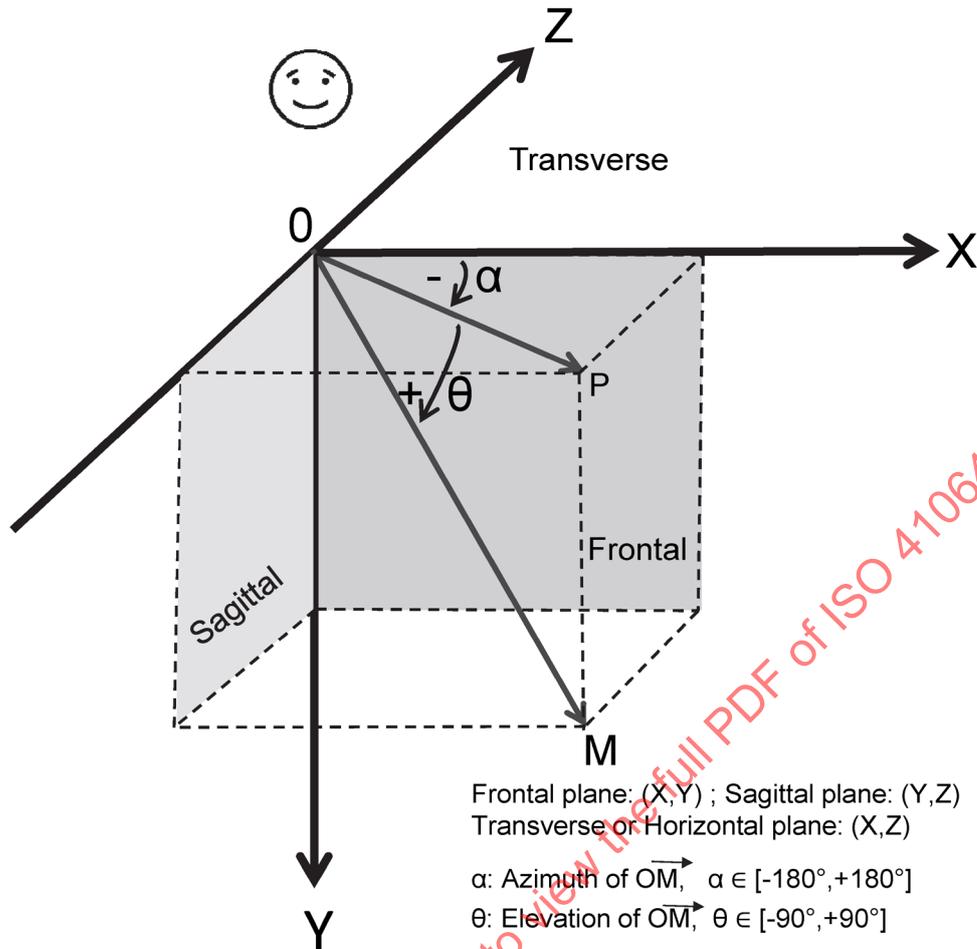
Figure 11 — Angle definitions in the X, Y, Z space

5.10.4 Manufacturer specific global measurement block

— A block with variable length for manufacturer specific global measurements can be added to this section, after the data on additional measurements.

— The start of the manufacturer specific block (counting from the beginning of the Section ID Header) shall be derived from the information given for the global ECG measurement data. For example, if the measurement blocks contain global measurements for each reference beat type (the number of main measurement blocks is equal to the number of reference beat types), the start of the manufacturer specific block will be 16 (i.e. the size of the "Section ID Header", see 5.2.7) + 6 + (Number of reference beat types times 16) + (Number of pacemaker spikes times 4) + (Number of pacemaker spikes times 6) + (2 + Number of QRSs) + (9 + the number of bytes of the tagged global measurements area) + 1. The end shall be given in the Section ID Header by the total length of the section (bytes 5 to 8 of the Section ID header), including the 16 bytes of the Section ID Header (see 5.2.7), the length of the manufacturer specific block, and the padding byte, if any (see 5.2.1).

5.10.5 Overview of the data part of the global measurements section

An overview of the data part of Section 7, global measurements, is presented in Figure 12.
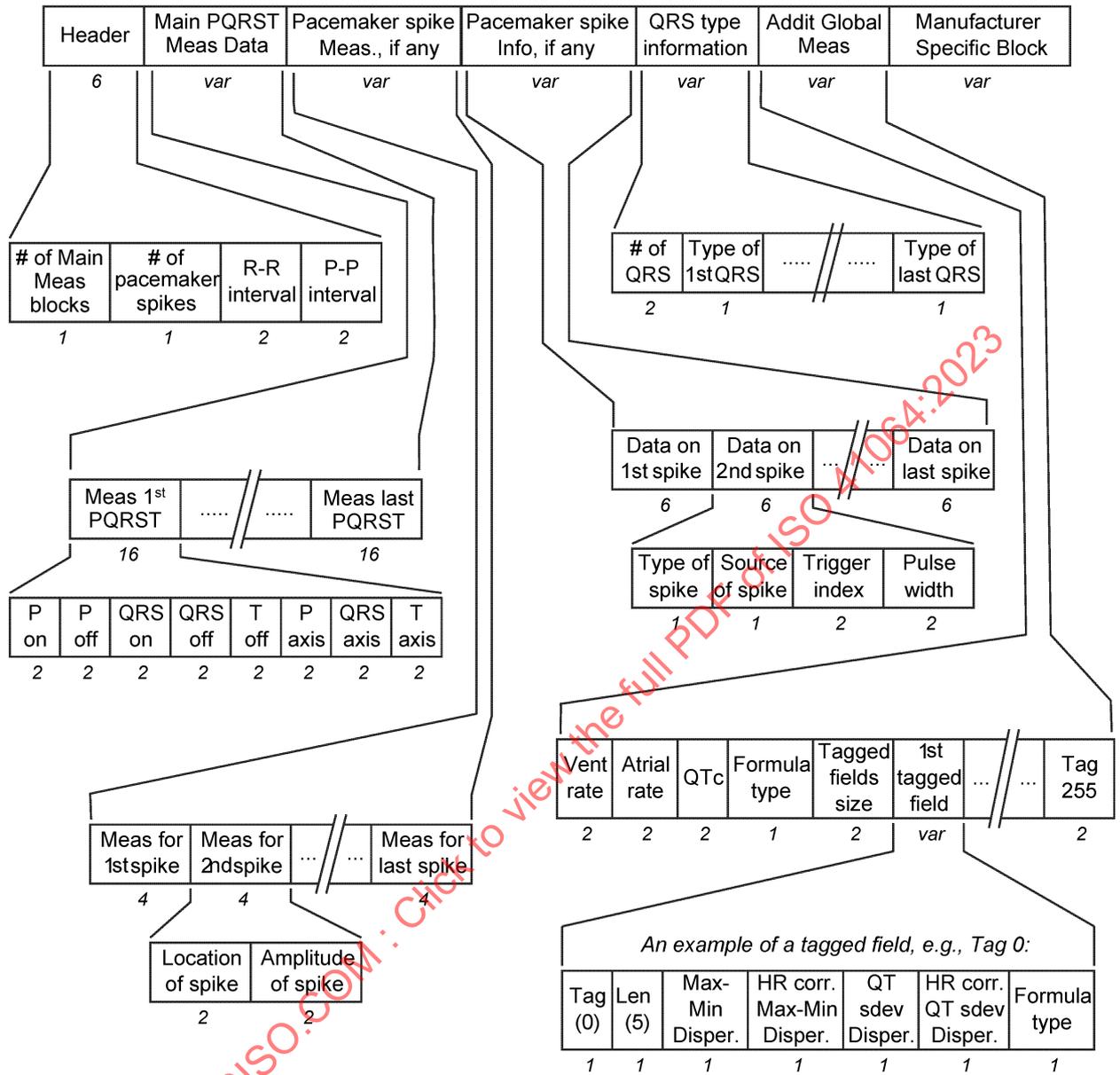
Figure 12 — Overview of the data part of the global measurements section

5.11 Storage of full text interpretive statements – Section 8

5.11.1 This section contains a text version of the latest diagnostic interpretation of the ECG.

5.11.2 If present, the section shall start with a "Section ID Header" as defined in 5.2.7.

5.11.3 The data portion of this section includes a data header followed by multiple statements.

5.11.4 Data part Header

The header of the data part of the section contains the status and the time and date of the storage and/or overreading of the interpretive statements, and the number of stored statements. Its format is as follows:

Byte	Contents
1	Binary: Textual interpretation report overreading Confirmation Status

Value	Type
0	Original report (not overread)
1	Confirmed report
2	Overread report, but not confirmed

Byte	Contents
2 to 3	Binary: Year (Full integer notation, as in 2018).
4	Binary: Month (range 01 to 12; 01 = January)
5	Binary: Day (range 01 to 31)
6	Binary: Hours (range 00 to 23)
7	Binary: Minutes (range 00 to 59)
8	Binary: Seconds (range 00 to 59)
9	Binary: Number of statements in this section
10 to 11	Signed Integer: Date&Time Time Zone (TZ), specified as an offset from UTC in minutes. Semantically equivalent to MDC_ATTR_TIME_ZONE
	The content of this field shall identify the time zone related to the local time stored here above in bytes 2 to 8. The format shall be identical to the Time Zone format specified in bytes 1–2 of Tag 34 in Table 2. In case the local Time Zone is unknown, TZ shall be set to 0x7FFF.
12 to 16	Reserved for future use. Shall be set to Null (0)

The date and time (bytes 2 to 8) of the storage and/or of the overreading of the interpretive statements shall be expressed as local time in the Time Zone of the overreader or of the interpretive device. Date and time are semantically equivalent to MDC_ATTR_TIME_ABS

NOTE   TZ has been introduced to specify the Time Zone of a remote overreading physician in case he/she is not located in the same Time Zone as the acquiring device.

The different statements then follow, starting from byte 17 on. The format for each single statement is defined hereafter in 5.11.5 and 5.11.6.

5.11.5 Statement data format

Each statement consists in a variable length text string field and is identified by an incremental sequence number. Its format is as follows:

Byte	Contents
1	Binary: Statement sequence number, starting with 1
2 to 3	Binary: Statement body length (number of bytes in the statement body field, starting with the first byte following this Statement body length field, and including the NULL terminator).
4 to ***	Statement body: UTF-8 encoded text string terminated by NULL.

5.11.6 No codes are allowed in the statements, unless accompanied by descriptive text.

5.11.7 Overview of the data part of the full text interpretive statements section

An overview of the data part of section 8, full text interpretive statements, is provided in Figure 13.
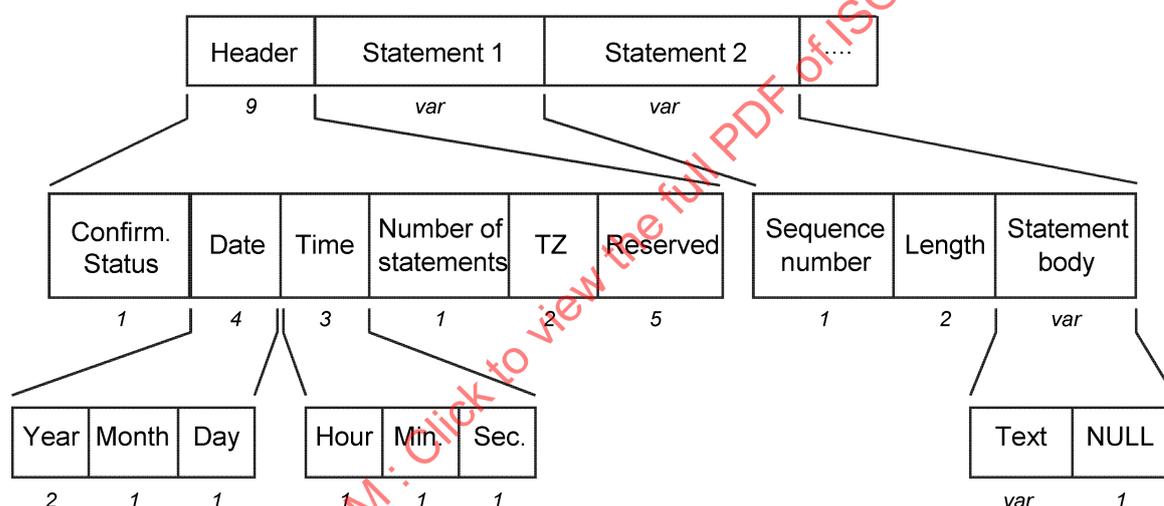
Figure 13 — Overview of the data part of Section 8

5.12 Storage of manufacturer specific interpretive statements and data related to the overreading trail – Section 9

5.12.1 This section is reserved for manufacturer specific diagnostic statements of the analysing device and overreading trail of the interpretation. The source of the analysing device and the name of the overreading physician (or device) are defined in the "Header Section" (Section 1).

5.12.2 If present, the section shall start with a "Section ID Header" as defined in 5.2.7.

5.12.3 The structure and format of the data part of this section are manufacturer specific.

5.13 Per-lead ECG measurements – Section 10

5.13.1 General

This section contains the per-lead measurements of the type 0 reference beat. The measurements are stored in separated blocks, one per recorded lead. The standard measurements and their format are

listed below in 5.13.6. A manufacturer specific area, and a list of special codes for peculiar conditions have been provided.

5.13.2 Section ID Header

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

5.13.3 Data part content

The data part of the per-lead ECG measurements section consists of a data part header followed by as many lead measurement blocks as there are measured leads (one lead measurement block for each measured lead). Each lead measurement block shall consist of four fields:

a) Lead identifier (Binary 2 bytes). Refer to 5.6.4, byte 9, for lead numbering scheme.

b) Length (unsigned integer) of the lead measurement block in bytes, excluding bytes 1 to 4 (Binary; 2 bytes).

c) Fixed block length (196 bytes), containing up to 84 basic measurements (signed integers) (Binary fields; 2 bytes each).

d) Manufacturer per-lead measurement area, if any, starting from byte 201 on (Binary). No specific guidelines are included for the layout or format of this manufacturer specific block.

The starting byte and the space left for the manufacturer specific measurement area are no longer backwards compatible with SCP-ECG versions 1.x and 2.x. Manufacturers must use section versioning to remove these limitations or, if the number of manufacturer specific measurements is larger than the allowed space, use manufacturer specific sections for storing these manufacturer specific ECG measurements.

5.13.4 Special codes utilization specification

Special codes, as defined in the CSE Project and in section 7 Global measurements, subclause 5.10.3.1, have been reserved to indicate:

29 999 (decimal)   Measurement not computed by the program.

29 998 (decimal)   Measurement result not found due to rejection of the lead by measurement program.

19 999 (decimal)   Measurement not found because wave (e.g. Q wave) was not present in the corresponding lead.

5.13.5 Per-lead ECG measurements data header

The header of the data part of this section contains the number of leads for which a measurement block is transmitted (binary, 2 bytes), followed by 2 bytes reserved for manufacturer-specific information.

5.13.6 Lead measurement block format

Let Pon, QRSon and Ton be called the local (ie lead specific) onsets and Poff, QRSoff and Toff be called the local (i.e. lead specific) offsets of the P, QRS and T-wave respectively.

Then, each lead measurement block shall consist of:

Byte   Contents

1 to 2   Lead ID

3 to 4   Length of the lead measurement block

5 to 6   P-duration (ms) (total P-duration, from Pon to Poff in specified lead, including all P-wave components, viz P+, P-, P', P", etc. components) [MDC_ECG_TIME_PD_P] and [*MDC_ECG_WAVC_PWAVE_DURN*]

7 to 8   PR-interval (ms) (from Pon to QRSon in specified lead) [MDC_ECG_TIME_PD_PQ]

9 to 10   QRS-duration (ms) (from QRSon to QRSoff in specified lead) [MDC_ECG_TIME_PD_QRS] and [*MDC_ECG_WAVC_QRSWAVE_DURN*]

11 to 12   QT-interval (ms) (from global QRS onset to Toff in specified lead [MDC_ECG_TIME_PD_QT] and [*MDC_ECG_WAVC_QRSTWAVE_DURN*] (see Note 4)

13 to 14   Q-duration (ms) [MDC_ECG_TIME_PD_Q] and [*MDC_ECG_WAVC_QWAVE_DURN*] and [*MDC_ECG_WAVC_QSWAVE_DURN*]

15 to 16   R-duration (ms) [MDC_ECG_TIME_PD_R_1] and [*MDC_ECG_WAVC_RWAVE_DURN*]

17 to 18   S-duration (ms) [MDC_ECG_TIME_PD_S_1] and [*MDC_ECG_WAVC_SWAVE_DURN*]

19 to 20   R'-duration (ms) [MDC_ECG_TIME_PD_R_2] and [*MDC_ECG_WAVC_RRWAVE_DURN*]

21 to 22   S'-duration (ms) [MDC_ECG_TIME_PD_S_2] and [*MDC_ECG_WAVC_SSWAVE_DURN*]

23 to 24   Q-amplitude (µV) [MDC_ECG_AMPL_Q]

25 to 26   R-amplitude (µV) [MDC_ECG_ELEC_POTL_R_1]

27 to 28   S-amplitude (µV) [MDC_ECG_ELEC_POTL_S_1]

29 to 30   R'-amplitude (µV) [MDC_ECG_ELEC_POTL_R_2]

31 to 32   S'-amplitude (µV) [MDC_ECG_ELEC_POTL_S_2]

33 to 34   J-point-amplitude (µV) (amplitude of the J-point = amplitude at the global end of QRS) [MDC_ECG_AMPL_J]

35 to 36   P(+)-amplitude (µV)

37 to 38   P(-) -amplitude (µV)

39 to 40   T(+)-amplitude (µV) [MDC_ECG_AMPL_T_MAX]

41 to 42   T(-)-amplitude (µV) [MDC_ECG_AMPL_T_MIN]

43 to 44   ST-slope (µV/s) (Slope of ST-segment, from global end of QRS plus 20 ms to global end of QRS plus 60 ms, in specified lead) [MDC_ECG_SLOPE_ST]

45 to 46   P morphology description, as defined below in 5.13.6.1

47 to 48   T morphology description, as defined below in 5.13.6.1

49 to 50   Iso-electric segment at onset of QRS (in ms) (Segment I, from global onset of QRS to QRSon in specified lead) [*MDC_ECG_WAVC_IWAVE_DURN*]

51 to 52   Iso-electric segment at the end of QRS (in ms) (Segment K, from QRSoff in specified lead to global QRS end) [*MDC_ECG_WAVC_KWAVE_DURN*]

53 to 54   VAT (ms) (Ventricular Activation Time) [MDC_ECG_TIME_PD_VENT_ACTIV] and [*MDC_ECG_WAVC_VAT_DURN*]

55 to 56   Quality code reflecting ECG recording conditions, as defined below in 5.13.6.2

57 to 58   ST-amplitude at the global end of QRS (J-point) plus 20 ms (µV)

[MDC_ECG_ELEC_POTL_ST_20]

59 to 60   ST-amplitude at the global end of QRS (J-point) plus 60 ms (μV) [MDC_ECG_ELEC_POTL_ST_60]

61 to 62   ST-amplitude at the global end of QRS (J-point) plus 80 ms (μV) [MDC_ECG_ELEC_POTL_ST_80]

63 to 64   ST-amplitude at the global end of QRS (J-point) plus 1/16 average R-R interval (μV)

65 to 66   ST-amplitude at the global end of QRS (J-point) plus 1/8 average R-R interval (μV)

67 to 68   ST-amplitude at global end of QRS (J-point) plus 40 ms (μV) [MDC_ECG_ELEC_POTL_ST_40]

69 to 70   ST-Jxx (μV) (ST-amplitude at global end of QRS (J-point) plus xx ms) [MDC_ECG_AMPL_ST]

71 to 72   ST-segment shape (immediately after global end of QRS), as defined below in 5.13.6.3 [MDC_ECG_SHAPE_ST] (see Note 11)

73 to 74   Second ST-T segment shape (after ST-T inflection point, or after global end of QRS+100 ms), as defined below in 5.13.6.3 [MDC_ECG_SHAPE_ST_T] (see Note 11)

75 to 76   Pon (ms) (onset of P-wave in the specified lead) [MDC_ECG_TIME_START_P] and [*MDC_ECG_WAVC_PWAVE_ONSET*]

77 to 78   Poff (ms) (end of P-wave in the specified lead) [MDC_ECG_TIME_END_P] and [*MDC_ECG_WAVC_PWAVE_OFFSET*]

79 to 80   QRSon (ms) (onset of QRS-wave in the specified lead) [MDC_ECG_TIME_START_QRS] and [*MDC_ECG_WAVC_QRSWAVE_ONSET*]

81 to 82   QRSoff (ms) (end of QRS-wave in the specified lead) [MDC_ECG_TIME_END_QRS] and [*MDC_ECG_WAVC_QRSWAVE_OFFSET*]

83 to 84   Ton (ms) (onset of T-wave in the specified lead) [MDC_ECG_TIME_START_T] and [*MDC_ECG_WAVC_TWAVE_ONSET*]

85 to 86   Toff (ms) (end of T-wave in the specified lead) [MDC_ECG_TIME_END_T] and [*MDC_ECG_WAVC_TWAVE_OFFSET*]

87 to 88   PRseg duration (ms) (from Poff to QRSon in specified lead) [MDC_ECG_TIME_PD_PQ_SEG] and [*MDC_ECG_WAVC_PRSEG_DURN*]

89 to 90   QTU (ms) (QTU interval, from global onset of QRS to end of U-wave in specified lead) [MDC_ECG_TIME_PD_QTU]

91 to 92   P(+)-duration (ms)

93 to 94   P(-)-duration (ms)

95 to 96   R"-duration (ms) [MDC_ECG_TIME_PD_R_3] and [*MDC_ECG_WAVC_RRRWAVE_DURN*]

97 to 98   S"-duration (ms) [MDC_ECG_TIME_PD_S_3] and [*MDC_ECG_WAVC_SSSWAVE_DURN*]

99 to 100   R"-amplitude (μV) [MDC_ECG_ELEC_POTL_R_3]

101 to 102   S"-amplitude (μV) [MDC_ECG_ELEC_POTL_S_3]

103 to 104   Rmax (μV) (maximum amplitude of R-wave) [MDC_ECG_AMPL_R] (see Note 14)

105 to 106   Smin (μV) (minimum amplitude of S-wave, i.e. maximum value of the absolute amplitude values of the different S-waves) [= - Smax, MDC_ECG_AMPL_S] (see Note14)

107 to 108   Pintegral ((μV x ms)/100) (Integral of P-wave in the specified lead, computed from global

P onset up to the global P end) [MDC_ECG_INTEGRAL_P] and [*MDC_ECG_WAVC_PWAVE_INTEGRAL*]

109 to 110   Parea ((μV x ms)/100) (Area of P-wave in the specified lead, computed from global P onset up to the global P end) [MDC_ECG_AREA_P] and [*MDC_ECG_WAVC_PWAVE_AREA*]

111 to 112   Qintegral ((μV x ms)/100) (Integral of Q-wave in the specified lead, computed from global QRS onset up to the end of Q wave or up to the global QRS end in case of a QS wave) [MDC_ECG_INTEGRAL_Q] and [*MDC_ECG_WAVC_QWAVE_INTEGRAL*]

113 to 114   Qarea ((μV x ms)/100) (Area of Q-wave in the specified lead, computed from global QRS onset up to the end of Q wave or up to the global QRS end in case of a QS wave) [MDC_ECG_AREA_Q] and [*MDC_ECG_WAVC_QWAVE_AREA*]

115 to 116   QRSintegral ((μV x ms)/100) (Integral of QRS-wave in the specified lead, computed from global QRS onset up to the global QRS end) [MDC_ECG_INTEGRAL_QRS] and [*MDC_ECG_WAVC_QRSWAVE_INTEGRAL*]

117 to 118   QRSarea ((μV x ms)/100) (Area of QRS-wave in the specified lead, computed from global QRS onset up to the global QRS end) [MDC_ECG_AREA_QRS] and [*MDC_ECG_WAVC_QRSWAVE_AREA*]

119 to 120   ST-Tintegral ((μV x ms)/100) (Integral of the ST-T segment in the specified lead, computed from the global end of QRS up to the global onset of T) [MDC_ECG_INTEGRAL_ST] and [*MDC_ECG_WAVC_STSEG_INTEGRAL*]

121 to 122   ST-Tarea ((μV x ms)/100) (Area of the ST-T segment in the specified lead, computed from the global end of QRS up to the global onset of T) [MDC_ECG_AREA_ST] and [*MDC_ECG_WAVC_STSEG_AREA*]

123 to 124   Tintegral ((μV x ms)/100) (Integral of T-wave in the specified lead, computed from the global onset of T up to the global end of T) [MDC_ECG_INTEGRAL_T] and [*MDC_ECG_WAVC_TWAVE_INTEGRAL*]

125 to 126   Tarea ((μV x ms)/100) (Area of T-wave in the specified lead, computed from the global onset of T up to the global end of T) [MDC_ECG_AREA_T] and [*MDC_ECG_WAVC_TWAVE_AREA*]

127 to 128   P1-localization (ms) (Duration of the interval between global P onset and first extremum of the P wave in the specified lead) [MDC_ECG_TIME_PD_P1] (see Note 18)

129 to 130   P2-localization (ms) (Duration of the interval between global P onset and second extremum of the P wave in the specified lead) [MDC_ECG_TIME_PD_P2]

131 to 132   P3-localization (ms) (Duration of the interval between global P onset and third extremum of the P wave in the specified lead) [MDC_ECG_TIME_PD_P3]

133 to 134   P1-duration (ms) (Duration of the first deflection in P wave)

135 to 136   P2-duration (ms) (Duration of the second deflection in P wave) [*MDC_ECG_WAVC_PPWAVE_DURN*]

137 to 138   P3-duration (ms) (Duration of the third deflection in P wave) [*MDC_ECG_WAVC_PPPWAVE_DURN*]

139 to 140   P1-amplitude (μV) (Amplitude level of the first extremum of the P-wave in the specified lead)

141 to 142   P2-amplitude (μV) (Amplitude level of the second extremum of the P-wave in the specified lead)

143 to 144   P3-amplitude (μV) (Amplitude level of the third extremum of the P-wave in the specified

lead) [MDC_ECG_AMPL_P3]

145 to 146   Pmax (μV) (maximum amplitude of P-wave) (see Note 21)

147 to 148   Pmin (μV) (minimum amplitude of P-wave) (see Note 21)

149 to 150   Jo-localization (ms) (Duration of the interval between global QRS onset and onset of end QRS notch in the specified lead)

151 to 152   Jp-localization (ms) (Duration of the interval between global QRS onset and the peak of an end QRS notch or the onset of an end QRS slur in the specified lead)

153 to 154   D1-duration (ms) (Duration from Jo to Jp in the specified lead)

155 to 156   D2-duration (ms) (Duration from Jp to Jt (end of end QRS notch) in the specified lead)

157 to 158   Jo-amplitude (μV) (Amplitude level of the Jo point in the specified lead)

159 to 160   Jp-amplitude (μV) (Amplitude level of the Jp point in the specified lead)

161 to 162   QTc (ms) (Corrected QT interval, correction method unknown or specified elsewhere, viz in the physician's guide) [MDC_ECG_TIME_PD_QTC_NOS]

163 to 164   QTcB (ms) (Corrected QT interval, Bazett formula) [MDC_ECG_TIME_PD_QTcB] and [MDC_ECG_TIME_PD_QT_CORR]

165 to 166   QTcF (ms) (Corrected QT interval, Fridericia formula) [MDC_ECG_TIME_PD_QTcF]

167 to 168   QTcL (ms) (Corrected QT interval, Linear formula)

169 to 170   PP interval (ms) (mean PP interval in specified lead) [MDC_ECG_TIME_PD_PP] (see Note 24)

171 to 172   RR interval (ms) (mean RR interval in specified lead) [MDC_ECG_TIME_PD_RR] (see Note 24)

173 to 200   Reserved for future use

201 to ***   Manufacturer specific block for measurement results

All measurements shall be expressed as signed integers. The amplitudes of the Q, S, S', S", T(-) and P(-) waves and Pmin, Smin shall be expressed as negative integers, as well as the J-point amplitude and J+20, J+40, J+60, J+80, Jxx, J+RR/16, J+RR/8, P1, P2, P3, ST-slope and all integrals, when they are negative. Note that the J-point (J), sometimes also called Junctional point or J termination (Jt, see J Am Coll Cardiol. 2015;66(4):470-477 [36]), is the same as the global QRS-end location.

Bytes 173 to 200 have to be set to zero and need to be transmitted if a manufacturer specific measurement block is included.

NOTE 1   All upper case format 11073-10102 REFIDs listed in this section are per-lead ECG measurements REFIDs. They apply to a specific ECG lead (identified in bytes 1-2) and are typically encoded by appending the 8-bit MDC_ECG_discrim_LEADS discriminator. For example, the P-wave duration in Lead V2 (Lead ID = 02) would be identified as MDC_ECG_TIME_PD_P_LEAD_V2. Alternatively, several per-lead measurements can also be encoded as 11073-10102 ECG WAVC wave components. The corresponding REFIDs are typed in upper case italic format. For example, although the preferred REFID for representing the Q wave duration in Lead V2 (Lead ID = 02) would be MDC_ECG_TIME_PD_Q_LEAD_V2, the latter can also be identified as MDC_ECG_WAVC_QWAVE_DURN. The MDC_ECG_WAVC type REFIDs however cannot contain any lead ID information. The relationship to Lead V2 can thus be either explicitly indicated for example by XML message structure (by using MDC_ECG_LEAD_V2 identifier when exporting to an XML file), or implicitly by using a table structure similar to the present measurement block structure.

NOTE 2   Manufacturers using other areas of interest (onset and/or end of the time fiducials) than the ones recommended in the present section when measuring durations, time intervals, areas, integrals and slopes typically specify the method they are using in the physician's guide.

NOTE 3   PR-interval is also called PQ-interval in Europe

NOTE 4   Using this definition for measuring the per-lead QT-intervals will remove QRS onset variability when measuring QT interval dispersion.

NOTE 5   There are different methods for measuring Q, R and S (or R', S', R" and S") durations. Some include the I and K isoelectric segments. The typical method is to exclude the isoelectric segments durations from the initial and terminal wave durations, and to store I and K durations separately, see European Heart Journal 1985; vol.6, pages 815-825 [44]. Manufacturers who are including the isoelectric segments durations in the initial and terminal wave durations typically specify which method they are using in the physician's guide.

NOTE 6   For the determination of the global end of QRS (J-point), see European Heart Journal 1985; vol.6, pages 815-825 [44] and J Am Coll Cardiol. 2015;66(4):470-477 [36].

NOTE 7   P+ (respectively P-) amplitudes can take the same values as [MDC_ECG_AMPL_P_MAX] (respectively [MDC_ECG_AMPL_P_MIN]), depending on P-wave morphology.

NOTE 8   For the definition of the iso-electric segments I and K see European Heart Journal 1985; vol.6, pages 815-825 [44]. Briefly, "I" is the interval between the global onset of QRS derived from all simultaneously recorded leads and QRSon, the onset of QRS in a specific lead. Conversely, "K" is the time between QRSoff, the end of QRS in a specific lead, and the global end of QRS.

NOTE 9   The ventricular activation time (VAT), also called time to the onset of the Intrinsic or Intrinsicoid Deflection, is measured from global QRS onset to the latest positive QRS peak, i.e. to the peak of the R wave or, if present, to the peak of the R' or R" waves in a specified lead.

NOTE 10   Time Point xx for ST-Jxx lead-by-lead measurements is defined in clause 5.10.3.7 Additional Global Measurements, Table 8, Tag 15

NOTE 11   ST morphology descriptors are computed from the first 100 ms following the global end of QRS (J-point), see J Am Coll Cardiol. 2015;66(4):470-477 [36].

NOTE 12   Pon, Poff, QRSon, QRSoff, Ton and Toff are the time in ms from the beginning of the reference beat, in the specified lead.

NOTE 13   PR segment is also called PQ segment in Europe.

NOTE 14   Rmax and Smin are respectively computed as Max [R, R', R"-amplitude] and Min [S, S', S"-amplitude].

NOTE 15   Wave and ST segment Integrals are computed in (µVolt x millisecond)/100 by integrating signed values from the global onset to the global offset of the corresponding waves.

NOTE 16   Wave and ST segment Areas are computed in (µVolt x millisecond)/100 by integrating absolute values from the global onset to the global offset of the corresponding waves.

NOTE 17   Qintegral typically take the same absolute value as Qarea, but their values depend on the correctness of wave delineation and baseline correction and on whether or not the isoelectric segment I is included.

NOTE 18   M shaped and W shaped P-waves (see 5.13.6.1) are considered as P waves having only one extremum P1 whose localisation corresponds to the peak with the largest absolute amplitude. In case the two peaks have equal amplitude, the first peak localisation is selected.

NOTE 19   P1-duration is presently not semantically equivalent to MDC_ECG_WAVC_PWAVE_DURN. Indeed, 11073-10102:2014 currently defines PWAVE as the "P wave", instead of defining PWAVE as the first deflection in P wave to be consistent with the PPWAVE definition.

NOTE 20   In 11073-10102:2014, P1-amplitude and P2-amplitude are ambiguously defined as [MDC_ECG_AMPL_P_MAX] and [MDC_ECG_AMPL_P_MIN], respectively.

NOTE 21   Pmax and Pmin are respectively computed as Max [P1, P2, P3-amplitude] and Min [P1, P2, P3-amplitude].

NOTE 22   For the definition of Jo, Jp, Jt, D1, D2 and end QRS notches or slurs, see J Am Coll Cardiol. 2015;66(4):470-477 [36].

NOTE 23   The corrections for heart rate are performed on the QT interval defined in bytes 11 to 12, i.e. from global QRS onset to Toff in the specified lead. The heart rate used for performing the corrections can be found in 5.10.3.7 Additional Global Measurements, Table 8, Tag 13, bytes 6-7. QTcB and QTcF have been introduced here

for compatibility reasons with 11073-10102, but their use should be discouraged because they overcompensate heart rate differences, see JACC 2009;53:982-91.

NOTE 24   Measurements in bytes 169-172 have been introduced for compatibility reasons with 11073-10102, but do not make much sense as they convey the same information as the corresponding global measurements.

5.13.6.1 P and T morphology codes

The P and T morphology description codes (Bytes 45 to 48) are defined as follows:

Value	Contents	
0	unknown	
1	positive	⌢
2	negative	⌣
3	positive/negative	∿
4	negative/positive	∿
5	positive/negative/positive	∿
6	negative/positive/negative	∿
7	notched M-shape	⋀
8	notched W-shape	⋁

5.13.6.2 Signal Quality codes

The ECG lead signal Quality Code (Bytes 55 to 56) is defined as follows:

2 binary bytes per lead, consisting of 8 two-bit fields. Each two-bit pair represents the noise level in one of four classes.

The least significant bit of byte 55 is defined as bit 0. The most significant bit of byte 56 is defined as bit 15.

Bit	Contents
0 to 1	AC (mains) noise
2 to 3	overrange
4 to 5	wander
6 to 7	tremor or muscle artefact
8 to 9	spikes or sudden jumps
10 to 11	electrode loose or off
12 to 13	pacemaker
14 to 15	interchanged lead

The four noise level classes of each of the eight 2 bit fields are coded as follows:

Level	Class
0	none/no
1	moderate/yes
2	severe
3	unknown

5.13.6.3 ST and ST-T shape/morphology codes

The ST and ST-T shape/morphology description codes (Bytes 71 to 74) are defined as follows:

Value	Contents
0	unknown
1	horizontal
2	upward sloping
3	upward sloping, linear (linear_up)
4	upward sloping, concave (concave_up)
5	downward sloping
6	downward sloping, linear (linear_down)
7	downward sloping, concave (concave_down)

ISO 11073–10102:2014 has currently only defined four enumerated values for coding ST and ST-T shape: concave_up, linear, concave_down, and unknown. Horizontal, upward sloping and downward sloping are recommended terms from J Am Coll Cardiol. 2015;66(4):470–477 [36].

5.13.7 Overview of the data part of the per-lead measurements section

An overview of the data part of this section is presented in Figure 14.
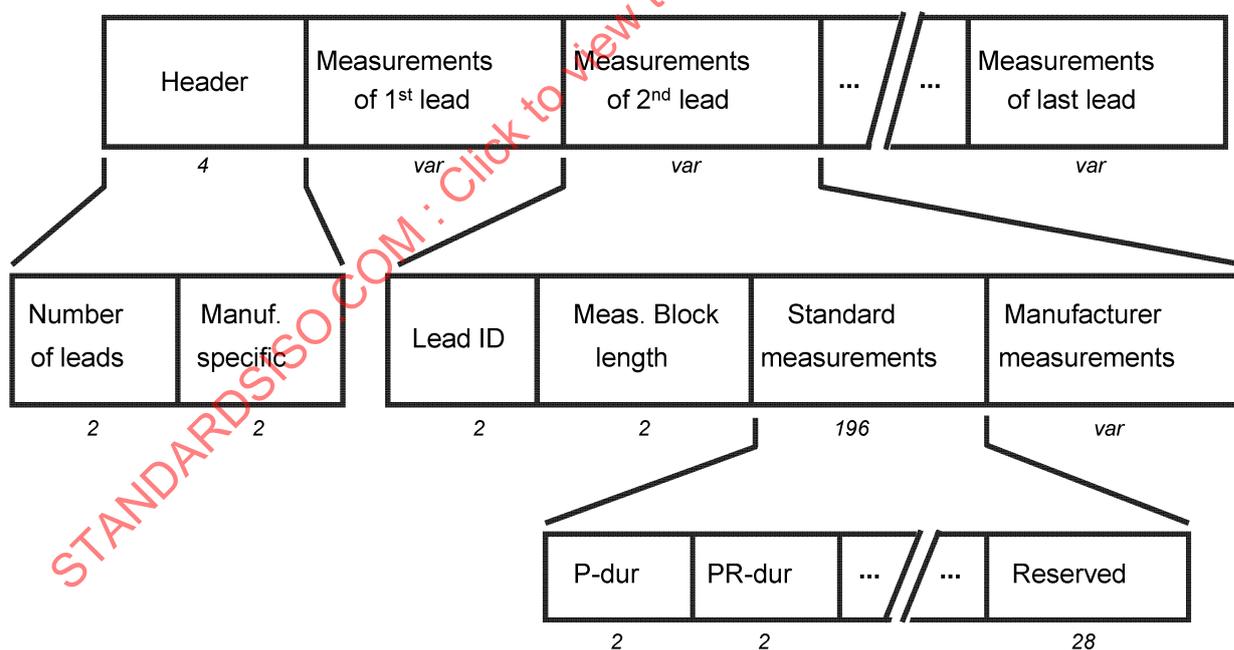
Figure 14 — Overview of the data part of the per-lead ECG measurements section

5.14 Storage of the universal ECG interpretive statement codes – Section 11

5.14.1 General

This section contains the most recent interpretation and overreading data. Different coding schemes are possible: (1) according to the Universal Statement Codes and Coding Rules defined in Annex B: (2) based on the categorized AHA statement codes specified in reference [21]; (3) according to the CDISC code (see reference [30]).

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

The data contained in this section shall be consistent with the data in Sections 8, 9 and 18 Annotated ECG.

5.14.2 Section ID header

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

5.14.3 Section data structure and format

Data shall be stored on a statement-by-statement basis. There are five types of statements possible:

1) Universal Statement Codes (as defined in Annex B).

2) Full Text (as used in Section 8).

3) Statement Logic (identifying logical relationships between statements).

4) Categorized AHA statement codes [21]

5) CDISC codes [30]

To store the five types of statements, three separate statement data field types were defined (see Figure 15).

Only one statement of type "Statement Logic" is allowed to identify the logical relationships between statements of the other types. If no "Statement Logic" type statement is included in the section, it is assumed that all recorded statements are equally valid, and have no "special" relationship to each other, except for what is declared in the statement. The number of statements of the types "Universal Statement Codes", "AHA statement codes", "CDISC codes" and "Full Text" are not restricted.

5.14.4 Section data part content

The data part of this section includes a data part header followed by one or more statements. The layout of the data part is presented in 5.14.5, Figure 15, and its content is explained hereafter.

5.14.4.1 Section data part Header

The header of the data part of the section contains the status and the time and date of the storage and/or overreading of the interpretive statements, and the number of stored statements. Its format is as follows:

Byte	Contents
1	Binary: Interpretation report overreading Confirmation Status

Value	Type
0	Original report (not overread)
1	Confirmed report
2	Overread report, but not confirmed

Byte	Contents
2 to 3	Binary: Year (Full integer notation, as in 2018)
4	Binary: Month (range 01 to 12; 01 = January)
5	Binary: Day (range 1 to 31)
6	Binary: Hours (range 0 to 23) (time is always local time)
7	Binary: Minutes (range 0 to 59)
8	Binary: Seconds (range 0 to 59)
9	Binary: Number of statements in this section
10 to 11	Date&Time Time Zone (TZ), specified as an offset from UTC in minutes (signed integer).
	Semantically equivalent to MDC_ATTR_TIME_ZONE
	The content of this field shall identify the time zone related to the local time stored here above in bytes 2 to 8. The format shall be identical to the Time Zone format specified in bytes 1–2 of Tag 34 in Table 2. In case the local Time Zone is unknown, TZ shall be set to 0x7FFF.
12 to 16	Reserved for future use. Shall be set to Null (0)

The different statements then follow, starting from byte 17 on. The format for each single statement is defined hereafter in 5.14.4.2 and 5.14.4.3.

The date and time information stored in this header (bytes 2 to 8) shall record the date and time of the creation and/or storage of the latest interpretive statement stored in this section (in case byte 1 is 0), or the date and time of the latest overreading or confirmation (in case the value of byte 1 is 1 or 2). Date and time shall be expressed as local time in the Time Zone of the overreader or of the interpretive device. This information may be different from the date and time of the signal recording.

Date and time are semantically equivalent to MDC_ATTR_TIME_ABS.

NOTE   TZ has been introduced to respectively specify the Time Zone of a remote interpretive device and/or of a remote overreading physician, in case they are not located in the same Time Zone as the acquiring device.

5.14.4.2 Statement data format

Each statement consists in a variable length statement field and is identified by an incremental sequence number.

Each statement field consists in a Statement type specifier followed by a variable length Statement body.

The Statement body itself consists in one or more NULL terminated data parts, depending on the Statement type (see 5.14.4.3). In the present version of this protocol, all data parts are UTF-8 encoded text strings.

The format of each single statement and its statement body are as follows:

Byte   Contents

1   Binary: Statement sequence number. Each statement has been given a sequence number (starting with 1) to allow easy binding by the Type 3 logical operands.

2 to 3   Binary: Statement field length (number of bytes in the statement field, including the statement body Type ID byte and all NULL terminators in the statement body, see Figure 15).

4 to *** Statement field:

> Byte   Contents
>
> 1   Binary: Statement type ID
>
>> Value   Type
>>
>> 1   Coded statement type, using SCP-ECG Universal Statement Codes
>>
>> 2   Full text type, as used in Section 8
>>
>> 3   Statement logic type, as described below in 5.14.4.3, Type 3
>>
>> 4   Coded statement type, using the AHA codes, see 5.14.4.3, Type 4
>>
>> 5   Coded statement type, using the CDISC codes, see 5.14.4.3, Type 5
>
> 2 to *** Statement body data. Depend on the statement body type specified in byte 1 of this statement field, terminated by NULL (0).

5.14.4.3 Statement body data content specification in function of the statement type

Type 1:   This type may contain one or more NULL (0) terminated data parts. Each data part shall contain one or more coded statement(s) optionally followed by one or more modifiers, according to the SCP-ECG Universal ECG interpretation statements coding rules (see Annex B). Statements may be linked by conjunctive terms, viz "_AND_" or ";AND;" (see Annex B, B.3.5 "Conjunctive terms" and B.4.3 "Examples").

          The data parts are of variable length and the number of data parts is not restricted. The only restriction is the total length of all data parts together, which is 65 535 bytes maximum.

Type 2:   This type has one data part containing only text characters, and is NULL (0) terminated.

Type 3:   This type has one data part containing only text characters, and is NULL (0) terminated. The content of this data part may be used to specify logical relationships between SCP-ECG statements of Type 1 or Type 4 by using logical operands acting on the SCP-ECG statements referred to by their sequence number.
          EXAMPLE   "(1+2);3" where "+" = "OR", ";" = "AND", and the parentheses "(...)" mark precedence. This means: statement nr. 1 OR statement nr. 2 AND statement nr. 3.

Type 4:   This type of statement body may contain one or more NULL (0) terminated data parts. Each data part shall contain one or more categorized AHA primary statement codes linked together by coded, general conjunctive terms such as "consider", "or", "and", "with" and "versus", according to the latest encoding specifications and pairing rules described in the "Scientific Statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society" [21]. Each primary statement may be optionally accompanied by one or more modifiers and/or by one or more secondary statements.

The data parts are of variable length and the number of data parts is not restricted. The only restriction is the total length of all data parts together, which is 65 535 bytes maximum.

Multiple AHA codes within each data part shall be concatenated by means of "_".

EXAMPLE   The following ECG interpretation statements:

- Atrial fibrillation

- Old anterior myocardial infarction

- Probable left ventricular hypertrophy

- ST-T changes compatible with left ventricular hypertrophy

of patient "X" may be represented by one SCP-ECG statement where the statement body will contain four [1] NULL terminated data parts respectively containing the four following coded text strings:

50

332_160

315_142

153

NOTE 1   The four textual ECG interpretation statements listed in the Type 4 example cannot be concatenated into one unique statement by means of the "AND" conjunctive term (AHA code 320). Indeed, statement "Atrial fibrillation" has no direct relation to "Anterior Myocardial Infarction", and thus cannot be concatenated with any of the other three statements. In this example, there are in fact two main categories of statements, one for the cardiac rhythm and one for the QRS contour interpretation. The three last statements can however be concatenated by means of the "AND" conjunctive term, viz 332_160_320_315_142_153, which leads to an SCP-ECG statement body consisting in two data parts only.

NOTE 2   Unfortunately, AHA does not specify any syntax for concatenating different interpretive statement codes. In this example, we have used "_ " to separate Primary Statements codes 160 and 142 from their respective Modifiers (codes 332 and 315).

Type 5:   This type of statement body shall contain one or more NULL terminated CDISC codes, one per data part.

EXAMPLE   The previous four textual ECG interpretation statements may be encoded by one SCP-ECG statement body field containing four NULL terminated data parts respectively containing the following CDISC codes:

C111092

C102685

C71076

C102706

NOTE 3   CDISC does not support the encoding of modifiers like probable or possible.

5.14.5 Overview of the data part of the universal ECG interpretation statement codes storage section

An overview of the data part of section 11, storage of the universal ECG interpretation statement codes, is provided in Figure 15.
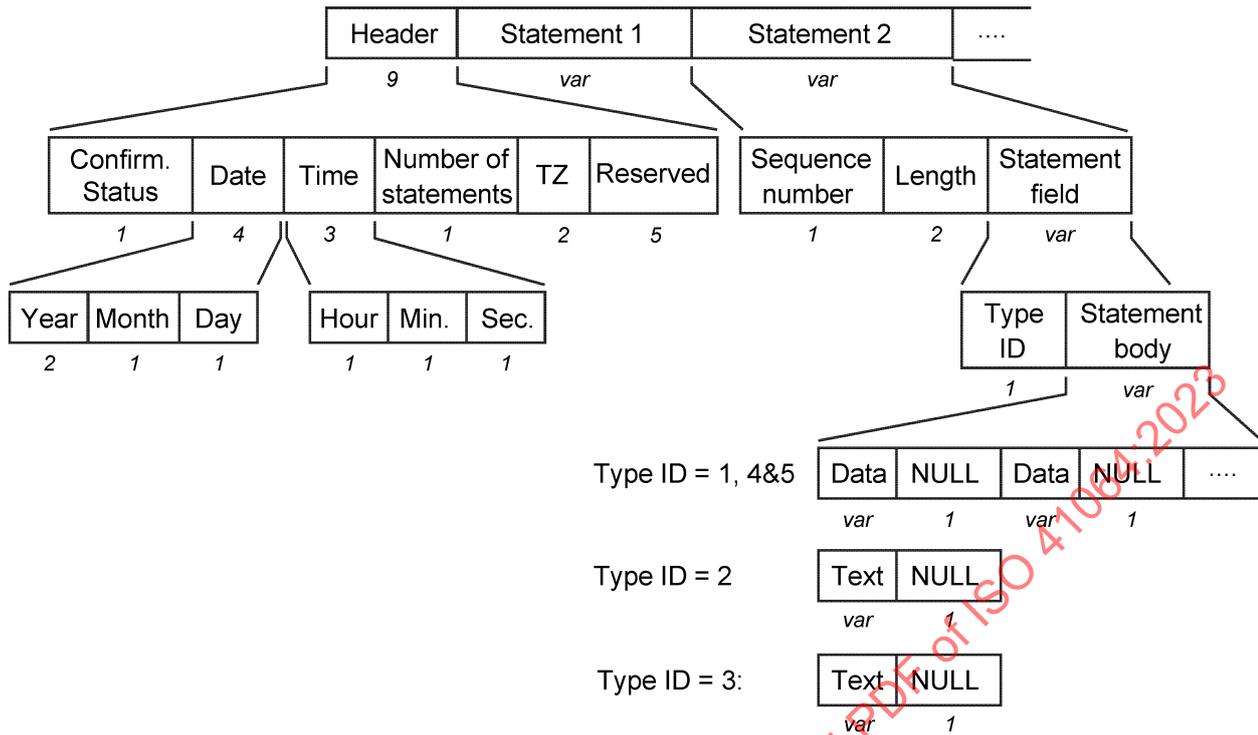
Figure 15 — Overview of the data part of Section 11

5.15 Long-term ECG rhythm data – Section 12

5.15.1 General

This section contains the raw signal data for different kinds of continuous ECG recordings. In order to preserve random access to the record's segments, in this section no compression or encoding is allowed. The use of this section is required only when there is the need to store several minutes (or hours) of continuously recorded signal data, which would not fit in Section 6. Despite in principle this extension allows storing very long recordings (up to several days), the final long-term ECG record size is limited to 4 GiB by the total SCP-ECG record length (see 5.2.5).

Since the number, kind and specification of the storage order of the long-term ECG leads are not necessarily the same as for the leads (specified in section 3) corresponding to Section 6 "Short-term ECG rhythm data" and Section 5 "Encoded type 0 reference beat data", this section has been designed to be completely self-standing, i.e. not dependent on the content of other sections, except for the patient data and ECG metadata stored in section 1. The section also provides a solution to supersede the filter settings provided in Section 1, Table 2, Tags 27 to 29, in case the filtering of the stored long-term ECG signals is different from the filtering performed during the signal acquisition process.

NOTE   This section only concerns continuous long-term ECG recordings and thus does not support intermittent long-term recordings which is covered by sections 13 and 14. This section can also be used complementarily to sections 13 and 14 to provide continuous monitoring of the ECG in protocol-based ECG recordings.

5.15.2 Section ID Header

If present, this section shall start with a "Section ID Header" and shall include the proper data part, as defined in 5.2.7. In particular, in the Section ID Header, the protocol version number stored in the

Header byte 10 shall reflect the current version of this document, since versions V1 and V2 do not support long-term ECG recordings (section 12 does not exist in SCP-ECG versions V1 and V2).

5.15.3 Data part content and format

The Section data part is composed of a header, a leads definition block and an ECG signals data block.

Unless specified otherwise, all text fields are encoded in UTF-8, all signal data are signed binary integers coded in 2's complement, and all other fields are unsigned binary integers.

5.15.4 Data part Header

5.15.4.1 Header format

The header has the following format:

Byte	Contents
1 to 4	Sampling rate (SR) in samples/s, (i.e. the number of samples per second in each lead) of the long-term ECG signals stored in this section Semantically equivalent to MDC_ECG_CTL_VBL_SAMPLE_RATE and MDC_ATTR_SAMPLE_RATE
5	Number of leads enclosed in this section (#LS)
6 to 9	Number of samples per lead, assuming that all the recorded leads in this section have the same duration (SPL) [MDC_ATTR_SAMPLE_COUNT]
10	Number of bytes per sample (BS). Possible values are limited to 1, 2, 3 or 4. Recordings from 12-bit systems shall be adapted to 16-bit words by sign extension in 2's complement notation.
11 to 14	Starting date of the ECG signal acquisition (Date_rec). The format shall be compliant with the "Date of Acquisition" format specified in the ECG metadata part of Section 1. (For the format details, refer to Table 2, Tag 25).
15 to 17	Starting time of the ECG signal acquisition (Time_rec). The format shall be compliant with the "Time of Acquisition" format specified in the ECG metadata part of Section 1. (For the format details, refer to Table 2, Tag 26).
18 to 21	Date of the last recording of the quality score annotation on the file (Date_ann). It is assumed that the lead signal quality score annotations of the whole lead set are performed on a same day, otherwise the date of the annotation of the last lead shall be recorded. The format shall be compliant with the "Date of Acquisition" format specified in the ECG metadata part of Section 1. (For the format details, refer to Table 2, Tag 25).
22 to 24	Time of the quality score annotation on the file (Time_ann). The local time of the last quality score annotation shall be recorded. The format shall be compliant with the "Time of Acquisition" format specified in the ECG metadata part of Section 1. (For the format details, refer to Table 2, Tag 26).
25 to 26	Date&Time Time Zone (TZ) related to the quality score annotation. Specified as an offset from UTC in minutes (signed integer). TZ shall save the time zone corresponding to the local time stored here above in bytes 18 to 24. In case the local Time Zone is unknown, TZ shall be set to 0x7FFF. Semantically equivalent to MDC_ATTR_TIME_ZONE The format shall be identical to the Time Zone format specified in bytes 1–2 of Tag 34 in

Table 2.

27   Section specific Filter (re)Setting (FRST)

The definition of the values taken by this byte are:

0   The filter settings stored in Table 2, Tag 27, 28 and 29 are used. This means that bytes 28 to 32 in this header shall be ignored.

1   The filter settings that shall be used for this long-term ECG section are specified hereafter in bytes 28 to 32, regardless of the values stored in Table 2, Tag 27, 28 and 29. The new settings only apply to the long-term ECG.

28 to 29   High-pass filter (HPF) [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 long-term ECG signals, in units of (1/100) Hertz. This value shall be reset (or discarded) if FRST = 0.

A value of 0xFFFF in this field means that the filter setting was not specified.

A value of zero in this field means that the recorded signals were DC-coupled and that no high-pass filtering was performed.

30 to 31   Low-pass filter (LPF) [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 long-term ECG signals, in units of Hertz. This value shall be reset (or discarded) if FRST = 0.

A value of 0xFFF in this field means that the filter setting was not specified.

Systems storing the raw long-term ECG signals without any further processing shall store the cut-off frequency of the anti-aliasing filter.

32   Filter bit map (FBM)

If FRST = 1, this field indicates if the ECG signal data of the long-term ECG stored in this section have been processed by other filters than those implicitly defined by the content of bytes 28 to 31. 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 bytes 28 to 31 was used.

If FBM = 255, then the FBM filter setting was not specified.

33 to 62   Reserved for future use. Shall be set to Null (0).

63 to 66   Length of the notes field in bytes (LN).

67 to 70   Length of the manufacturer-specific additional information field in bytes (LMI)

variable   Notes field. This is a free text field for test-specific annotations, comments and notes. It shall be null terminated.

variable   Manufacturer-specific information field (MI)

The date and time of the ECG acquisition and of the quality score annotation shall be expressed as local time in the Time Zone of the acquisition device and of the quality score annotator. The Time Zone of the ECG signals acquisition shall be saved in Table 2, Tag 34, and the Time Zone of the annotator in this section header, bytes 25 to 26.

The starting date and time of the signal acquisition shall be the local date and time of the acquisition of the first sample stored in this section.

NOTE 1   Unlike Section 6, where sample time interval in microseconds is adopted (an example is given in 5.9.3), the sampling rate has been preferred in this Section. Similarly, the length of the encoded leads is provided in bytes in Section 6 and in samples here. The proposed choice in the current section allows accommodating sampling frequencies typical of some Holter systems (e.g. 180, 300 or 360 Hz), whose reciprocal is not exactly representable by integers.

NOTE 2   The filter settings are assumed to be unchanged for the whole recording duration.

NOTE 3   TZ has been introduced to specify the Time Zone of a remote quality score annotator in case he/she is not located in the same Time Zone as the acquiring device.

5.15.4.2 Additional specifications

None of the fields in this header can be overlooked. If some of the values are the same as in the header of Section 6 or in Section 1, this header shall be filled up again.

The information on the presence and type of pacing device, if any, shall be provided in Section 1 (Table 2, Tag 32 and Tag 36).

5.15.5 Leads Definition block

5.15.5.1   The leads order of the stored long-term ECG signal data and their IDs are defined in this part of the section. The leads order specified in the leads definition block shall reflect their order in the interleaved format used for storing the ECG signals data block (see 5.15.6). The length of this leads definition block is related to the number of leads #LS and is a multiple of 4 bytes, since 4 bytes are required to fully specify a single lead. For each lead of the number of leads #LS stored in the header of the section data part, the same hereafter specified structure repeats:

Byte	Contents
1	Lead identification (ID). The same SCP-ECG numbering scheme as in 5.6.4, Table 4, shall be used to specify the lead that has been used. Semantically equivalent to MDC_ECG_Lead_xxx (see 5.6.4 Note).
2 to 3	Multiplier for the amplitude value (AVM). This value, expressed as in Sections 5 and 6 in nanovolts, refers to the specific lead and cannot be generalized to the other leads. An example of use is given in 5.8.3.
4	Signal quality score (QS). This is a post-recording evaluation of the overall quality of the lead, scored according to the ISHNE Holter Standard Output File Format specifications [26][53] that are summarized hereafter in Table 9.

Table 9 — Long-term ECG lead quality score

0	Unknown (unrated)
1	Good quality permanently
2	Intermittent noise < 10 % of total length
3	Frequent noise (>10 %)
4	Lead disconnection (<10 %)
5	Lead disconnection (>10 %)

5.15.5.2   If needed, the time locations of specific noisy segments may be indicated in Section 18 "Additional ECG Annotations". In this case, MDC_ECG_NOISE_YYYY_ONSET and MDC_ECG_NOISE_YYYY

_OFFSET REFIDs shall be used, where YYYY may take the following values: CLEAN, MODERATE, SEVERE or NOSIGNAL (to be combined with the _LEAD discriminator).

5.15.5.3   The start of the leads definition block (counting from the beginning of the Section ID Header) can be derived from the information given for the length of the Notes and manufacturer-specific information field MI as follows: 16 (i.e. 5.2.7) + 70 + LN + LMI + 1

NOTE   Compared to other long-term recording standards such as ISHNE which uses a fixed leads definition block length, in this document only the used leads are stored in the Leads Definition block. In this way, any number of leads (up to 254) can be stored and no special null characters need to be stored for unused leads.

5.15.6 ECG signals data block

The ECG signals data block contains the samples of the long-term ECG recording. The ECG signals shall be stored in 2's complement, little-endian binary format and shall be implemented according to an interleaved scheme among the different leads. In this way, the samples from the recorded leads will be arranged in the order specified in the Leads Definition block, one after the other, and the sequence will be repeated for every sampling period. Such an approach, in contrast with the one exploited in Section 6, has been introduced to ease the process of exporting signal data from devices such as a Holter monitors or other long-term ECG loggers, usually storing the samples from the different channels in this way [26] [53]. In fact, this solution allows keeping the samples taken at a specific sampling interval in contiguous memory locations.

NOTE   No sample numbering is used in this section.

5.15.6.1   The order used to store the different lead samples is the one specified in the Leads Definition block.

EXAMPLE   If only 3 leads are recorded, namely II, V4 and V2, in this order, and if we call [n] the n-th sample, starting from 1 (first sample number), then the data block will result in II[1], V4[1], V2[1], II[2], V4[2], V2[2], II[3], V4[3], V2[3], etc.

5.15.6.2   Lead defaults shall be indicated sample by sample using the most negative number representable with the available number of bytes per sample (e.g. −32 768, or 0x8000, when using 2 bytes per sample).

5.15.6.3   In order to correctly represent the amplitudes of the ECG signals when reading this ECG signals data block, the proper AVM values (defined in 5.15.5.1, and specific for each lead) shall be applied.

The start of the ECG signals data block (counting from the beginning of the Section ID Header) can be derived from the information given for the length of the Notes and of the Manufacturer-specific information field MI in the Header and from the number of stored leads (#LS) as follows: 16 (i.e. 5.2.7) + 70 + LN + LMI + (#LS x 4) + 1.

5.15.7 Overview of the data part of the long-term ECG rhythm data section

An overview of the data part of section 12, long-term ECG rhythm data, is provided in Figure 16.
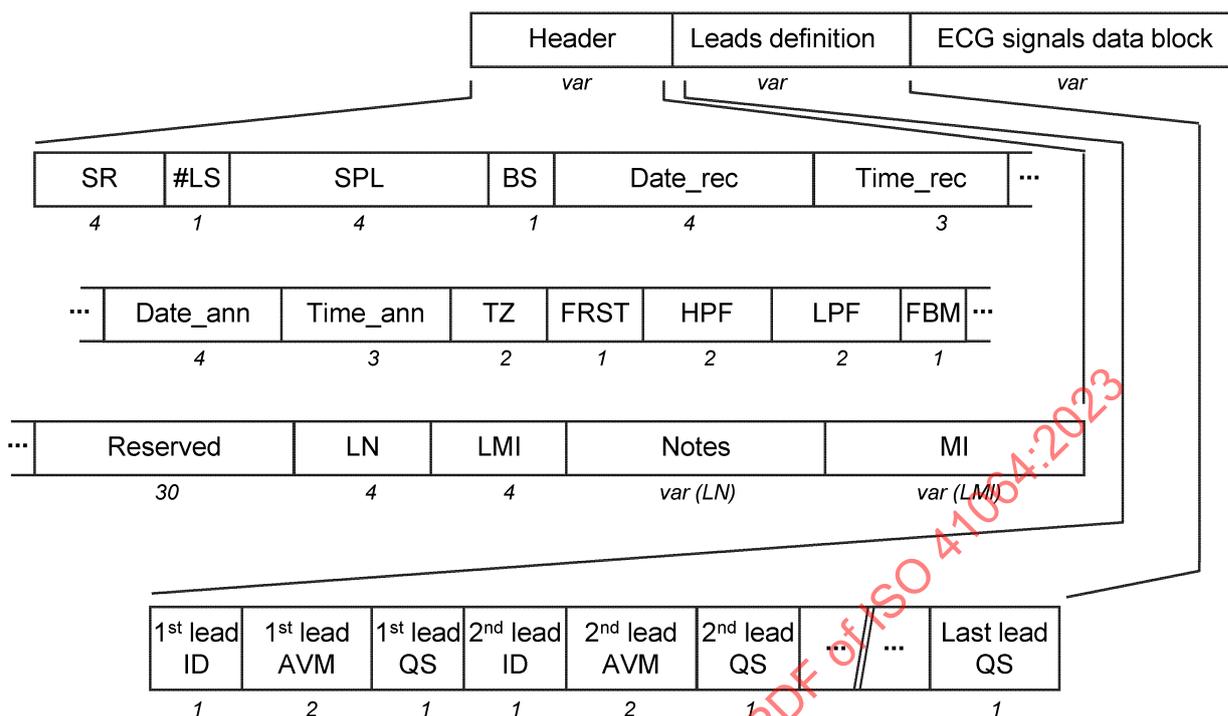
Figure 16 — Overview of the data part of Section 12

5.16 Stress tests, Drug trials and Protocol based ECG recordings Metadata – Section 13

5.16.1 General

Starting with version V3.0, in addition to the short duration resting ECG (section 6), the corresponding type 0 reference beat (section 5), and the long-term ECG (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 12, several selected short to medium duration ECG sequences can also be stored in section 14 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 as well as the storage of additional, simultaneously recorded high resolution, large bandwidth ECGs for improved spike detection and measurement.

It shall be noticed that, if two or more of the following sections (or groups of sections) 5, 6, 12, 13+14 are present, then it is mandatory that all these sections refer to the same patient and that the signal data have been acquired with the same device. Nevertheless, some device settings viz using a different sampling rate for the recording of the standard ECG and for the recording of high bandwidth ECG sequences could be specific for the different sections.

Furthermore, if section 14 is present, then section 13 is mandatory. Conversely, section 13 can be present whereas section 14 is not.

5.16.1.1 Three different ways (hereafter called "Mode") for storing and referring to the ECG signals collected during stress tests, drug trials and other protocol based tests are supported:

— Mode = 0: only short or medium duration ECG sequences from the stress test, drug trials procedure or protocol-based ECG acquisition are captured. No continuous, long-term ECG rhythm data are recorded. The selected short-duration ECG sequences are usually associated to a change of the load in the exercise ECG or correspond to a periodic recording during drugs trials, or an eyeballed

selection of different ECG excerpts from a previously stored continuous ECG recording, or whatever else.

— Mode = 1: the full long-term, continuous ECG recording is captured during the whole acquisition session and stored in section 12, without storing any short-duration ECG sequence in section 14. If some specific areas of interest of the continuous, long-term ECG recording need to be highlighted, rather than saving, as for mode 0, the corresponding short-duration ECG excerpts in section 14, this mode offers the possibility to refer to specific parts of the signals stored in the long-term section by means of pointers saved in section 13.

— Mode = 2: a combination of modes 0 and 1. It allows, for example, storing selected high resolution short to medium duration ECG sequences in section 14 as for Mode = 0, while keeping a rhythm trace in the long-term section for global monitoring purposes. The signals in section 12 and the excerpts in section 14 can be stored with different settings, for example using a different number of leads, different sampling rates, different filter settings (if any), etc.

5.16.1.2   If Mode = 0 is selected, Section 14 shall contain the short duration ECG sequences as raw data. If Mode = 1 is selected, Section 14 shall not be used and thus should be empty. In fact, in this case, explicit reference to the long-term recording in terms of position in time of the "excerpts" or "areas of interest" can be provided in the events metadata blocks of section 13. If Mode = 2, both section 12 and section 14 are used.

5.16.1.3   The maximum number of short-duration ECG segments that can be considered is limited to 255. There is no limitation in size for the short-duration records stored in section 14, except that the whole SCP-ECG record is limited to 4 GiB.

NOTE   Except when Mode 2 is selected, the concomitant use of sections 12 and 14 is forbidden.

5.16.1.4   Regardless of the selected Mode, the metadata associated to the ECG excerpts (either expressly stored in Section 14 or pinpointed in the long-term recording as areas of interest representative of different time periods of the acquisition session) are stored in Section 13. It includes the information about the number of excerpts, the presence of a separate rest ECG recording, the signal data of the reference beats (selected or computed ones, such as average or median beats) or the localization of the reference beats in the long-term (section 12) or in the selected ECG sequences repository (Section 14), etc.

5.16.1.5   To appropriately specify a protocol-based ECG recording, section 13 must be completely filled in.

5.16.1.6   Unless specified otherwise, all text fields are encoded in UTF-8, all signal data are represented by signed binary integers coded in 2's complement, and all other fields are unsigned binary integers.

5.16.2 Section ID Header

If present, this section shall start with a "Section ID Header" and shall include the proper data part, as defined in 5.2.7. In particular, in the Section ID Header, the protocol version number stored in the Header byte 10 shall reflect the current version of this document, since versions V1 and V2 do not support stress tests, drug trials procedures and protocol-based ECG recordings (section 13 and 14 do not exist in SCP-ECG versions V1 and V2).

5.16.3 Data part content and format

The Section data part is composed of a data header, a leads definition block and a variable number of metadata blocks.

5.16.3.1 Data part Header

The header is used to provide information common to all the metadata blocks stored in sections 13 and to the general protocol-based ECG recording. It has the following format:

Byte	Contents
1	Type of protocol-based ECG recording (TYPE). This field can take the following values:

    0   Unspecified

    1   Stress test

    2   Drug trial

    3   High bandwidth ECG recording for pacemaker spikes analysis

    4   Other protocol-based ECG recording

5 to 255 Reserved for future use.

2 Mode flag (MODE). (see also 5.16.1.1 and 5.16.1.2)

    0   Rhythm signal data, if any, are only stored as short to medium duration ECG excerpts in section 14. No long-term ECG recording is stored in section 12.

    1   No short-duration ECG excerpts are stored in section 14. ECG areas of interest and/or excerpts of the raw ECG signals stored in Section 12 (long-term ECG) are directly identified by pointers recorded hereafter in the metadata blocks and thus may be used to retrieve, if needed, event-related short-duration ECG excerpts from the continuous ECG recording stored in section 12.

    2   Both the short-duration ECG sequences stored in section 14 and the long-term ECG recording stored in section 12 are used for the same purpose of stress tests, drug trials procedures, protocol-based ECG recordings or high performance pacemaker spikes analysis.

Any other Mode value is reserved for future use, and would lead to discarding the content of this section.

3 Rest ECG flag (REST)

    0   The standard rest ECG, usually recorded before the beginning of the stress tests, drug trials procedures and protocol-based ECG recordings, is not stored in this SCP-ECG record, even if recorded with the same device as the one used to record the ECGs stored in this SCP-ECG record.

    1   The standard rest ECG, recorded with the same device before the beginning of the stress tests, drug trials procedures and protocol-based ECG recordings, has been stored in the appropriate sections of the present SCP-ECG record (sections 5 and/or 6, etc.).

4 Number of recorded events metadata blocks (#BK).

If Mode = 0, it corresponds, at minima, to the number of short-duration ECG sequences or excerpts collected or extracted during the test, and saved in Section 14. It also comprises the number of additional event metadata blocks stored in this section, viz the storage of other than type 0 reference beats (see 5.16.3.3).

If Mode = 1, it corresponds to the number of event metadata blocks stored in this section (see 5.16.3.3), each one pinpointing the related ECG area of interest (short-duration ECG sequence) within the unique record of raw ECG signal data stored in section 12 (long-term ECG).

If Mode = 2, it adds up all event metadata blocks corresponding to the events pinpointed in the long-term ECG stored in section 12 and in the ECG sequences stored in section 14.

5 to 8   Sampling rate (SR) in samples/s (i.e. the number of samples per second in each lead) of the reference beats signal data (if any) stored in this section's metadata blocks.

Semantically equivalent to MDC_ECG_CTL_VBL_SAMPLE_RATE and MDC_ATTR_SAMPLE_RATE

Shall be set to "0" if no reference beat signal data are stored in section 13.

NOTE 1   This value only applies to the reference beat signal data stored in this section's metadata blocks, if any. Short-duration ECG segments (Mode 0 or 2) and long-duration ECG rhythm recordings (Mode 1 or 2) have their own sampling rate specification, respectively provided in Sections 14 and 12.

9   Number of bytes per sample (BS) of the reference beats signal data (if any) stored in this section's metadata blocks. Possible values are limited to 1, 2, 3 or 4. Recordings from 12-bit systems shall be adapted to 16-bit words by sign extension in 2's complement notation.

Shall be set to "0" if no reference beat signal data are stored in section 13.

NOTE 2   This value only applies to the reference beat signal data stored in this section's metadata blocks, if any. Short-duration ECG segments (Mode 0 or 2) and long-duration ECG rhythm recordings (Mode 1 or 2) have their own number of bytes per sample specification, respectively provided in Sections 14 and 12.

10   Number of leads (#LS) adopted for the reference beats signal data (if any) stored in this section's metadata blocks.

Shall be set to "0" if no reference beat signal data are stored in section 13.

NOTE 3   This value only applies to the reference beat signal data stored in this section's metadata blocks, if any. Short-duration ECG segments (Mode 0 or 2) and long-duration ECG rhythm recordings (Mode 1 or 2) have their own number of leads specification, respectively provided in Sections 14 and 12.

11 to 62   Reserved for future use (shall always be set to zero).

63 to 66   Length of the Header Notes field in bytes (LHN).

67 to 70   Length of the manufacturer-specific additional information field in bytes (LMI).

variable   General notes on this section.

This is a free-text field. It shall be null terminated. This field can be used for example to describe the device used for exercise ECG (cycloergometer, treadmill, stepper, etc.) or high-bandwidth ECGs recording, and give some details about the recording procedure.

variable   Manufacturer-specific information field (MI).

The information on the presence and type of pacing device, if any, shall be provided in Section 1 (Table 2, Tag 32 and Tag 36).

NOTE 4   Unlike Section 6, where sample time interval in microseconds is adopted (an example is given in 5.9.3), in this Section the sample rate has been preferred.

NOTE 5   None of the fields of this header can be overlooked even if some of the values are the same as in the header of other sections.

5.16.3.2 Leads Definition block

The leads order and IDs (compliant with #LS) and the amplitude value multipliers (AVM) to be used for all reference beats signal data stored, if any, in the events metadata blocks specified in Clause 5.16.3.3, are defined in this part of the section. The length of the leads definition block is related to the number of leads #LS, and is a multiple of 3 bytes. For each lead of the #LS leads stored in byte 6 of the header of this section data part, the same hereafter specified structure repeats. It is important to notice that the leads order and IDs and the per-lead multiplier for the amplitude value (AVM) defined in this Leads definition block are common to each reference beat stored in the metadata blocks of this section.

Byte	Contents
1	Lead identification (ID). The same SCP-ECG numbering scheme as in 5.6.4, Table 4, shall be used to know what the lead represents. Semantically equivalent to MDC_ECG_Lead_xxx (see 5.6.4 Note).
2 to 3	Multiplier for the amplitude value (AVM). This value, expressed as in Sections 5 and 6 in nanovolts, refers to the specific lead and cannot be generalized to the other leads. An example of use is given in 5.8.3.

5.16.3.3 Events Metadata Blocks

The events that are considered in this part of the document are either the recording of the metadata associated to a selected or pinpointed ECG sequence (respectively stored in section 14 or in section 12), or the recording of a computed or a selected reference beat and its associated metadata, or the simultaneous recording in a same metadata block of the metadata associated to an ECG sequence or ECG excerpt and the reference beat corresponding to this ECG sequence or excerpt.

The number of metadata blocks that will be stored in this Section data part is the number #BK stored in byte 4 of the Header of this section (see 5.16.3.1). For every single metadata block, the same structure repeats. It consists of a block-specific header related to the signals of the reference beat, if any, and to the associated metadata.

Byte	Contents
1	Block Id (BId). Allowed values range from 1 to 255. This block Id uniquely identifies the reference beat stored in or pinpointed by this metadata block as well as the metadata associated to a selected ECG sequence or ECG excerpt, if no reference beat is pinpointed or stored in the metadata block.
2	Related ECG Sequence data Block identification Number (RBN). This byte is used to specify to which ECG signal data the metadata stored in this metadata block are associated. If the related ECG signals are stored in Section 14, then RBN shall store the value of the related ECG data Block identification Number BN (see 5.17.6.6 byte 1), i.e. RBN = BN. If the related ECG signals are stored in Section 12, then RBN shall be set to zero (RBN = 0).
3	ECG sequence metadata specification block Status Flag (SeqSF). Allowed values are 0 and 1. Shall be set to 1 if the areas of interest saved hereafter in BDR and BTR and the test

metadata saved beyond byte 27 have been stored in this metadata block to specify the metadata associated to the ECG sequence identified here above by the content of byte 2 (RBN). The current metadata block Id shall be saved in the Associated metadata Block Id in Section 14 (see 5.17.6.6 byte 2), i.e. ABId = BId.

In all other cases SeqSF shall be set to 0.

4 to 7   Starting date (BDR) of the area of interest in the ECG record, corresponding to the event pinpointed by the information contained in this block. The format shall be compliant with the "Date of Acquisition" format specified in the ECG metadata part of Section 1 (for the format details, refer to Table 2, Tag 25).

If SeqSF = 1, then the value assigned to BDR shall be the date of the acquisition of the first sample of the related ECG sequence (pinpointed by RBN) stored in Section 14.

If RBN = 0, the value assigned to BDR should be the date of the acquisition of the first sample of the area of interest (ECG excerpt) pinpointed in the long-term ECG by SSB and LAIB.

In all other cases the value assigned to BDR should be the date of the acquisition of the first sample of the area of interest (ECG excerpt) pinpointed in the ECG sequence #RBN by BDR, BTR and either directly or indirectly, by SSB and LAIB.

BDR shall be expressed as local time in the Time Zone specified by Tag 34 in Table 2.

8 to 10   Starting time (BTR) of the area of interest in the ECG record, corresponding to the event pinpointed by the information contained in this block. The format shall be compliant with the "Time of Acquisition" format specified in the ECG metadata part of Section 1 (for the format details, refer to Table 2, Tag 26).

If SeqSF = 1, then the value assigned to BTR shall be the time of the acquisition of the first sample of the related ECG sequence (pinpointed by RBN) stored in Section 14.

If RBN = 0, the value assigned to BTR should be the time of the acquisition of the first sample of the area of interest (ECG excerpt) pinpointed in the long-term ECG by SSB and LAIB.

In all other cases the value assigned to BTR should be the time of the acquisition of the first sample of the area of interest (ECG excerpt) pinpointed in the ECG sequence #RBN by BDR, BTR and either directly or indirectly, by SSB and LAIB.

BTR shall be expressed as local time in the Time Zone specified by Tag 34 in Table 2.

11 to 14   Starting sample number (SSB) of the ECG area of interest (ECG sequence or ECG excerpt), corresponding to the event related to this metadata block.

If Mode = 1 or 2, this field contains the sample number (referred to a generic lead, all the leads having the same number of samples) of the first ECG sample of the ECG area of interest pinpointed by BDR, BTR, SSB and LAIB in the long-term ECG recording and related to the event (stress test or drug trial episode, reference beat specification, etc.) corresponding to the information stored in this metadata block.

If Mode = 0, this field contains the sample number (referred to a generic lead, all the leads having the same number of samples) of the first ECG sample of the ECG area of interest pinpointed by BDR, BTR, SSB and LAIB in the short-term ECG recording #RBN and related to the event (stress test or drug trial episode, reference beat specification, etc.) corresponding to the information stored in this metadata block.

In case BDR and BTR are identical to the date and the time of the acquisition of the first ECG sample of the analysed ECG signal, then SSB shall be set to 1.

15 to 16   Length (in samples per lead) of the area of interest in the ECG sequence (or ECG excerpt) pinpointed by this metadata block (LAIB).

If Mode = 1 or 2, this field contains the length of the pinpointed ECG area of interest (related to the event corresponding to the information stored in this metadata block), expressed in number of samples in the long-term ECG recording (Section 12).

If Mode = 0, this field contains the length of the pinpointed ECG area of interest (related to the event corresponding to the information stored in this metadata block), expressed in number of samples in the short-term ECG recording #RBN (Section 14).

NOTE 1   The number and definition of the leads, the sampling rate and the AVM to be considered here for extraction or display of the corresponding ECG area of interest are specified in section 12 long-term ECG and/or in section 14 short-term ECG sequences.

NOTE 2   LAIB includes sample SSB. The last sample of the specified area of interest will thus be sample number (SSB + LAIB −1).

17   Reference beat type and localization (RBTL) code (binary).

This fields specifies which type of reference beat, if any, is stored in or pinpointed by this metadata block: type 0 or other than type 0, computed by an averaging (or median calculation) algorithm or selected within the raw ECG signals recordings without any additional processing (except may be some filtering specified hereafter in bytes 24 to 29). It also specifies whether the reference beat signal data are located hereafter at the end of this metadata block, or in the original ECG signal recordings, i.e. in sections 12 or 14.

The definition of the bits corresponding to this byte are:

    0   A reference beat has been specified (bit 0 = 1) / not specified (bit 0 = 0).

    1   The specified reference beat is of type 0 (bit 1 = 1) / not of type 0 (bit 1 = 0). (see Note 3)

    2   The specified reference beat is a computed one (bit 2 = 1) / a selected one (bit 2 = 0). (see Note 4)

    3   If bit 3 = 1, the specified reference beat is stored hereafter in the metadata block. (see Note 4)

    4   If bit 4 = 1, the specified reference beat is "included" in the long-term ECG (section 12) and bytes 24 to 29 of this metadata block shall be set to 0.

    5   If bit 5 = 1, the specified reference beat is "included" in the related ECG sequence (section 14), pinpointed by the content of RBN (byte 2 above). Bytes 24 to 29 of this metadata block shall be set to 0.

    6 to 7   Reserved for future use. Shall be set to 0.

If bit 0 = 0 (no reference beat has been specified), then all other bits of RTBL shall be set to 0 and bytes 18 to 29 of this metadata block shall be set to 0.

If bit 2 = 1, then the computed reference beat shall be stored hereafter at the end of this metadata block and bit 3 is set to 1.

NOTE 3   A type 0 reference beat can be represented by MDC_ECG_QRS_MORPH_NUM with value set to 0.

NOTE 4   Using the following bit settings combination RBTL [0] = 1, RBTL [2] = 0, RBTL [3] = 1, offers the possibility to store a selected reference beat having different acquisition parameters (viz sampling rate, AVM, number of bytes per sample BS, etc.) than the signals stored in section 12 "long-term ECG rhythm data" or in section 14 "selected ECG sequences repository".

NOTE 5   Bits 3 to 5 are mutually exclusive, i.e. only one can be set to 1.

NOTE 6   Some examples of use of RBTL are given hereafter in the specifications of the content of bytes 18 to 23.

18 to 21   Sample number of the first sample of the reference beat (SRB).

If RBTL[0] = 1 and RBTL[2] = 1, the reference beat is not a real beat, but a computed one (e.g. a median or an average beat), that is stored after the Notes field of this metadata block. SRB shall be set to 1. (See Note 8)

If RBTL[0] = 1 and RBTL[2] = 0), the reference beat is a selected beat. Then:

If RBTL[3] = 1, the reference beat signal data are stored in the actual metadata block. SRB shall be set to 1. (See Note 8)

If RBTL[4] = 1, the reference beat signal data are part of the long-term ECG record (section 12). The first sample of the reference beat is sample number SRB of the ECG stored in section 12 "long-term ECG rhythm data". (See Note 9)

If RBTL[5] = 1, the reference beat signal data are part of the ECG sequence pinpointed by the content of RBN. The first sample of the reference beat is sample number SRB of the corresponding short-duration ECG (pinpointed by its block identification number BN, see 5.17.6.6, byte 1) in section 14. (See Note 10)

If RBTL[0] = 0, then SRB shall be set to 0.

NOTE 7   It is assumed that the sample number of the first sample of any stored ECG signal data block is Sample 1.

NOTE 8   The leads and the AVM to be considered for extraction or display of the corresponding reference beat are specified in 5.16.3.2. The sampling rate is specified in 5.16.3.1, bytes 5 to 8.

NOTE 9   The number and definition of the leads, the sampling rate and the AVM to be considered for extraction or display of the corresponding reference beat are specified in section 12, long-term ECG rhythm data.

NOTE 10 The number and definition of the leads, the sampling rate and the AVM to be considered for extraction or display of the corresponding reference beat are specified in section 14, selected ECG sequences repository.

22 to 23   Length, in number of samples per lead, of the reference beat signal data stored in or pinpointed by this metadata block (LRB).

If RBTL[0] = 0, no reference beat signal data are stored nor pinpointed by this metadata block and LRB shall be set to 0. Else:

If RBTL[3] = 1, the reference beat signal data are stored in this metadata block. The number and the definition of the leads and the AVM to be considered for extraction or display of the corresponding reference beat are specified in 5.16.3.2. The sampling rate is specified in 5.16.3.1, bytes 5 to 8.

If RBTL[4] = 1, the reference beat signal data are "included" in the long-term ECG recording, section 12. The number and definition of the leads, the sampling rate and the AVM to be considered for extraction or display of the corresponding reference beat are specified in section 12, long-term ECG rhythm data. The last sample of the reference beat pinpointed by this metadata block in the long-term ECG is sample number (SRB+LRB-1).

If RBTL[5] = 1, the reference beat signal data are "included" in the short-term ECG sequence (pinpointed by RBN in this metadata block) stored in Section 14, selected ECG sequences repository. The number and definition of the leads, the sampling rate and the AVM to be considered for extraction or display of the corresponding reference beat are specified in section 14. The last sample of the reference beat pinpointed by this metadata block in the corresponding short-term ECG sequence is sample number (SRB+LRB-1).

NOTE 11 It is assumed that the number of samples is the same for every lead of the reference beat stored in or pinpointed by the current metadata block, and that the number of ECG leads of the ECG signals respectively stored in sections 12, 13 and 14 does not change during the whole acquisition process.

24   Block specific Filter (re)Setting (FRST) for the reference beat stored in this metadata block.

The definition of the values taken by this byte are:

0   No specific filter settings have been defined for the reference beat stored in this metadata block. This means that if FRST = 0, bytes 25 to 29 shall be ignored.

1   The filter settings that shall be considered for the reference beats in this metadata block are defined hereafter, regardless of the values stored in other sections. The new settings only apply to this block of metadata in this section, and are specified in bytes 25 to 29.

NOTE 12 If RBTL[3] = 0, the filter settings are those of the section where the actual reference beat, if any, is stored (either section 12 or section 14). In this case FRST is set to zero, along with the content of bytes 25 to 29.

25 to 26   High-pass filter (HPF) [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 reference beat signals, in units of (1/100) Hertz. This value shall be reset (or discarded) if FRST = 0.

NOTE 13 A value of 0xFFFF in this field means that the filter setting was not specified.

NOTE 14 A value of zero in this field means that the stored reference beat signals were extracted from DC-coupled recordings and that no high-pass filtering was performed.

27 to 28   Low-pass filter (LPF) [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 long-term ECG signals, in units of Hertz. This value shall be reset (or discarded) if FRST = 0.

Systems storing reference beat signals that were extracted from the original, raw ECG signal recordings without any further processing shall store the cut-off frequency of the anti-aliasing filter.

NOTE 15 A value of 0xFFFF in this field means that the filter setting was not specified.

29   Filter bit map (FBM) (binary).

If FRST = 1, this field indicates if the ECG signal data of the reference beat stored in this metadata block have been processed by other filters than those implicitly defined by the content of bytes 25 to 28. The definition of the different bits of the FBM bit map are detailed in Annex A, Table A.6.

NOTE 16 If FBM = 0, no additional filtering than those implicitly defined by bytes 25 to 28 was used.

NOTE 17 If FBM = 255, then the FBM filter setting was not specified.

30 to 31   Systolic blood pressure (SBP), in mmHg [MDC_BLD_NONINV_SYS].

Only positive integer values can be used. A value of zero indicates that this measurement was not performed. A value of 0xFFFF indicates that the measure was performed but its value is unreliable, unavailable or corrupted.

32 to 33   Diastolic blood pressure (DBP), in mmHg [MDC_PRESS_BLD_NONINV_DIA].

Only positive integer values can be used. A value of zero indicates that this measurement was not performed. A value of 0xFFFF indicates that the measure was performed but its value is unreliable, unavailable or corrupted.

34 to 35   Heart rate (HR), in beats per minutes (bpm), expressed with a positive integer value [MDC_ECG_HEART_RATE].

A value of zero indicates that this measurement was not performed. A value of 0xFFFF indicates that the measure was performed but its value is unreliable, unavailable or corrupted.

36   Breathing rate (BR), in breaths per minute, expressed with a positive integer value [MDC_RESP_RATE].

A value of zero indicates that this measurement was not performed. A value of 0xFF indicates that the measure was performed but its value is unreliable, unavailable or corrupted.

37   Blood oxygen saturation (SpO2), expressed with a positive integer value [MDC_SAT_O2].

A value of zero indicates that this measurement was not performed. A value of 0xFF indicates that the measure was performed but its value is unreliable, unavailable or corrupted.

38 to 39   Workload level (WL), expressed with a positive integer value.

A value of 0xFFFF indicates that WL is either unknown or irrelevant, viz for drug tests or other situations where no workload is applied. If this field is set to 0xFFFF, bytes 40 and 41 shall be discarded.

40 to 41   Unit code of the WL work Load Level measurement (ULL) (unsigned binary).

The binary code used to represent ULL, the Unit of measure of the work Load Level WL stored in bytes 38 to 39, shall be the UoM base code taken from ISO/IEEE 11073-10101 [8], Table A.6.4.1: Vital signs units of measurements and their updates maintained in the corresponding units-of-measure table defined in the NIST RTMMS repository [59].

NOTE 18 The most relevant units and ULL code values for exercise ECG on treadmill, cycloergometer and stepper are listed in Annex A, Table A.7

42   Fatigue scale (FTSC) code:

    0   Unspecified

    1   6–20 Borg scale

    2   0–10 Modified Borg Scale (see Note 20)

    3   1–10 User defined scale

    4   user defined (e.g. visual analogue scale)

    5–255 Reserved for future use

NOTE 19 The 6–20 Borg scale is the recommended one.

NOTE 20 In this case, value 0,5 is coded as 20

43   Fatigue level (FTLV), expressed with a positive integer value.

A 0xFF in this field is adopted for drug tests or other situations where no fatigue changes are recorded.

44 Lower limit of the user-defined fatigue scale (LLFT).

When fatigue scale (byte 42) is different from 3, this byte should be set to zero.

45 Upper limit of the user-defined fatigue scale (ULFT).

When fatigue scale (byte 42) is different from 3, this byte should be set to zero.

46 Dyspnea scale (DYSC) code:

    0   Unspecified

    1   Medical Research Council (MRC) breathlessness scale

    2   0–10 Modified Borg Scale for Perceived Dyspnea (see Note 22)

    3   User defined (e.g. visual analogue scale)

  4–255 Reserved for future use

NOTE 21 The MRC scale is the typical one.

NOTE 22 In case DYSC=2, value 0,5 is coded as 20.

47 Dyspnea level (DYLV), expressed with a positive integer value.

A 0xFF in this field is adopted for protocols where this parameter is not evaluated.

48 Lower limit of the user-defined dyspnea scale (LLDT).

When dyspnea scale (byte 46) is different from 3, this byte should be set to zero.

49 Upper limit of the user-defined dyspnea scale (ULDT).

When dyspnea scale (byte 46) is different from 3, this byte should be set to zero.

50 to 62 Reserved for future use (shall always be set to zero).

63 to 64 Length, in bytes, of a Note field for this metadata block (LMDN).

The notes may be used for example to describe and document the different phases of the test (including drug administration, if any) and the particularities of the different ECG signal data corresponding to the related event.

Variable (LMDN) Note field explaining the phases of the test (MD notes).

This is a free text field that can be filled in with annotations from the technician, cardiologist, etc. It shall be null terminated.

Variable If RBTL[3] = 1, signal data of the 1st lead of reference beat (RB).

The size of this field and of each of the following ones is LRB x BS bytes. Unlike section 5, here no compression is allowed.

variable If RBTL[3] = 1, signal data of the 2nd lead of reference beat.

variable If RBTL[3] = 1, signal data of the 3rd lead of reference beat, etc.

5.16.4 Overview of the data part of the Stress tests, drug trials and protocol based ECG recordings metadata

An overview of the data part of section 13 is provided in Figure 17.
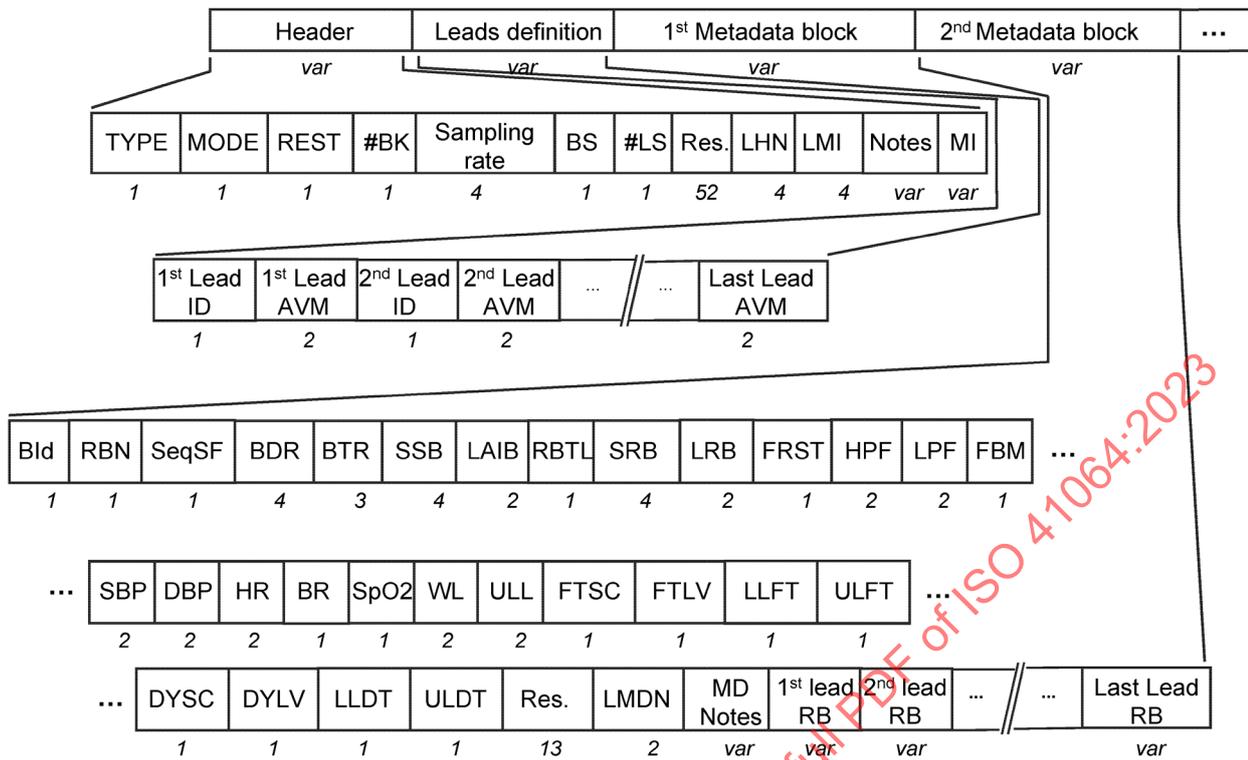
Figure 17 — Overview of the data part of Section 13

5.17 Selected ECG Sequences Repository – Section 14

5.17.1 General

5.17.1.1 Section explanation

This Section is complementary to Section 13 and is used to store the short to medium duration ECG sequences acquired during the recording of stress tests, drug trials procedures or protocol-based ECG recordings. It may also be used to store high resolution, large bandwidth ECG recordings for improved pacemaker spikes detection and analysis while simultaneously storing a standard ECG in sections 6 or 12. It is assumed that for recording such protocol based and large bandwidth ECGs, the same equipment and the same electrode settings are used all over the test, only some filter settings and recording duration may change from one sequence recording to the other.

5.17.1.2 Usage constraint

Section 14 cannot be used if section 13 is not present.

5.17.1.3 Use cases

If this section is present and if MODE = 0 or 2 (see 5.16.3.1, byte 2), then this section shall be completely filled in.

If this section is present and if MODE = 1 or is different from 0 and 2, this section shall be discarded.

5.17.1.4 Associated metadata

The metadata associated to the ECG sequences stored in the ECG data blocks at the end of this section shall be saved in Section 13, including the information about the number of sequences/events, the presence of a rest ECG recording and/or of reference beat signal data recordings, etc.

5.17.2 Section ID header

If present, this section shall start with a "Section ID Header" and shall include the proper data part, as defined in 5.2.7. In particular, in the Section ID Header, the protocol version number stored in the Header byte 10 shall reflect the current version of this document, since previous versions do not support stress tests, drug trials procedures and protocol-based ECG recordings (section 14 does not exist in SCP-ECG versions V1 and V2).

5.17.3 Data part content and format

The Section data part is composed of a header, a leads definition block and a variable number of ECG signals data blocks.

5.17.4 Data part Header

The header is used to provide information that are common to all the ECG data blocks stored in this section. It has the following format:

Byte	Contents
1	Number of ECG sequences (#SEQ) stored in this section.
2 to 5	Sampling rate (SR) in samples/s (i.e. the number of samples per second in each lead) of the ECG sequences stored in this section.
	Semantically equivalent to MDC_ECG_CTL_VBL_SAMPLE_RATE and MDC_ATTR_SAMPLE_RATE.
6	Number of bytes per sample (BS) of the ECG sequences stored in this section. Possible values are limited to 1, 2, 3 or 4. Recordings from 12-bit systems shall be adapted to 16-bit words by sign extension in 2's complement notation.
7	Number of leads (#LS) adopted for the ECG sequences stored in this section.
8 to 62	Reserved for future use (shall always be set to zero).
63 to 66	Length of the Header Notes field in bytes (LHN).
67 to 70	Length of the manufacturer-specific additional information field in bytes (LMI).
variable	General Header Notes on this section. This is a free-text field. It shall be null terminated.
variable	Manufacturer-specific information field (MI).

Some of the parameters listed in this header (e.g. sampling rate) can have different values compared to those related to the rest ECG or to the long-term ECG and even to the reference beats stored in the associated section 13. However, this flexibility is not granted for the ECG signals stored in this section. All ECG sequences specified in Clause 5.17.6 shall be recorded with the same sampling rate, number of bytes per sample #BS and number of leads #LS, as specified above in bytes 2 to 7.

5.17.5 Leads Definition block

The leads order and IDs (compliant with #LS) and the amplitude value multipliers (AVM) to be used for all ECG sequences stored after this Leads definition block, are defined in this part of the section. The length of the leads definition block is related to the number of leads #LS, and is a multiple of 3 bytes. For

each lead of the #LS leads stored in byte 7 of the header of this section data part, the same hereafter specified structure repeats. It is important to notice that the leads order and IDs and the per-lead multiplier for the amplitude value (AVM) defined in this Leads definition block are common to each ECG sequence stored in this section.

Byte	Contents
1	Lead identification (ID). The same SCP-ECG numbering scheme as in 5.6.4, Table 4, shall be used to know what the lead represents. Semantically equivalent to MDC_ECG_Lead_xxx (see 5.6.4 Note).
2 to 3	Multiplier for the amplitude value (AVM). This value, expressed as for Sections 5 and 6 in nanovolts, refers to the specific lead and cannot be generalized to the other leads. An example of use is given in 5.8.3.

5.17.6 ECG sequences

5.17.6.1   This Section is composed of a variable number of ECG data blocks, as many as the number #SEQ identified in byte 1 of the Data part Header of this Section. Some ECG recording information viz the date and time of the recording, etc. are already provided in Section 13, since they are also useful for the retrieval and (re)analysis of the reference beats (selected beats or median complexes), etc.

5.17.6.2   It is assumed that the leads order and the multiplier for the amplitude value (AVM) do not change over the whole test. In order to correctly represent the amplitude of the ECG signals when retrieving the signal samples from this section, the proper AVM values (defined in 5.17.5, and specific for each lead) shall be applied.

5.17.6.3   All leads of a given ECG sequence are assumed to have the same number of samples. The signal sample values are stored exploiting an interleaved format among the different leads. In this way, the samples from the recorded leads are arranged in the order identified in the Leads Definition block (see 5.17.5), one after the other, and the sequence repeats for every sampling period. Such an approach, in contrast with the ones exploited in Section 6 and in Section 13 for the storage of the reference beats (if any), is in line with the one adopted in Section 12 for the long-term ECG.

5.17.6.4   Only the used leads are stored. In this way, no special null characters must be stored for unused leads. The order is the one specified in the Leads Definition block (see 5.17.5). For instance, if only 3 leads are recorded, namely II, V4 and V2, in this order, and if we call [n] the n-th sample, starting from 1 (first sample number), then the data block will result in II[1], V4[1], V2[1], II[2], V4[2], V2[2], II[3], V4[3], V2[3], etc.

5.17.6.5   The different ECG sequences are stored in 2's complement binary format, little-endian. Only raw signal data are allowed, without any compression, difference encoding, etc. Lead defaults shall be indicated sample by sample using the default −32 768 (or 0x8000) value, when using 2 bytes per sample.

5.17.6.6   The format of a single ECG data block is given hereafter. For every block of data, the same structure repeats:

Byte	Contents
1	Block identification Number (BN). BN is a sequential number. The first ECG data block is block 1. Allowed values range from 1 to #SEQ.
2	Associated metadata Block Id (ABId). ABId shall store the metadata block ID "Bid" (see 5.16.3.3) that identifies the data

structure in which one can find the metadata related to the ECG signal data that are stored at the end of this block, i.e. ABId = BId.

3 to 6   Number of samples per lead for this block (#SPLBK).

NOTE 1   It is assumed that in this section the number of samples is the same for every lead of a given ECG data block.

NOTE 2   It is also assumed that the number of stored leads does not change during the whole test, and thus that each raw signal data block in this section has the same number of leads as specified in the data part Header, Clause 5.17.4, byte 7.

NOTE 3   The length of the encoded leads is provided in bytes in Section 6 and in number of samples here.

7   Block specific Filter (re)Setting (FRST).

The definition of the values taken by this byte are:

0   The filter settings stored in Table 2, Tag 27, 28 and 29 are used. This means that bytes 8 to 12 hereafter shall be ignored.

1   The filter settings that shall be used for the ECG signals stored at the end of this single ECG data block are specified hereafter in bytes 8 to 12, regardless of the values stored in Table 2, Tag 27, 28 and 29. The new settings only apply to this block of ECG signal data in this section.

NOTE 4   Different filter settings can be used at different time periods of a protocol based ECG recording. If the settings do not change for the whole test, then the same filter values are repeated for every ECG data block.

8 to 9   High-pass filter (HPF) [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 signals of the stored ECG sequence, in units of (1/100) Hertz. This value shall be reset (or discarded) if FRST = 0.

NOTE 5   A value of 0xFFFF in this field means that the filter setting was not specified.

NOTE 6   A value of zero in this field means that the recorded signals were DC-coupled and that no high-pass filtering was performed.

10 to 11   Low-pass filter (LPF) [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 sequence, in units of Hertz. This value shall be reset (or discarded) if FRST = 0.

Systems storing raw ECG sequences without any further processing shall store the cut-off frequency of the anti-aliasing filter.

NOTE 7   A value of 0xFFFF in this field means that the filter setting was not specified.

12   Filter bit map (FBM) (binary)

If FRST = 1, this field indicates if the ECG signal data stored in this ECG data block have been processed by other filters than those implicitly defined by the content of bytes 8 to 11. The definition of the different bits of the FBM bit map are detailed in Annex A, Table A.6.

NOTE 8   If FBM = 0, no additional filtering than those implicitly defined by bytes 8 to 11 was used.

NOTE 9   If FBM = 255, then the FBM filter setting was not specified.

variable   Raw ECG rhythm signal data of the ECG sequence stored in this data block.

NOTE 10   Unlike section 6, no compression nor redundancy reduction is allowed here.

5.17.7 Overview of the data part of the selected ECG sequences repository section

An overview of the data part of section 14, selected ECG sequences repository, is provided in Figure 18.
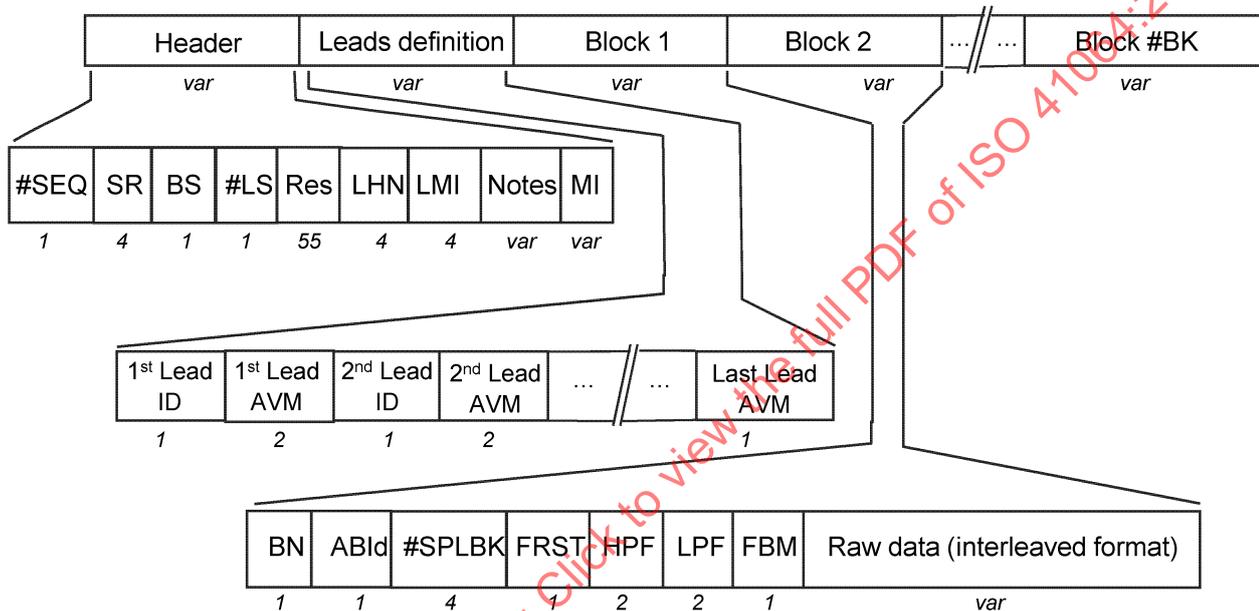
Figure 18 — Overview of the data part of Section 14

5.18 Beat-by-Beat ECG measurements and annotations – Section 15

5.18.1 General

Several computer programs are able to analyse continuous, long duration ECG recordings and to annotate several features of each beat. This version of the standard has been extended to provide means to define and store large sets of beat-by-beat measurements and annotations in a structured, but nevertheless highly flexible manner.

Beat-by-beat measurements and annotations may be stored in one or more measurements arrays structured as MxN matrices (M Beats x N Measurements/Annotations), much like the structure used for storing long-term ECG signals in section 12 or short to medium duration ECG sequences in section 14. Instead of representing samples, here each of the M matrix lines (hereafter called beat Measurements and annotations Block, in short MB) represents a beat and each of the N columns represents a beat measurement (fiducial location, wave amplitude or duration, etc.) or a beat annotation (beat type, beat label, etc.), instead of a lead.

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 storing, in this

section, several pre-defined global and per-lead beat measurements and annotations, for the reference beats stored in or pinpointed by section 13 and for all or for only some selected beats of the 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 within the short-term ECG(s) stored in section 6 and/or in section 14.

The data format outlined in this section has been designed to support a large number of use cases, such as selecting and daily analysing a set of 10 min duration time windows from a continuous long-term ECG recording, for example for time windows starting at 2 am and 4:30 pm, and then storing (P-on, P-off, QRS-on, QRS-off, T-off) and some additional useful annotations for all beats within the selected 10 min time windows, for assessing day and night differences and day to day variability of the selected measurements.

In another scenario, one may choose to select and store the measurements and annotations for K preselected, not necessarily consecutive beats, one MB per selected beat, for thorough QT studies for example.

To facilitate comparison of a series of beat-by-beat measurements with reference beats measurements, the standard also allows to save in separate measurements arrays, the measurements and annotations performed on the reference beats stored in or pinpointed by sections 5 and 13, one reference beat "measurements block MB" per "measurement array", i.e. one "measurements array" per reference beat.

5.18.1.1   It is mandatory that all measurements and annotations refer to the same patient and that all computed measurements stored in this section of the current SCP-ECG record have been produced by the same ECG analysing software or device. Nevertheless, some filter settings could be specific for the different measurements arrays.

The possibility of storing measurements and annotations for long-term recordings and multiple short duration ECG sequences as well as for computed and/or selected (reference) beats can be exploited to accommodate several use cases and support the monitoring of the changes of the ECG during stress tests, drug tests and other protocol-based ECG recordings, intermittent long-term ECG recordings, etc. This Section and Sections 13&14 have been added in this version of the document to this aim.

5.18.1.2   This section is self-contained, i.e. no other information than the patient data stored in section 1 are needed for exploiting the data content of section 15, if one wants to only exchange beat-by-beat measurements without exchanging signal data.

The section also provides a solution to supersede the filter settings provided in Section 1, Table 2, Tags 27 to 29, and in sections 12 to 14, in case the filtering used to calculate the beat measurements and other annotations is different from the filtering performed during the signal acquisition process and/or before storing the ECG signals, which is usually the case in modern electrocardiographs.

5.18.1.3   The maximum number of measurements arrays that can be stored is limited to 255. There is no limitation in size for these measurements arrays, except that the whole SCP-ECG record is limited to 4 GiB.

5.18.1.4   Each Beat Measurements Block MB consists in a Beat ID, the Beat Starting Sample Number, the Beat label, five standard measurements (global P-on, P-off, QRS-on, QRS-off, T-off) and #ABM optional (ABM = 0 – 65 535), "Additional Beat Measurements and annotations" (see 5.18.4.1 and Figure 19). This number ABM of additional measurements and annotations may vary from one SCP-ECG record to another, but shall be the same for all beat measurements arrays stored in a same SCP-ECG record.

5.18.1.5   Except for the Beat ID and the Beat Starting Sample Number, all other measurements and annotations values shall be encoded by two bytes.

5.18.1.6 All intra-beat time point values must be expressed as sample numbers relative to the beginning BSSN (see 5.18.4.1 bytes 5 to 8) of the analysed beat. The first sample of the beat is numbered 1.

5.18.1.7 Unless specified otherwise, all incomputable measurements and not computed measurements and annotations values shall be pinpointed by one of the special codes listed in 5.10.3.1.

5.18.1.8 Unless specified otherwise, in this section all numeric fields are encoded as unsigned binary integers. Text fields are encoded in UTF-8.

5.18.2 Section ID Header

If present, this section shall start with a "Section ID Header" and shall include the proper data part, as defined in 5.2.7. In particular, in the Section ID Header, the protocol version number stored in the Header byte 10 shall reflect the current version of this document, since versions V1 and V2 do not support this beat-by-beat measurements section (section 15 does not exist in SCP-ECG versions V1 and V2).

5.18.3 Section data part

The Section data part is composed of a data Header, an optional "Additional Beat Measurements and Annotations Definition Block", and a variable number of Measurements Arrays.

5.18.3.1 Data Header

The header is used to provide information that are common to all measurements arrays stored in section 15. It has the following format:

Byte	Contents
1	Confirmed / Non confirmed measurements and annotations Status.

Value	Type
0	Original measurements and annotations (not overread).
1	Confirmed measurements and annotations.
2	Measurements and annotations (partially) overread, but not confirmed.

2 to 8   Date and time of measurements and annotations recording and/or overreading (D/T).

Semantically equivalent to MDC_ATTR_TIME_ABS.

The byte format is identical to the date and time formats specified in section 8 (see 5.11.4):

Byte

2 to 3   Binary: Year (Full integer notation, as in 2018) [MDC_DIM_YR]

4   Binary: Month (range 01 to 12; 01 = January) [MDC_DIM_MON]

5   Binary: Day (range 1 to 31) [MDC_DIM_DAY]

6   Binary: Hours (range 0 to 23) (time is always local time) [MDC_DIM_HR]

7   Binary: Minutes (range 0 to 59) [MDC_DIM_MIN]

8   Binary: Seconds (range 0 to 59) [MDC_DIM_SEC]

NOTE 1   The date and time information stored in this header indicates the date and time of the

creation and/or storage of the latest measurements array of this section (in case the value of byte 1 is 0), or the date and time of the latest overreading or confirmation (in case the value of byte 1 is 1 or 2). This information is usually different from the date and time of the signal recording.

NOTE 2   Time and date is expressed as local time in the Time Zone of the overreader and/or of the analysing device.

9 to 10   Date&Time Time Zone (TZ), specified as an offset from UTC in minutes. (Signed integer).

Semantically equivalent to MDC_ATTR_TIME_ZONE.

The content of this field shall identify the time zone related to the local time stored here above in bytes 2 to 8. The format shall be identical to the Time Zone format specified in bytes 1–2 of Tag 34 in Table 2. In case the local Time Zone is unknown, TZ shall be set to 0x7FFF.

11 to 12   Number of Additional Beat Measurements and Annotations (#ABM).

This field records the number of additional measurements and annotations (if any) which are specified in the Additional Measurements and Annotations Definition Block and whose values or codes will be stored beat-by-beat as a two-byte signed integer value in each (single) beat measurements block MB, after the Toff measurement field (see 5.18.4.1 and Figure 19).

If #ABM = 0, no additional beat measurements and annotations are stored, there is no Additional Measurements and Annotations Definition Block (its size is 0), the first Beat-by-Beat Measurements Array starts immediately after the Manufacturer-specific information field MI, if any, and the size of each single beat measurements block MB is only 20 bytes.

13   Number of recorded Beat-by-Beat Measurements Arrays (#BMA).

Allowed values range from1 to 255.

14 to 62   Reserved for future use (shall always be set to zero).

63 to 66   Length of the Header Notes field in bytes (LHN).

67 to 70   Length of the Manufacturer-specific additional Information field in bytes (LMI).

variable   General Header Notes on this section. This is a free-text field. It shall be NULL terminated.

variable   Manufacturer-specific Information field (MI).

5.18.3.2 Additional Beat Measurements and Annotations Definition block

The additional beat measurements and annotations (compliant with #ABM) and the order in which they are stored in each beat measurements data block MB, are defined in this part of the section. The specification of the additional measurements / annotations order shall reflect the order used for storing the 2-byte measurement/annotation values in each beat measurement data block MB (see 5.18.4). The length of the additional beat measurements and annotations definition block is related to the number of additional measurements #ABM and is a multiple of 10 bytes. For each measurement / annotation of the #ABM additional measurements stored in bytes 11 to 12 of the header of this section data part, the same structure repeats. It is assumed that the additional beat measurements and annotations order and the units or type of these measurements (Units) are the same for each measurements array stored in this section. They may however change from one SCP-ECG record to another.

Byte	Contents

1   Measurements and annotations Reference Thesaurus Code (RTC)

This byte indicates where to find the definition and the semantics of the additional measurement or annotation specified in bytes 2 to 5.

Value	Reference Thesaurus
0	Undefined
1	ISO 11073-10102 [9] and/or its running updates stored in the NIST RTMMS repository [59]
2	SCP-ECG section 7 (Global Measurements)
3	SCP-ECG section 10 (Per-Lead Measurements)
4	ISO 11073-10101 [8] and/or its running updates stored in the NIST RTMMS repository [59]
5 to 99	Reserved for future use
100 to 255	Manufacturer specific codes

2 to 5   Measurement Identification code (MIC).

The measurement / annotation shall be identified by a unique code that shall allow to know what the measurement / annotation represents.

If RTC = 1, then MIC shall store the CF_CODE10 value corresponding to the REFID of the measurement/annotation as defined in ISO 11073-10102 [9] and/or in the running updates tables stored in the NIST RTMMS repository [59].

If RTC = 2, the measurement / annotation has neither been listed in ISO 11073-10101 [8] nor in ISO 11073-10102 [9] but has been defined in SCP-ECG section 7 "Global ECG Measurements", Clause 5.10.3.7 "Additional Global measurements". Then, the Lead Identification value (LID, byte 6 hereafter) shall be set to "199" and MIC shall store in "Byte" 3, the value of the Tag defined in Table 8, and in "Byte" 2 (the least significant byte of the 4-byte integer stored in "Byte" 2 to 5), the position of the measurement's most significant byte in the tagged value field. "Byte" 4 and 5 shall be set to "0".

EXAMPLE   Measurement "Heart rate corrected Dispersion: Max–Min" (Position = Byte 2) of the "QTpeak All-lead Dispersion" (Tag = 1) is encoded by: MIC = 258 (0x00000102).

If RTC = 3, the measurement has neither been listed in ISO 11073-10101 [8] nor in ISO 11073-10102 [9] but has been defined in SCP-ECG section 10 "per-lead ECG measurements", Clause 5.13.6. Then, the LID value shall be set to the proper Lead ID and MIC shall store in "Byte" 2 (the least significant byte), the position of the measurement's most significant byte in the lead measurement block defined in 5.13.6 "Lead measurement block format". "Byte" 3 to 5 shall be set to "0".

EXAMPLE   Measurement "P(+)-amplitude" (Bytes 35–36) is encoded by: MIC = 36 (0x00000024).

If RTC = 4, then MIC shall store the CF_CODE10 value corresponding to the REFID of the measurement/annotation as defined in ISO 11073-10101 [8] and/or in the running updates tables stored in the NIST RTMMS repository [59].

If RTC = 0, then no measurement thesaurus is available. This RTC code may be used for testing purpose. In that case, it is recommended to differentiate the corresponding measurements and annotations identification codes (MIC) by using for example an

incremental number.

If RTC = 100 to 255, then the measurement/annotation is manufacturer specific. It is recommended that the corresponding measurements and annotations are specified in the Manufacturer-specific Information field (MI) and in the manufacturer's physician's guide.

6   Lead Identification (LID).

This discriminator shall be used to identify to which specific ECG lead, if any, the measurement specified by MIC applies. The same SCP-ECG numbering scheme as in 5.6.4, Table 4, shall be used to specify the lead that has been used.

Semantically equivalent to MDC_ECG_Lead_xxx (see 5.6.4 Note).

If the measurement/annotation implicitly refers to the global set of leads, viz the QRS morphology class number (coded by MDC_ECG_QRS_MORPH_NUM), or to a global measurement, then LID shall be set to the SCP-ECG code "199".

The same yields for some of the WAVC components specified in ISO 11073-10102, viz MDC_ECG_WAVC_PWAVE and MDC_ECG_WAVC_QRSWAVE, which might be used to either specify the global duration of the P-wave and of the QRS complex, or the duration of the P-wave and of the QRS complex in a specific lead, depending on the measurements context of use. LID shall thus be set to "199" if the measurement is a global one, to the relevant lead code if the measurement concerns a specific lead, and to "0" if unspecified. It is however recommended to remove any ambiguity by using only CF_CODE10 codes corresponding to global measurement REFIDs listed in ISO 11073-10102 Table A.12, or to per-lead measurements listed in ISO 11073-10102 Table A.13, whenever possible.

NOTE 1   If the MIC value corresponds to the CF_CODE10 of a per-lead ECG measurement listed in Table A.10 of ISO 11073-10102, it implicitly includes the Lead ID and thus would not require to specify the LID code. Indeed, all per-lead ECG measurements listed in Table A.10 of ISO 11073-10102 apply to a specific ECG lead and include the 8-bit MDC_ECG_discrim_LEADS discriminator. For example, the P-wave duration in Lead V2 would be identified as MDC_ECG_TIME_PD_P_LEAD_V2 and CF_CODE10 = 137732. For consistency and ease of use reasons, it is however recommended to specify in byte 6 the target lead, even if implicitly defined by the CF_CODE10 code, i.e. in the previous example to set LID = 4 (SCP-ECG code for V2).

NOTE 2   ISO 11073-10102 allows using per-lead REFIDs for specifying global durations and global onset and offset of some waves, viz the global onset of the P and T-wave and the global P-wave duration. For example, the global P-wave duration (evaluated over all leads) may be identified as MDC_ECG_TIME_PD_P_LEAD_CONFIG (CF_CODE10 = 137728) when using the per-lead ECG numeric form, or by MDC_ECG_TIME_PD_P_GL (CF_CODE10 = 147256) when using the global measurement form. Here the LEAD_CONFIG discriminator (code = 0) is used to specify that the measurement is a global one, i.e. it applies to all leads simultaneously. Coding LEAD_CONFIG "0" is in some way contradictory with the definition given in SCP-ECG Table 4, where SCP-ECG Code = 0 means "Unspecified lead" (see Table 4, Note 1). It is thus typical to set LID to the SCP-ECG code "199" for all global measurements, i.e. for the measurements specified in ISO 11073-10102 Table A.12 and for the relevant per-lead measurements specified in ISO 11073-10102 Table A.13, when the lead discriminator is LEAD_CONFIG.

7 to 8   Measurement/annotation Units code and/or type (Units).

These two bytes specify the physical unit of the selected beat measurement/annotation value (and its type, if dimensionless) that will be stored in the selected Beat Measurements data block MB, as a result of the measurement / annotation process corresponding to the additional measurement / annotation defined in bytes 2 to 5.

Typical additional measurement results are wave component time points (expressed in sample numbers), wave durations (expressed in sample intervals or in ms), wave amplitudes, vector magnitudes and orientations, etc. The later are usually expressed in µV

and in angular degrees.

Physical units shall be identified by means of their UoM base code according to ISO/IEEE 11073-10101 [8] and the updates maintained in the corresponding units-of-measure table defined in the NIST RTMMS repository [59].

Units of dimensionless annotations viz the QRS morphology class number or the ECG rhythm type shall be encoded by 512, the UoM base code for MDC_DIM_DIMLESS (see example in 5.18.6).

Table A.8 in Annex A points out the most useful units for the purpose of this beat-by-beat measurements and annotations section and defines the codes that shall be used for the measurement and annotation types not yet defined by the 11073–10101 standard.

9 to 10   Measurement Value Multiplier (MVM) for the measurement specified in bytes 2 to 5.

The Measurement Value Multiplier (MVM) shall be used as a normalization factor to allow storage of large quantities expressed in physical units pinpointed by bytes 7 to 8 as a two-byte signed integer.

For dimensionless annotations and measurements coded 512 (UoM base code for MDC_DIM_DIMLESS, see Annex A, Table A.8) or expressed in sample numbers and in sample intervals, MVM shall be set to 1.

Example   Let's suppose that bytes 2 to 5 contain the CF_CODE10 for MDC_ECG_INTEGRAL_ QRS_V2 and that bytes 7 to 8 contain the UoM code for values expressed in μV x ms (MDC_DIM_NANO_VOLT_SEC). Then a QRS wave integral value in lead V2 of 100 mV x ms, i.e. of 100 000 000 μV x μs, can be encoded as a 2-byte signed integer equal to 1000 and MVM = 100 (or equal to 10 000 and MVM = 10).

NOTE 1   If #ABM = 0, then this additional beat measurements and annotations definition block is empty (its size equals 0).

NOTE 2   There is no easy way to specify which measurement values can take negative values (viz amplitude and angular degrees). It is thus mandatory that all additional measurement values are stored as 2-byte signed integers (see 5.18.4.1, bytes 21 to 22 and beyond).

5.18.3.3 Beat-by Beat Measurements Arrays

The number of beat-by-beat measurements arrays that will be saved in this Section data part is the number #BMA stored in byte 13 of the data Header of this section (see 5.18.3.1). For every Beat-by-Beat Measurements Array, the same structure repeats. It consists of an array specific header with information about the related ECG recording and/or ECG excerpt, and an optional notes field followed by the different beat measurements blocks (MBs). The header also contains information about the analysis Time Window corresponding to the measurements and annotations results stored in this array, and several metadata such as the sampling rate and specific filtering, if any. It also specifies the number of beat measurement blocks stored at the end of the array header after the notes field as well as some general measurement results such as the mean RR and PP intervals.

Beat-by-Beat Measurements Array Header

Byte	Contents
1	Measurements Array Id (MAId). Allowed values range from 1 to 255.
2	Related ECG signal data section (ECG_DS).
	This byte is used in combination with byte 3 to specify in which section one can find the raw ECG signal data corresponding to the measurements / annotations stored in this specific array.

Value	ECG signal type and localization
0	Unknown, or the raw ECG signals from which the beat-by-beat measurements / annotations stored in this array have been derived are not saved in this SCP-ECG file
5	Rest ECG reference beat (Section 5)
6	Rest ECG rhythm data (Section 6)
12	Long-term ECG rhythm data (Section 12)
13	Selected ECG reference beats (Section 13)
14	Selected ECG sequences repository (Section 14)

3   Related ECG Data Block Number (ECG_DBN).

This byte is used to specify, in case ECG_DS = 13 or 14, to which ECG sequence or ECG reference beat the stored beat measurements / annotations correspond.

If ECG_DS = 13, then ECG_DBN shall store the metadata block ID "BId" (see 5.16.3.3) corresponding to the analysed reference beat, i.e. ECG_DBN = BId.

If ECG_DS = 14, then ECG_DBN shall store the block identification number "BN" (see 5.17.6.6) corresponding to the analysed ECG sequence, i.e. ECG_DBN = BN.

In all other cases ECG_DBN shall be set to zero.

4 to 7   Analysis Time Window Starting Date (TWSD).

The value assigned to TWSD shall be the date of the acquisition of the first ECG sample of the ECG area of interest (also pinpointed by ECG_DS, ECG_DBN, TWST, TWSS and TWSL) corresponding to the Time Window for which the beat measurements and annotations stored hereafter have been computed or, in case ECG_DS = 0, the date of the acquisition of the first ECG sample analysed in the original, non-saved ECG recording.

In case ECG_DS = 13, the stored measurements are related to the reference beat identified by its metadata block Id BId and TWSD shall take the same value as BDR (see 5.16.3.3 bytes 4 to 7).

The format of TWSD shall be compliant with the "Date of Acquisition" format specified in the ECG metadata part of Section 1. (For the format details, refer to Table 2, Tag 25).

8 to 10   Analysis Time Window Starting Time (TWST).

The value assigned to TWST shall be the time of the acquisition of the first ECG sample of the ECG area of interest (also pinpointed by ECG_DS, ECG_DBN, TWSD, TWSS and TWSL) corresponding to the Time Window for which the measurements stored in this measurements array have been computed or, in case ECG_DS = 0, the time of the acquisition of the first ECG sample analysed in the original, non-saved ECG recording.

In case ECG_DS = 13, the stored measurements are related to the reference beat identified by its metadata block Id BId and TWST shall take the same value as BTR (see 5.16.3.3 bytes 8 to 10).

The format of TWST shall be compliant with the "Time of Acquisition" format specified in the ECG metadata part of Section 1. (For the format details, refer to Table 2, Tag 26).

NOTE 1 In case the analysis Time Window of the saved measurements and annotations is identical to the time window during which the analysed ECG signal has been acquired, then TWSD and TWST (defined above in bytes 4 to 10) respectively take the same values as the date and the time of the acquisition of the first ECG sample of the raw ECG recording or sequence pinpointed by

ECG_DS and ECG_DBN.

11 to 14   Analysis Time Window Starting Sample number (TWSS).

This field contains the sample number (referred to a generic lead, all the leads having the same number of samples) of the first ECG sample of the ECG area of interest specified by the previously defined starting date (TWSD) and time (TWST) and by the analysis Time Window Length (TWSL, defined hereafter in bytes 15 to 18), in the raw ECG recording pinpointed by ECG_DS and ECG_DBN or, in case ECG_DS = 0, in the original, non-saved ECG recording.

In case ECG_DS ≠ 13 and TWSD and TWST are identical to the date and the time of the acquisition of the first ECG sample of the analysed ECG signal, then TWSS shall be set to 1.

In case ECG_DS = 13, the stored measurements are related to the reference beat identified by its metadata block Id BId and TWSS shall take the same value as SRB (see 5.16.3.3 bytes 18 to 21).

15 to 18   Analysis Time Window Length, in Samples per lead (TWSL).

This field contains the length (in number of samples) of the analysis Time Window, in the raw ECG recording pinpointed by ECG_DS and ECG_DBN or, in case ECG_DS = 0, in the original, non-saved ECG recording.

In case ECG_DS = 13, the stored measurements are related to the reference beat identified by its metadata block Id BId and TWST should take the same value as LRB (see 5.16.3.3 bytes 22 to 23).

TWSL includes sample TWSS. The last sample of the specified area of interest will thus be sample number (TWSS + TWSL −1)

NOTE 2   If the value of ECG_DS is different from "0", then the number and definition of the leads, the sampling rate and the AVM to be considered here for extraction or display of the corresponding ECG area of interest are specified in the sections pinpointed by ECG_DS and ECG_DBN.

19 to 22   Sampling Rate, in samples per second (SR).

Semantically   equivalent   to   MDC_ECG_CTL_VBL_SAMPLE_RATE   and MDC_ATTR_SAMPLE_RATE.

This field shall replicate the sampling rate of the original ECG recording specified in the sections pinpointed by ECG_DS and ECG_DBN. It has been included here to make this section self-standing and to convert measurement time points (viz beat and wave locations) and durations expressed in sample numbers and in sample intervals, into physical time and duration.

In case the value of ECG_DS equals "0", then bytes 19 to 22 shall store the sampling rate of the original ECG on which the measurements / annotations stored in this measurements array have been computed.

NOTE 3   Instead of storing as in Section 6 the sample time interval in microseconds (an example is given in Clause 5.9.3), in this Section the sample rate has been preferred, as in sections 12 (long-term ECG), 13 and 14.

23   Measurements Array specific Filter Setting (MAFS).

The definition of the values taken by this byte are:

0   Unspecified.

No specific filter settings have been specified and the filter settings used for processing the ECG signals corresponding to the measurements / annotations stored

in this measurements array are unknown. This means that bytes 24 to 28 shall be discarded and that the users must refer to the physician's guide to know which specific filtering has been used, if any.

If ECG_DS does not equal "0" (see above, byte 2), then the filter settings stored in Table 2, Tag 27, 28 and 29 and/or in the sections pinpointed by ECG_DS may be used to know if the ECG signals stored in the respective ECG signal data sections have been filtered, and how.

1   No specific filter settings used.

No specific filters other than the ones specified in Table 2, Tag 27, 28 and 29 and/or in the sections pinpointed by ECG_DS have been used for processing the ECG signals corresponding to the measurements / annotations stored in this measurements array. The relevant filter settings initially stored in Table 2 and/or in the sections pinpointed by ECG_DS are replicated hereafter in bytes 24 to 28, to facilitate the retrieval of the corresponding information and thus make this section self-standing.

2   Specific filter settings used.

The filter settings that have been used for processing the ECG signals corresponding to the measurements / annotations stored in this measurements array in this section are defined hereafter, regardless of the values stored in Table 2 or in the sections pinpointed by ECG_DS. The new settings only apply to this measurements array in this section, and are specified in bytes 24 to 28.

24 to 25   High-pass filter (HPF) [MDC_ECG_CTL_VBL_ATTR_FILTER_HIGH_PASS].

If MAFS = 2, this field contains the "cut-off" frequency (−3 dB) of the high-pass filter that has been used, if any, for computing the measurements stored in this measurements array, in units of (1/100) Hertz.

NOTE 4   A value of 0xFFFF in this field means that the filter setting was not specified.

NOTE 5   A value of zero in this field means that the recorded signals were DC-coupled and that no high-pass filtering was performed.

26 to 27   Low-pass filter (LPF) [MDC_ECG_CTL_VBL_ATTR_FILTER_CUTOFF_FREQ].

If MAFS = 2, this field contains the "cut-off" frequency (−3 dB) of the low-pass filter that has been used, if any, for computing the measurements stored in this measurements array, in units of Hertz.

Systems that do not perform any low-pass filtering for computing measurements and annotations shall replicate the low-pass filter setting of the recorded signal data.

NOTE 6   A value of 0xFFFF in this field means that the filter setting was not specified.

28   Filter bit map (FBM) (binary).

If MAFS = 2, this field indicates if other filters, which were not implicitly defined by the content of bytes 24 to 27, have been used during the processing of the ECG. The definition of the different bits of the FBM bit map are detailed in Annex A, Table A.6.

NOTE 7   If FBM = 0, no additional filtering than those implicitly specified in bytes 24 to 27 was used.

NOTE 8   If FBM = 255, then the FBM filter setting was not specified.

29 to 30   Average RR interval in milliseconds for all QRS complexes of the ECG sequence corresponding to the analysed time window and to the present measurements array.

Semantically equivalent to MDC_ECG_TIME_PD_RR_GL_MEAN.

NOTE 9   In case no average RR interval is computed/computable, this is specified by storing one of the special codes defined in 5.10.3.1.

31 to 32   Average PP interval in milliseconds for all P waves of the ECG sequence corresponding to the analysed time window and to the present measurements array.

Semantically equivalent to MDC_ECG_TIME_PD_PP_GL_MEAN.

NOTE 10 In case no average PP interval is computed/computable, this is specified by storing one of the special codes defined in 5.10.3.1.

33 to 36   Number of stored beats (#Beats).

37 to 62   Reserved for future use (shall always be set to zero).

63 to 64   Length, in bytes, of a Note Field for this Measurements Array (LMAN).

The notes may be used for example to describe and document the different ECG processing steps and the particularities of the selected analysis time window or of the manufacturer specific measurements / annotations stored in this particular array.

Variable (LMAN)   Measurements Array Notes field explaining the particularities of the processing steps and/or of the non-standard measurements. This is a free text field that can also be filled in with annotations from the technician, cardiologist, etc. It shall be null terminated.

Variable   Set of Measurements and annotations (Measurements Block) for the 1st Beat (MB1).

NOTE 11 The size of this field and of each of the following ones is (20 + #ABM x 2) bytes.

variable   Set of Measurements and annotations (Measurements Block) for the 2nd Beat (MB2).

...   etc.

To facilitate the retrieval of the beat measurements and annotations metadata and thus make this section self-contained, none of the fields of this array header can be overlooked even if some of the values are the same as in Section 1 or in the signal sections. This array header shall be filled up again.

The information on the presence and type of pacing device, if any, shall be provided in Section 1 (Table 2, Tag 32 and Tag 36).

5.18.4 (Single) Beat Measurements data Block (MB) structure

5.18.4.1 Description of the data content of each beat Measurements and annotations data Block

Byte   Contents

1 to 4   Beat ID (BID).

Sequential number. May be used in combination with the Measurements Array Id MAId

(see 5.18.3.3 byte 1) to facilitate retrieval of the measurements and annotations of a specific beat when referenced in another section.

5 to 8   Beat Starting Sample Number (BSSN), expressed as a sample number relative to TWSS, the Starting Sample number of the analysed ECG excerpt corresponding to the analysis Time Window.

Semantically equivalent to MDC_ECG_BEAT_ONSET and to MDC_ECG_WAVC_PQRSTWAVE_ ONSET. (See Note 2)

This field contains the sample number BSSN (referred to a generic lead, all the leads having the same number of samples) of the first ECG sample of the beat pinpointed by BID, with reference to TWSS, the Starting Sample number of the analysis Time Window.

If ECG_DS = 5 or ECG_DS = 13 and RTBL[2] = 1 (see 5.16.3.3 byte 17), then BSSN = 1 (the measurements and annotations concern a computed reference beat).

9 to 10   Beat label, encoded using the CODE10 code corresponding to the REFIDs for beat labels listed in Table A.9 "ECG beat annotations" of ISO 11073-10102 [9] and/or in the running updates tables stored in the NIST RTMMS repository [59].

Semantically equivalent to MDC_ECG_QRS_TYPE.

"Beat label" shall be encoded by 8192 (CODE10 for MDC_ECG_BEAT) if undefined (no beat label available for this beat).

11 to 12   Global P onset, expressed as a sample number relative to the beginning BSSN of the analysed beat (signed integer).

Semantically equivalent to MDC_ECG_TIME_START_P_LEAD_CONFIG and to the two level encoding [MDC_ECG_LEAD_CONFIG, MDC_ECG_WAVC_PWAVE_ONSET].

13 to 14   Global P offset, expressed as a sample number relative to the beginning BSSN of the analysed beat (signed integer).

Semantically equivalent to MDC_ECG_TIME_END_P_LEAD_CONFIG and to the two level encoding [MDC_ECG_LEAD_CONFIG, MDC_ECG_WAVC_PWAVE_OFFSET].

15 to 16   Global QRS onset, expressed as a sample number relative to the beginning BSSN of the analysed beat (signed integer).

Semantically equivalent to MDC_ECG_TIME_START_QRS_LEAD_CONFIG and to the two level encoding [MDC_ECG_LEAD_CONFIG, MDC_ECG_WAVC_QRSWAVE_ONSET].

17 to 18   Global QRS offset, expressed as a sample number relative to the beginning BSSN of the analysed beat (signed integer).

Semantically equivalent to MDC_ECG_TIME_END_QRS_LEAD_CONFIG and to the two level encoding [MDC_ECG_LEAD_CONFIG, MDC_ECG_WAVC_PWAVE_OFFSET].

19 to 20	Global T offset, expressed as a sample number relative to the beginning BSSN of the analysed beat (signed integer).
	Semantically equivalent to MDC_ECG_TIME_END_T_LEAD_CONFIG and to the two level encoding [MDC_ECG_LEAD_CONFIG, MDC_ECG_WAVC_TWAVE_OFFSET].
21 to 22	1st Additional Beat Measurement/annotation, if any (ABM1) (signed integer)
23 to 24	2nd Additional Beat Measurement/annotation, if any (ABM2) (signed integer)
25 to 26	3rd Additional Beat Measurement/annotation, if any (ABM3) (signed integer)
...	etc., up to Additional Beat Measurement/annotation ABMn, n = #ABM (signed integer)

Any measurement computed as a "Time Point" (including any additional beat measurement computed as a time point) shall be expressed as a sample number relative to the beginning BSSN (Beat Starting Sample Number) of the analysed beat. The first sample of the beat is numbered 1. Unlike Section 7, where wave time points are given in milliseconds (see 5.10.3.3), in this Section sample numbers have been preferred. Timings in milliseconds may be easily computed by subtracting "1" from the values in sample numbers (the first sample of the beat starts at time 0) and then by multiplying the result by 1000 and dividing it by the sampling rate SR stored in bytes 19 to 20 of the Measurements Array Header (see 5.18.3.3, bytes 19 to 22).

For example, in case of a median beat, BSSN = 1 and if the location of the global onset of the P-wave is sample number 11 and SR = 500 s/sec, then the P-onset is located 20 ms after the median beat onset.

Additional beat measurements values shall be stored after byte 20 as 2-byte signed integers. Care should be taken to limit "positive" values to a maximum of 32767 and to avoid using one of the special codes listed in 5.10.3.1, except if relevant. Annotations based on ISO 11073-10102 REFIDs shall be stored as CODE10 code values (unsigned integers).

NOTE 1   As all other time points in this data set (viz Global P onset, etc.) are expressed as sample numbers with reference to BSSN, it is suggested to choose a BSSN time point that is upstream of the global P onset, but nevertheless allows to discriminate the present beat from the previous one when using BSSN to visually locate the beat on the original ECG recording (although using the global onset of QRS or any intra QRS fiducial point would be a better choice for visually identifying the beat pinpointed by BSSN on the display or printout of the original ECG signals).

A common practice is to select a BSSN located 20 ms before global P onset or 150 ms before global onset of QRS in case no P wave was detected.

NOTE 2   BSSN can also be encoded using one of the following REFIDs: MDC_ECG_BEAT_TIME, MDC_ECG_BEAT_XX and MDC_ECG_WAVC_PQRSTWAVE_XX, where suffix XX can take one of the following values: TIME_POINT, ONSET, ONSET_IMPL. Another option is to use MDC_ECG_BEAT_TOC, although the latter is typically reserved for encoding intra QRS fiducials.

NOTE 3   Typical examples of beat labels are:

— VPC (Ventricular premature contraction beat). Is encoded by 8336 (CODE10 for MDC_ECG_BEAT_V_P_C);

— Normal Beat. Is encoded by 8208 (CODE10 for MDC_ECG_BEAT_NORMAL);

— Paced Beat. Is encoded by 8704 (CODE10 for MDC_ECG_BEAT_PACED), etc.

5.18.4.2 Overview of the data content of a single beat Measurements and annotations Block (MB)

An overview of the data content of a typical beat Measurements and annotations Block (MB) is provided in Figure 19, where ABM stands for Additional Beat Measurement or annotation (see 5.18.3.2).

BID	BSSN	Beat label	Pon global	Poff global	QRSon global	QRSoff global	Toff global	1st ABM	2nd ABM	...//...	Last ABM
4	4	2	2	2	2	2	2	2	2	var	2

Figure 19 — Overview of the data content of each beat Measurements Block MB

5.18.5 Overview of the data part of the Beat-by-Beat ECG measurements and annotations section

An overview of the data part of section 15, Beat-by-Beat ECG measurements and annotations, is provided in Figure 20.
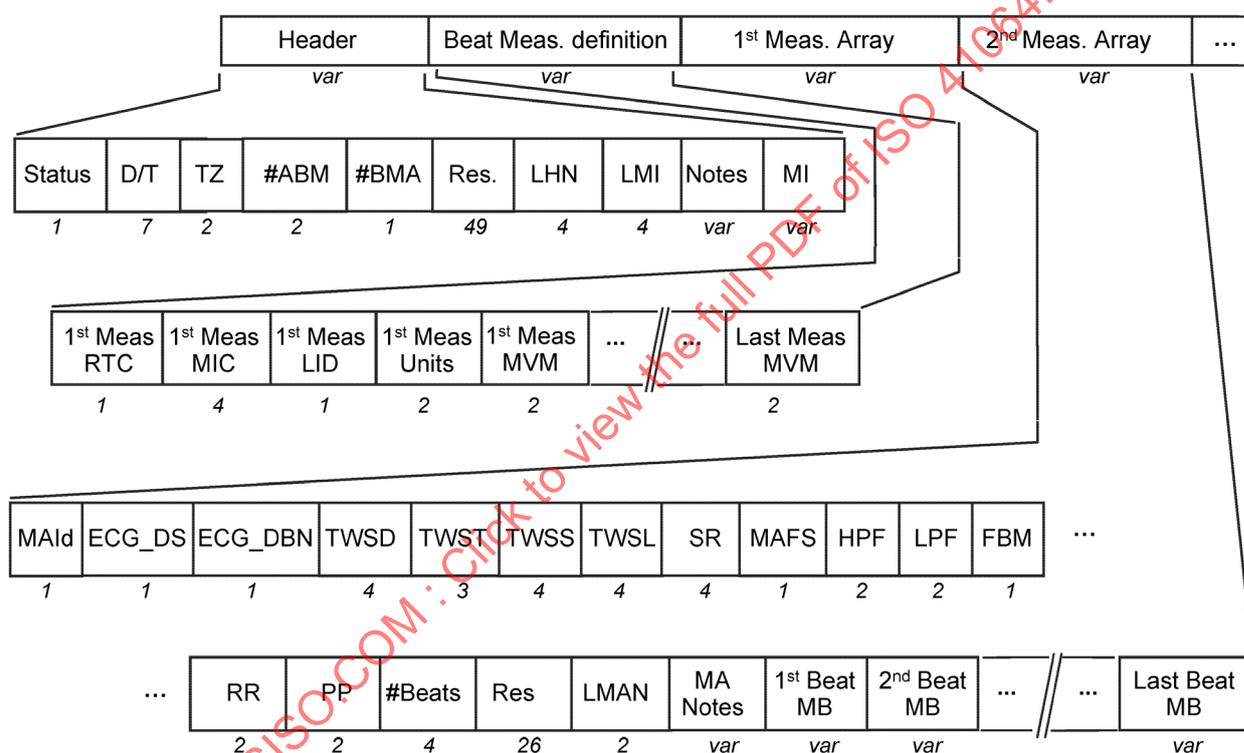
Figure 20 — Overview of the data part of Section 15

5.18.6 Example of encoded beat measurements and annotations

Table 10 below displays some of the coded content of a typical (Beat x Measurements/Annotations) Array for a few beats from a real 10 min duration ECG record, where we assume that the sampling rate is 500 samples/s and that the first three and the last Additional Beat Measurements and annotations (ABMs) defined in the "Additional Beat Measurements and Annotations Definition block" are respectively the following:

— "Beat type" (i.e. the QRS morphology class number, coded by MIC = 1 and MDC_ECG_QRS_MORPH_NUM, CF_CODE10 = 666688),

— "Rhythm type" (coded by MIC = 1 and MDC_ECG_RHYTHM_TYPE, CF_CODE10 = 666692),

— "QRS axis" (coded by MIC = 1 and MDC_ECG_ANGLE_QRS_FRONT, CF_CODE10 = 147204),

— "ST40_V", i.e. the "Magnitude of the vector at 40 ms after the end of QRS complex" (coded by MIC = 1 and MDC_ECG_MAG_J40_VECT, CF_CODE10 = 147328), in µV.

Beat labels and wave onsets and offsets have been encoded as specified in 5.18.4.1.

Beat type values have been coded as usual by 0, 1, 2 etc., where "0" represents the dominant class (see 5.1.11 and Annex D).

Rhythm type values have been encoded by the CODE10 values corresponding to the REFIDs "ECG rhythm annotations" listed in Table A.10 "ECG rhythms" of ISO 11073-10102 [9].

For the QRS axis in the frontal plane the convention shown in Figure 10 has been used.

Measurements not found (no P wave during atrial fibrillation) or not computed are respectively coded 19 999 and 29 999 (see 5.10.3.1).

In this 10 min ECG record example, at the beginning the rhythm is sinus normal, beat N° 2 is a VPC. Around time t = 1 min, there are two premature atrial beats, followed by atrial flutter. Around time t = 2 min, the rhythm then changes to atrial fibrillation which lasts until the end of the record.

Table 10 — Tabular representation of the coded content of a typical (Beat x Measurements/Annotations) Array

BID	BSSN	Beat Label	Pon	Poff	QRSon	QRSoff	Toff	ABM_1 Beat type	ABM_2 Rhythm type	ABM_3 QRS axis	...	Last ABM ST40_V
1	470	8208 [a]	15	60	90	135	290	0	9239 [e]	−15	...	15
2	870	8336 [b]	19999	19999	80	150	305	1	0	29999 [h]	...	120
3	1470	8208	17	61	92	136	294	0	0	−13	...	12
...	...	...	...	...	...	...	...	...	...	...	...	...
60	30000	8208	N	29999	91	133	292	0	0	−10	...	18
61	30260	8304 [c]	19999	19999	65	130	298	2	0	29999 [h]	...	70
62	30500	8272 [d]	19999	19999	89	134	293	0	0	−12	...	14
63	31015	8208	15	60	91	137	292	0	0	−15	...	17
64	31240	8208	19999	19999	90	133	289	0	9460 [f]	−10	...	16
65	31520	8208	19999	19999	88	134	290	0	0	−11	...	12
...	...	...	...	...	...	...	...	...	...	...	...	...
180	59740	8208	19999	19999	91	135	293	0	0	−14	...	18
181	60000	8208	19999	19999	90	136	292	0	9476 [g]	−9	...	22
182	60230	8208	19999	19999	87	132	287	0	0	−12	...	16
...	...	...	...	...	...	...	...	...	...	...	...	...

BID	BSSN	Beat Label	Pon	Poff	QRSon	QRSoff	Toff	ABM_1 Beat type	ABM_2 Rhythm type	ABM_3 QRS axis	...	Last ABM ST40_V
M	299480	8208	19999	19999	91	134	292	0	0	−11	...	14

[a] CODE10 for MDC_ECG_BEAT_NORMAL

[b] CODE10 for MDC_ECG_BEAT_V_P_C

[c] CODE10 for MDC_ECG_BEAT_ATR_P_C_ABERR

[d] CODE10 for MDC_ECG_BEAT_ATR_P_C

[e] CODE10 for MDC_ECG_RHY_SINUS_NORMAL_RHY_ONSET_IMPL

[f] CODE10 for MDC_ECG_RHY_ATR_FLUT_ONSET

[g] CODE10 for MDC_ECG_RHY_ATR_FIB_ONSET

[h] It is assumed that the program having produced this measurements/annotations array only computes axes for dominant beats

5.19 Selected ECG beats measurements and annotations – Section 16

5.19.1 General

Although section 15 already provides means to store several pre-defined global and per-lead beat measurements and annotations for different subsets of computed or selected (reference) beats of the analysed signals, there are various scenarios which require for example to store a few measurements and annotations for all beats of the rhythm signals, and a larger set of measurements and annotations for a much smaller number of beats, ie for some selected or computed reference beats. One solution would be to extend the number of (optional) additional measurements in section 15 to include the additional measurements used for quantifying the selected or computed reference beats, but this could introduce huge overheads as all measurement and annotations arrays in section 15 do have the same Measurement Block (MB) length which would require to store Void measurement values for the non-selected beats, even if not computed.

Section 16 provides a solution to store a different set of measurements and annotations than the ones 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 systematic reserved fields viz for systematically storing the PP and RR intervals and the global onsets and offsets of the P, QRS and T waves (the latter can nevertheless be stored, if need be, as optional measurements).

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

Beat measurements (fiducial location, wave amplitude or duration, etc.) and annotations (beat type, beat label, etc.) may be stored in one or more measurements blocks (hereafter called beat Measurements and annotations Block, in short MB), one MB per selected beat.

The beats may have been selected within the set of reference beats of different types stored in sections 5 or 13 or pinpointed by the metadata stored in section 13, or have been selected one by one by a physician or by a protocol based algorithm within the long-term ECG stored in section 12 or within the short-term ECG(s) stored in section 6 and/or in section 14.

5.19.1.1 It is mandatory that all measurements and annotations stored in this section of the current SCP-ECG record refer to the same patient and that all computed and stored measurements have been produced by the same ECG analysing software or device. It is also assumed that the filter settings (viz specific band pass filtering, if any) used for processing the selected beats are the same for all measurements and annotations blocks stored in this section of the SCP-ECG record.

5.19.1.2   This section is self-contained, i.e. no other information than the patient data stored in section 1 are needed for exploiting the data content of section 16, if one wants to only exchange selected beat measurements without exchanging signal data.

The section also provides a solution to supersede the filter settings provided in Section 1, Table 2, Tags 27 to 29, and in sections 12 to 14, in case the filtering used to calculate the beat measurements and other annotations is different from the filtering performed during the signal acquisition process and/or before storing the ECG signals, which is usually the case in modern electrocardiographs.

5.19.1.3   The maximum number of measurements blocks that can be stored is limited to 65 535. There is no limitation in size for these measurements blocks, except that the whole SCP-ECG record is limited to 4 GiB.

5.19.1.4   Each Beat Measurements Block MB consists in a Beat ID, pointers to the sections in which the selected beat signal data are stored, the sampling rate of the beat signal data, the Beat Starting Sample Number BSSN in the original raw signals record (if any), the Beat label, and #OBM (OBM = 0 – 65 535) "Optional Beat Measurements and annotations" (see 5.19.4.1 and Figure 21). This number OBM of optional measurements and annotations may vary from one SCP-ECG record to another, but shall be the same for all selected beat measurements blocks stored in a same SCP-ECG record.

5.19.1.5   Except for the pointers to the signal data sections ECG_DS and ECG_DBN, the Sampling Rate SR and the Beat Starting Sample Number, all other measurements and annotations values shall be encoded by two bytes.

5.19.1.6   All intra-beat time point values shall be expressed as sample numbers relative to the beginning BSSN (see 5.19.4.1, bytes 9 to 12) of the analysed beat. The first sample of the beat is numbered 1.

5.19.1.7   Unless specified otherwise, all incomputable measurements and not computed measurements and annotations values shall be pinpointed by one of the special codes listed in 5.10.3.1.

5.19.1.8   Unless specified otherwise, in this section all numeric fields are encoded as unsigned binary integers. Text fields are encoded in UTF-8.

5.19.2 Section ID Header

If present, this section shall start with a "Section ID Header" and shall include the proper data part, as defined in 5.2.7. In particular, in the Section ID Header, the protocol version number stored in the Header byte 10 shall reflect the current version of this document, since versions V1 and V2 do not support this selected beats measurements section (section 16 does not exist in SCP-ECG versions V1 and V2).

5.19.3 Section data part

5.19.3.1 General

The Section data part is composed of a data Header, an "Optional Beat Measurements and Annotations Definition Block", and a variable number of Beat Measurements Blocks.

5.19.3.2 Data Header

The header is used to provide information that are common to all Beat Measurements Blocks stored in section 16 after the "Optional Beat Measurements and Annotations Definition Block". It has the following format:

Byte   **Contents**

1   Confirmed / Non confirmed measurements and annotations Status.

   Value   Type

   0   Original measurements and annotations (not overread).

   1   Confirmed measurements and annotations.

   2   Measurements and annotations (partially) overread, but not confirmed.

2 to 8   Date and time of measurements and annotations recording and/or overreading (D/T).

   Semantically equivalent to MDC_ATTR_TIME_ABS.

   The byte format is identical to the date and time formats specified in section 8 (see 5.11.4):

   Byte

   2 to 3   Binary: Year (Full integer notation, as in 2018) [MDC_DIM_YR]

   4   Binary: Month (range 01 to 12; 01 = January) [MDC_DIM_MON]

   5   Binary: Day (range 1 to 31) [MDC_DIM_DAY]

   6   Binary: Hours (range 0 to 23) (time is always local time) [MDC_DIM_HR]

   7   Binary: Minutes (range 0 to 59) [MDC_DIM_MIN]

   8   Binary: Seconds (range 0 to 59) [MDC_DIM_SEC]

   NOTE 1 The date and time information stored in this header indicates the date and time of the creation and/or storage of the latest beat measurements block of this section (in case the value of byte 1 is 0), or the date and time of the latest overreading or confirmation (in case the value of byte 1 is 1 or 2). This information is usually different from the date and time of the signal recording.

   NOTE 2 Time and date is expressed as local time in the Time Zone of the overreader and/or of the analysing device.

9 to 10   Date&Time Time Zone (TZ), specified as an offset from UTC in minutes (Signed integer).

   Semantically equivalent to MDC_ATTR_TIME_ZONE.

   The content of this field shall identify the time zone related to the local time stored here above in bytes 2 to 8. The format shall be identical to the Time Zone format specified in bytes 1–2 of Tag 34 in Table 2. In case the local Time Zone is unknown, TZ shall be set to 0x7FFF.

11 to 12   Number of Optional Beat Measurements and Annotations (#OBM).

   This field records the number of optional measurements and annotations (if any) which are specified in the Optional Measurements and Annotations Definition Block and whose values or codes will be stored beat-by-beat as a two-byte signed integer value in each (single) beat measurements block MB, after the Beat Label field (see 5.19.4.1 and Figure 21).

   If #OBM = 0, no optional beat measurements and annotations are stored, there is no

Optional Measurements and Annotations Definition Block (its size is 0), the first selected beat Measurements Block starts immediately after the Manufacturer-specific information field MI, if any, and the size of each single beat measurements block MB is only 14 bytes.

13 to 14   Number of recorded (selected) Beats Measurements Blocks (#BMB).

Allowed values range from1 to 65 536.

15   Selected Beats Measurements specific Filter Setting (BMFS).

The definition of the values taken by this byte are:

0   Unspecified.

No specific filter settings have been specified and the filter settings used for processing the ECG signals corresponding to the measurements / annotations stored in the selected beat measurements blocks are unknown. This means that bytes 16 to 20 shall be discarded and that the users must refer to the physician's guide to know which specific filtering has been used, if any.

If ECG_DS does not equal "0" (see 5.19.4.1 byte 3), then the filter settings stored in Table 2, Tag 27, 28 and 29 and/or in the sections pinpointed by ECG_DS may be used to know if the ECG signals stored in the respective ECG signal data sections have been filtered, and how.

1   No specific filter settings used.

No specific filters other than the ones specified in Table 2, Tag 27, 28 and 29 and/or in the sections pinpointed by ECG_DS have been used for processing the ECG signals corresponding to the measurements / annotations stored in the selected beat measurements blocks. The relevant filter settings initially stored in Table 2 and/or in the sections pinpointed by ECG_DS are replicated hereafter in bytes 16 to 20, to facilitate the retrieval of the corresponding information and thus make this section self-standing.

2   Specific filter settings used.

The filter settings that have been used for processing the ECG signals corresponding to the measurements / annotations stored in the selected beat measurements blocks in this section are defined hereafter, regardless of the values stored in Table 2 or in the sections pinpointed by ECG_DS. The new settings only apply to the beat measurements blocks in this section, and are specified in bytes 16 to 20.

16 to 17   High-pass filter (HPF) [MDC_ECG_CTL_VBL_ATTR_FILTER_HIGH_PASS]

If BMFS = 2, this field contains the "cut-off" frequency (−3 dB) of the high-pass filter that has been used, if any, for computing the measurements stored in this selected beat measurements block, in units of (1/100) Hertz.

NOTE 3   A value of 0xFFFF in this field means that the filter setting was not specified.

NOTE 4   A value of zero in this field means that the recorded signals were DC-coupled and that no high-pass filtering was performed.

18 to 19   Low-pass filter (LPF) [MDC_ECG_CTL_VBL_ATTR_FILTER_CUTOFF_FREQ]

If BMFS = 2, this field contains the "cut-off" frequency (−3 dB) of the low-pass filter that has been used, if any, for computing the measurements stored in this selected beat measurements block, in units of Hertz.

Systems that do not perform any low-pass filtering for computing measurements and annotations shall replicate the low-pass filter setting of the recorded signal data.

NOTE 5   A value of 0xFFFF in this field means that the filter setting was not specified.

20   Filter bit map (FBM) (binary).

If BMFS = 2, this field indicates if other filters, which were not implicitly defined by the content of bytes 16 to 19, have been used during the processing of the ECG. The definition of the different bits of the FBM bit map are detailed in Annex A, Table A.6.

NOTE 6   If FBM = 0, no additional filtering than those implicitly specified in bytes 28 to 31 was used.

NOTE 7   If FBM = 255, then the FBM filter setting was not specified.

21 to 62   Reserved for future use (shall always be set to zero).

63 to 66   Length of the Header Notes field in bytes (LHN).

67 to 70   Length of the Manufacturer-specific additional Information field in bytes (LMI).

variable   General Header Notes on this section. This is a free-text field. It shall be NULL terminated.

variable   Manufacturer-specific Information field (MI).

5.19.3.3 Optional Beat Measurements and Annotations Definition block

The optional beat measurements and annotations (compliant with #OBM) and the order in which they are stored in each beat measurements data block MB, are defined in this part of the section. The specification of the optional measurements / annotations order shall reflect the order used for storing the 2-byte measurement/annotation values in each beat measurement data block MB (see 5.19.4). The length of the optional beat measurements and annotations definition block is related to the number of optional measurements #OBM and is a multiple of 10 bytes. For each measurement / annotation of the #OBM optional measurements stored in bytes 11 to 12 of the header of this section data part, the same structure repeats. It is assumed that the optional beat measurements and annotations order and the units or type of these measurements (Units) are the same for each beat measurements block stored in this section. They may however change from one SCP-ECG record to another.

Byte   Contents

1   Measurements and annotations Reference Thesaurus Code (RTC).

This byte indicates where to find the definition and the semantics of the optional measurement or annotation specified in bytes 2 to 5.

Value	Reference Thesaurus
0	Undefined
1	ISO 11073-10102 [9] and/or its running updates stored in the NIST RTMMS repository [59]
2	SCP-ECG section 7 (Global Measurements)
3	SCP-ECG section 10 (Per-Lead Measurements)
4	ISO 11073-10101 [8] and/or its running updates stored in the NIST RTMMS repository [59]
5 to 99	Reserved for future use
100 to 255	Manufacturer specific codes

2 to 5   Measurement Identification code (MIC).

The measurement / annotation shall be identified by a unique code that shall allow to know what the measurement / annotation represents.

The same RTC-dependent MIC coding rules as the rules defined in 5.18.3.2, bytes 2 to 5, for specifying additional beat measurements and annotations in section 15, apply.

6   Lead Identification (LID).

This discriminator shall be used to identify to which specific ECG lead, if any, the measurement specified by MIC applies. The same SCP-ECG numbering scheme as in 5.6.4, Table 4, shall be used to specify the lead that has been used.

Semantically equivalent to MDC_ECG_Lead_xxx (see 5.6.4 Note).

If the measurement/annotation implicitly refers to the global set of leads, viz the QRS morphology class number (coded by MDC_ECG_QRS_MORPH_NUM), or to a global measurement, then LID shall be set to the SCP-ECG code "199".

For additional comments, see 5.18.3.2, Lead Identification (byte 6), Notes 1 and 2.

7 to 8   Beat measurement/annotation Units code and/or type (Units).

These two bytes specify the physical unit of the selected beat measurement/annotation value (and its type, if dimensionless) that will be stored in the selected Beat Measurements data block MB, as a result of the measurement / annotation process corresponding to the measurement / annotation defined in bytes 2 to 5.

Typical measurement results are wave component time points (expressed in sample numbers) wave durations (expressed in sample intervals or in ms), wave amplitudes, vector magnitudes and orientations, etc. The later are usually expressed in μV and in angular degrees.

Physical units shall be identified by means of their UoM base code according to ISO/IEEE 11073-10101 [8] and the updates maintained in the corresponding units-of-measure table defined in the NIST RTMMS repository [59].

Units of dimensionless annotations viz the QRS morphology class number or the ECG rhythm type shall be encoded by 512, the UoM base code for MDC_DIM_DIMLESS (see example in 5.18.6).

Table A.8 in Annex A points out the most useful units for the purpose of this selected ECG-beats measurements and annotations section and defines the codes that shall be used for the measurement and annotation types not yet defined by the 11073–10101 standard.

9- to 10   Measurement Value Multiplier (MVM) for the measurement specified in bytes 2 to 5.

The Measurement Value Multiplier (MVM) shall be used as a normalization factor to allow storage of large quantities expressed in physical units pinpointed by bytes 7 to 8 as a two-byte signed integer (see example of use in 5.18.3.2, bytes 9 to 10).

For dimensionless annotations and measurements coded 512 (UoM base code for MDC_DIM_DIMLESS, see Annex A, Table A.8) or expressed in sample numbers and in sample intervals, MVM shall be set to 1.

NOTE 1   If #OBM = 0, then the beat measurements and annotations definition block is empty (its size = 0).

NOTE 2   There is no easy way to specify which measurement values can take negative values (viz amplitude and angular degrees). It is thus assumed that all beat measurement values are stored as 2-byte signed integers (see 5.19.3.4, bytes 15 to 16 and beyond).

5.19.3.4 Selected Beats Measurements Blocks

The number of beat measurements blocks that will be saved in this Section data part after the beat measurements and annotations definition block is the number #BMB stored in bytes 13 to 14 of the

data Header of this section (see 5.19.3.2). For every Beat Measurements data Block, the same structure defined hereafter in 5.19.4, repeats.

5.19.4 (Single) Beat Measurements data Block (MB) structure

5.19.4.1 Description of the data content of each beat Measurements and annotations data Block

Byte	Contents

1 to 2 Beat ID (BID).

Sequential number. May be used to facilitate retrieval of the measurements and annotations of a specific beat when referenced in another section.

3 Related ECG signal data section (ECG_DS).

This byte is used in combination with byte 4 to specify in which section one can find the raw ECG signal data corresponding to the measurements / annotations stored in this specific beat measurements block.

Value	ECG signal type and localization
0	Unknown, or the raw ECG signals from which the selected beat measurements / annotations stored in this block have been derived are not saved in this SCP-ECG file
5	Rest ECG reference beat (Section 5)
6	Rest ECG rhythm data (Section 6)
12	Long-term ECG rhythm data (Section 12)
13	Selected ECG reference beats (Section 13)
14	Selected ECG sequences repository (Section 14)

4 Related ECG Data Block Number (ECG_DBN).

This byte is used to specify, in case ECG_DS = 13 or 14, to which ECG sequence or ECG reference beat the stored beat measurements / annotations correspond.

If ECG_DS = 13, then ECG_DBN shall store the metadata block ID "BId" (see 5.16.3.3) corresponding to the analysed reference beat, i.e. ECG_DBN = BId.

If ECG_DS = 14, then ECG_DBN shall store the block identification number "BN" (see 5.17.6.6) corresponding to the analysed ECG sequence, i.e. ECG_DBN = BN.

In all other cases ECG_DBN shall be set to zero.

5 to 8 Sampling Rate, in samples per second (SR).

Semantically equivalent to MDC_ECG_CTL_VBL_SAMPLE_RATE and MDC_ATTR_SAMPLE_RATE.

This field shall replicate the sampling rate of the original ECG recording specified in the sections pinpointed by ECG_DS and ECG_DBN. It has been included here to make this section self-standing and to convert measurement time points (viz beat and wave locations) and durations expressed in sample numbers and in sample intervals, into physical time and duration.

In case the value of ECG_DS equals "0", then bytes 5 to 8 shall store the sampling rate of the original ECG on which the measurements / annotations stored in this beat measurements block have been computed.

9 to 12	Beat Starting Sample Number (BSSN), expressed as a sample number relative to the first sample of the analysed ECG record.

Semantically equivalent to MDC_ECG_BEAT_ONSET and MDC_ECG_WAVC_PQRSTWAVE_ONSET

This field contains the sample number BSSN (referred to a generic lead, all the leads having the same number of samples) of the first ECG sample of the analysed beat (identified by BID), in the raw ECG recording pinpointed by ECG_DS and ECG_DBN or, in case ECG_DS = 0, in the original, non-saved ECG recording.

If ECG_DS = 5 or ECG_DS = 13 and RTBL[2] = 1 (see 5.16.3.3 byte 17), then BSSN = 1 (the measurements and annotations concern a computed reference beat).

13 to 14	Beat label, encoded using the CODE10 code corresponding to the REFIDs for beat labels listed in Table A.9 "ECG beat annotations" of ISO 11073-10102 [9] and/or in the running updates tables stored in the NIST RTMMS repository [59].

Semantically equivalent to MDC_ECG_QRS_TYPE.

"Beat label" shall be encoded by 8192 (CODE10 for MDC_ECG_BEAT) if undefined (no beat label available for this beat).

15 to 16	1st Optional Beat Measurement/annotation, if any (OBM1) (signed integer)
17 to 18	2nd Optional Beat Measurement/annotation, if any (OBM2) (signed integer)
19 to 20	3rd Optional Beat Measurement/annotation, if any (OBM3) (signed integer)
…	etc., up to Optional Beat Measurement/annotation OBMn, n = #OBM (signed integer)

Any optional measurement stored as a "Time Point" shall be expressed as a sample number relative to the beginning BSSN (Beat Starting Sample Number) of the analysed beat. The first sample of the beat is numbered 1. Unlike Section 7, where wave time points are given in milliseconds (see 5.10.3.3), in this Section sample numbers have been preferred. Timings in milliseconds may be easily computed by subtracting "1" from the values in sample numbers (the first sample of the beat starts at time 0) and then by multiplying the result by 1000 and dividing it by the sampling rate SR stored in bytes 5 to 8 of this Beat Measurements Block.

For example, in case of a median beat, BSSN = 1 and if the location of the global onset of the P-wave is sample number 11 and SR = 500 s/sec, then the P-onset is located 20 ms after the median beat onset.

Optional beat measurements values shall be stored after byte 14 as 2-byte signed integers. Care should be taken to limit "positive" measurement values to a maximum of 32767 and to avoid using one of the special codes listed in 5.10.3.1, except if relevant. Annotations based on ISO 11073-10102 REFIDs shall be stored as CODE10 code values.

NOTE 1   As all other time points in this data set (viz Global P onset, etc.) shall be expressed as sample numbers with reference to BSSN, it is suggested to choose a BSSN time point that is upstream of the global P onset, but nevertheless allows to discriminate the present beat from the previous one when using BSSN to visually locate the beat on the original ECG recording (although using the global onset of QRS or any intra QRS fiducial point would be a better choice for visually identifying the beat pinpointed by BSSN on the display or printout of the original ECG signals).

A common practice is to select a BSSN located 20 ms before global P onset or 150 ms before global onset of QRS in case no P wave was detected.

NOTE 2   BSSN can also be encoded using one of the following REFIDs: MDC_ECG_BEAT_TIME, MDC_ECG_BEAT_XX and MDC_ECG_WAVC_PQRSTWAVE_XX, where suffix XX can take one of the following values: TIME_POINT, ONSET, ONSET_IMPL. Another option is to use MDC_ECG_BEAT_TOC, although the latter is typically reserved for encoding intra QRS fiducials.

NOTE 3   Typical examples of beat labels are:

— Normal Beat. Is encoded by 8208 (CODE10 for MDC_ECG_BEAT_NORMAL);

— Paced Beat. Is encoded by 8704 (CODE10 for MDC_ECG_BEAT_PACED), etc.

— VPC (Ventricular premature contraction beat). Is encoded by 8336 (CODE10 for MDC_ECG_BEAT_V_P_C).

5.19.4.2 Overview of the data content of a single beat Measurements and annotations Block (MB)

An overview of the data content of a typical beat Measurements and annotations Block (MB) is provided in Figure 21, where OBM stands for Optional Beat Measurement or annotation (see 5.19.3.2, bytes 11 to 12, and 5.19.3.3).

BID	ECG_DS	ECG_DBN	SR	BSSN	Beat label	1st OBM	2nd OBM	…∥…	Last OBM
2	1	1	4	4	2	2	2	var	2

Figure 21 — Overview of the data content of each beat Measurements Block MB

5.19.5 Overview of the data part of the Selected ECG beats measurements and annotations section

An overview of the data part of section 16, Selected ECG beats measurements and annotations, is provided in Figure 22.

Header		Beat Meas. Def.	1st Meas. Block	2nd Meas. Block	...
var		*var*	*var*	*var*	

Status	D/T	TZ	#OBM	#BMB	...
1	7	2	2	2	

...	BMFS	HPF	LPF	FBM	Res.	LHN	LMI	Notes	MI
	1	2	2	1	42	4	4	*var*	*var*

1st Meas RTC	1st Meas MIC	1st Meas LID	1st Meas Units	1st Meas MVM	...	...	Last Meas MVM
1	4	1	2	2			2

BID	ECG_DS	ECG_DBN	SR	BSSN	Beat Label	1st OBM	2nd OBM	...	...	Last OBM
2	1	1	4	4	2	2	2			2
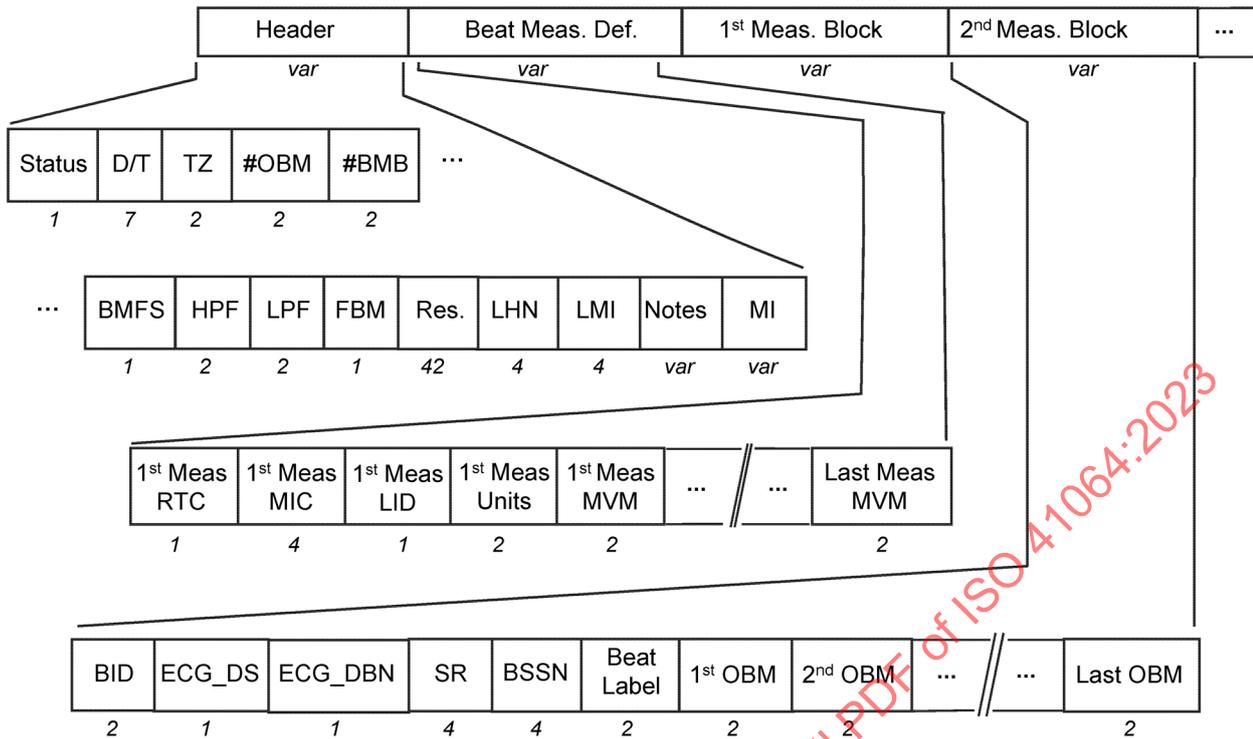
Figure 22 — Overview of the data part of Section 16

5.20 Pacemaker Spikes measurements and annotations – Section 17

5.20.1 General

Current pacing devices generate small amplitude pulses with narrow widths, and the use of bipolar lead wires, conduction through the thorax, as well as the attenuating effect of projecting the bipolar pacing lead vector onto the standard 12-leads used for signal acquisition on the body, result in a significantly smaller pacemaker pulse signal being seen on the ECG tracing. Low sampling rates and low-pass filtering further contribute to degrade the pulse shaped signal which looks like a spike on standard ECG tracings. High-bandwidth electrocardiographic systems with sampling rates up to 150 000 samples/sec and/or specialized acquisition modules however are increasingly providing the ability to measure the details of any pacemaker pulse characteristics from the surface ECG. For compatibility reasons with ISO/IEEE 11073-10102 [9], in this section and all over the document the term "pacemaker spike" is used to designate an ECG component that the scientific literature is increasingly denominating "pacemaker pulse".

Several ECG computer programs are able to analyse continuous long duration recordings of patients with an implanted pacing device and to annotate several features of each pacemaker spike. This version of the document has been extended to include support for defining and storing large sets of spike-by-spike measurements and annotations in a structured, but nevertheless highly flexible manner.

Starting with version V3.0, the standard now allows storing, in this section, 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). The selected time windows, if any, may have been settled by a physician or correspond to a given study protocol, or may have been determined by an algorithm.

The data format outlined in this section has been designed to support a large number of use cases, such as selecting and analysing very short ECG sequences with only two or three QRS complexes, or daily analysing a set of 30 min duration time windows from a continuous long-term ECG recording, for example for time windows starting at 2 am and 4:30 pm, and then storing the spike duration and amplitude and some additional useful annotations for all spikes within the selected 30 min time windows, for monitoring the functioning of the implanted pacing device in different situations.

Spike measurements and annotations are stored spike-by-spike in one or more spike measurements array(s), one measurement array per analysed area of interest (full long-term ECG record, selected ECG sequence or reference beat). The spike measurement arrays are structured as MxN matrixes (M Spikes x N Measurements/Annotations), much like the structure used for storing beat-by-beat ECG measurements in section 15. Instead of representing beat measurements, here each of the M matrix lines (hereafter called "Spike Measurements and annotations Block" or spike MB) represents a spike and each of the N columns represents a spike measurement (spike location, spike amplitude or duration, spike area, etc.) or a spike annotation (spike type, spike appropriateness, artefact, paced beat location, etc.).

Pacemaker spikes of different origin shall be stored in different array lines, one per paced chamber and per paced beat.

5.20.1.1   If two or more spike measurements arrays related to a same ECG signal data section (viz sections 12 or 14), are present, it is mandatory that the computerized spike measurements stored in the current SCP-ECG record have been produced by the same ECG analysing software or device. Nevertheless, some filter settings could be specific for the different measurements arrays.

The possibility of storing spike measurements and annotations for long-term recordings and multiple short duration ECG sequences recorded at different sampling rates (viz for example storing spike measurements performed with a standard spike detection program on a standard 12-lead ECG stored in section 6 or in section 12 and storing spike measurements performed with a high-resolution ECG analysis program on simultaneously recorded high-bandwidth ECGs stored in section 14) as well as for computed and/or selected reference beats can be exploited to accommodate several use cases, support the monitoring of the functioning of implanted pacing devices, improve computerized interpretation or human overreading of paced rhythms and allow correlations with clinical patients' outcomes. This section and sections 12 to 14 have been added in this version of the document to this aim.

5.20.1.2   This section is self-contained, i.e. no other information than the patient data stored in section 1 are needed for exploiting the data content of section 17, if one wants to only exchange spike-by-spike measurements and annotations without exchanging signal data.

The section also provides a solution to supersede the filter settings provided in Section 1, Table 2, Tags 27 to 29, and in sections 12 to 14, whenever the filtering used to calculate the spike measurements and other annotations is different from the filtering performed during the signal acquisition process and/or before storing the ECG signals, which is usually the case in modern electrocardiographs.

5.20.1.3   Each single Spike Measurements Block (MB) consists in a Spike ID, the spike location (Spike Location Sample Number) in the pinpointed ECG record, the spike type (Spike label), an identifier (Lead ID) of the lead in which the spike is the most discernible and in which the spike duration and/or spike amplitude measurements were performed, the location of the paced beat (if any), the spike duration, spike amplitude and K additional (K = 0 – 65 535) spike measurements and annotations (see 5.20.4.1 and Figure 23). This number K of optional, additional measurements and annotations may vary from one SCP-ECG record to another, but shall be the same for all spike measurement arrays stored in a same SCP-ECG record.

5.20.1.4   Except for the Spike ID, the Spike Location Sample Number, the Lead ID, the Spike Amplitude and the location of the Paced Beat, all other measurements and annotations values, including additional spike amplitudes, if any, shall be encoded by two bytes.

5.20.1.5 All additional point-in-time measurement values, if any, shall be expressed as relative time in sample intervals from the Spike Location Sample Number.

5.20.1.6 Unless specified otherwise, all incomputable measurements and not computed measurements and annotations values shall be pinpointed by one of the special codes listed in 5.10.3.1.

5.20.1.7 Unless specified otherwise, all numeric values are unsigned binary integers. All text strings are encoded in UTF-8.

5.20.2 Section ID Header

If present, this section shall start with a "Section ID Header" and shall include the required fields, as defined in 5.2.7. In particular, in the Section ID Header, the protocol version number stored in the Header byte 10 shall reflect the current version of this document, since versions V1 and V2 do not support this spike-by-spike measurements section (section 17 does not exist in SCP-ECG versions V1 and V2).

5.20.3 Section data part

5.20.3.1 General

The Section data part is composed of a Data Header, an optional "Additional Spike Measurements and Annotations Definition Block", and a variable number of Spike Measurements Arrays.

5.20.3.2 Section Data Header

The header is used to provide information that are common to all measurement arrays stored in section 17. It has the following format:

Byte **Contents**

1 Confirmed / Non confirmed spikes measurements and annotations Status.

Value Type

0 Original spike measurements and annotations (not overread).

1 Confirmed spike measurements and annotations.

2 Spike measurements and annotations (partially) overread, but not confirmed.

2 to 8 Date and time of spikes measurements and annotations recording and/or overreading (D/T).

Semantically equivalent to MDC_ATTR_TIME_ABS.

The byte format is identical to the date and time formats specified in section 8 (see 5.11.4):

Byte

2 to 3 Binary: Year (Full integer notation, as in 2018) [MDC_DIM_YR]

4 Binary: Month (range 01 to 12; 01 = January) [MDC_DIM_MON]

5 Binary: Day (range 1 to 31) [MDC_DIM_DAY]

6 Binary: Hours (range 0 to 23) (time is always local time) [MDC_DIM_HR]

7 Binary: Minutes (range 0 to 59) [MDC_DIM_MIN]

8   Binary: Seconds (range 0 to 59) [MDC_DIM_SEC]

NOTE 1   The date and time information stored in this header indicates the date and time of the creation and/or storage of the latest spikes measurements array of this section (in case the value of byte 1 is 0), or the date and time of the latest overreading or confirmation (in case the value of byte 1 is 1 or 2). This information is usually different from the date and time of the signal recording.

NOTE 2   Date and time is expressed as local date and time in the Time Zone of the overreader and/or of the analysing device.

9 to 10   Date&Time Time Zone (TZ), specified as an offset from UTC in minutes. (Signed integer).

Semantically equivalent to MDC_ATTR_TIME_ZONE.

The content of this field shall identify the time zone related to the local time stored here above in bytes 2 to 8. The format shall be identical to the Time Zone format specified in bytes 1–2 of Tag 34 in Table 2. In case the local Time Zone is unknown, TZ shall be set to 0x7FFF.

11 to 12   Number of Additional Spike Measurements and Annotations (#ASM).

This field records the number of additional measurements and annotations (if any) which are specified in the Additional Spikes Measurements and Annotations Definition Block and whose values or codes will be stored spike-by-spike as a two-byte signed integer value in each (single) spike measurements block MB, after the Paced Beat Location field (see 5.20.4.1, bytes 22 to 23 and beyond, and Figure 23).

If #ASM = 0, no additional spikes measurements and annotations are stored, there is no Additional Spikes Measurements and Annotations Definition Block (its size is 0), the first Spike-by-Spike Measurements Array starts immediately after the Manufacturer-specific information field MI, if any, and the size of each single spike measurements block MB is only 21 bytes.

13   Number of recorded Spike-by-Spike Measurements Arrays (#SMA).

Allowed values range from 1 to 255.

14 to 62   Reserved for future use (shall always be set to zero).

63 to 66   Length of the Header Notes field in bytes (LHN).

67 to 70   Length of the Manufacturer-specific additional Information field in bytes (LMI).

variable   General Header Notes on this section. This is a free-text field. It shall be NULL terminated.

variable   Manufacturer-specific Information field (MI).

5.20.3.3 Additional Spikes Measurements and Annotations Definition block

The additional spikes measurements and annotations (compliant with #ASM) and the order in which they are stored in each spike measurements data block MB, are defined in this part of the section. The specification of the additional measurements / annotations order shall reflect the order used for storing the 2-byte measurement/annotation values in each spike measurement data block MB (see 5.20.4). The length of the additional spikes measurements and annotations definition block is related to the number of additional measurements #ASM and is a multiple of 10 bytes. For each spike measurement / annotation of the #ASM additional spike measurements stored in bytes 11 to 12 of the data header of this section, the same structure repeats. It is assumed that the additional spikes measurements and annotations order and the units or type of these measurements (Units) are the same for each measurement array stored in this section. They may however change from one SCP-ECG record to another.

Byte	Contents

1   Spikes Measurements and Annotations Reference Thesaurus Code (RTC).

This byte indicates where to find the definition and the semantics of the additional spike measurement / annotation specified in bytes 2 to 5.

Value	Reference Thesaurus
0	Undefined
1	ISO 11073-10102 [9] and/or its running updates stored in the NIST RTMMS repository [59]
2 to 99	Reserved for future use
100 to 255	Manufacturer specific codes

2 to 5   Spike Measurement Identification code (MIC).

The spike measurement / annotation shall be identified by a unique code that shall allow to know what the measurement / annotation represents.

If RTC = 1, then MIC shall store the CF_CODE10 value corresponding to the spike measurement/annotation REFID as defined in ISO 11073-10102 [9] and/or in the running updates tables stored in the NIST RTMMS repository [59].

If RTC = 0, then no measurement thesaurus is available. This RTC code may be used for testing purpose. In that case, it is recommended to differentiate the corresponding spike measurements and annotations identification codes (MIC) by using for example an incremental number.

If RTC = 100 to 255, then the spike measurement/annotation is manufacturer specific. It is recommended that the corresponding measurements and annotations are specified in the Manufacturer-specific Information field (MI) and in the manufacturer's physician's guide.

6   Lead Identification (LID).

This discriminator shall be used to identify to which specific ECG lead, if any, the measurement specified by MIC applies. The same SCP-ECG numbering scheme as in 5.6.4, Table 4, shall be used to specify the lead that has been used.

Semantically equivalent to MDC_ECG_Lead_xxx, see 5.6.4 Note.

NOTE   As specified in 5.6.4 (Table 4), applicable codes are from 1 to 184 and 199. Codes 200 to 255 are reserved to specify manufacturer specific leads. Code 199 Is used to specify that the spike measurement / annotation does not refer to a specific lead, but that it is the result of a global evaluation having taken all (or several) leads into account. This is distinguished from the case where the lead used to perform the measurement / annotation is unspecified, which is coded "0".

7 to 8   Spike measurement/annotation Units code and/or type (Units).

These two bytes specify the physical unit of the spike measurement/annotation value (or its type, if dimensionless) that will be stored in the Spike Measurements data Block MB, as a result of the spike measurement / annotation process corresponding to the additional measurement / annotation defined in bytes 2 to 5.

Typical additional spike measurement results are Spike point-in-time measurement values (expressed in sample intervals with reference to the Spike Location Sample Number SLSN defined in 5.20.4.1), spike durations (expressed in µs), spike amplitudes and/or areas, etc. The later are usually expressed in µV and in µV x µs.

Physical units shall be identified by means of their UoM base code according to

ISO/IEEE 11073-10101 [8] and the updates maintained in the corresponding units-of-measure table defined in the NIST RTMMS repository [59].

Units of dimensionless annotations viz pacing stimulus type, appropriateness and the capture state shall be encoded by 512, the UoM base code for MDC_DIM_DIMLESS.

Table A.8 in Annex A points out the most useful units for the purpose of this selected ECG-beats measurements and annotations section and defines the codes that shall be used for the measurement and annotation types not defined by the 11073–10101 standard.

9 to 10   Measurement Value Multiplier (MVM) for the measurement specified in bytes 2 to 5.

The Measurement Value Multiplier (MVM) shall be used as a normalization factor to allow storage of large quantities expressed in physical units pinpointed by bytes 7 to 8 as a two-byte signed integer.

For dimensionless annotations and measurements coded 512 (UoM base code for MDC_DIM_DIMLESS, see Annex A, Table A.8) or expressed in sample numbers and in sample intervals, MVM shall be set to 1.

EXAMPLE   Let's suppose that bytes 2 to 5 contain the CF_CODE10 for MDC_ECG_WAVP_PACE_INTEGRAL and that bytes 7 to 8 contain the UoM code for values expressed in µV x ms (MDC_DIM_NANO_VOLT_SEC). Then a pacemaker pulse integral value of 100 mV x ms, i.e. of 100 000 000 µV x µs, can be encoded as a 2-byte signed integer equal to 1000 and MVM = 100 (or equal to 10 000 and MVM = 10).

NOTE   If #ASM = 0, then this optional spikes measurements and annotations definition block is empty (its size = 0) and the 1st Spike-by-Spike Measurements Array starts immediately after the section data header (see Figure 24).

5.20.3.4 Spike-by-Spike Measurements Arrays

The number of spike-by-spike measurements arrays that will be saved in this Section data part is the number #SMA stored in byte 13 of the Header of this section (see 5.20.3.2). For every single Spike-by-Spike Measurements Array, the same structure repeats. It consists of an array specific header with information about the localization of the related ECG signal data and/or ECG excerpt, and an optional notes field followed by the different spike measurements blocks (MBs). The header also contains information about the analysis Time Window corresponding to the spike measurements and annotations results stored in this array, and several metadata such as the sampling rate and specific filtering, if any. It also specifies the number of spike measurement blocks stored at the end of the array header after the notes field.

Spike-by-Spike Measurements Array Header

Byte   Contents

1   Measurements Array Id (MAId). Allowed values range from 1 to 255.

2   Related ECG signal data section (ECG_DS).

This byte is used in combination with byte 3 to specify in which section one can find the raw ECG signal data corresponding to the spike measurements / annotations stored in this specific array.

Value	ECG signal type and localization
0	Unknown, or the raw ECG signals from which the spike-by-spike measurements / annotations stored in this array have been derived are not saved in this SCP-ECG file

5	Rest ECG reference beat (Section 5)
6	Rest ECG rhythm data (Section 6)
12	Long-term ECG rhythm data (Section 12)
13	Selected ECG reference beats (Section 13)
14	Selected ECG sequences repository (Section 14)

3   Related ECG Data Block Number (ECG_DBN).

This byte is used to specify, in case ECG_DS = 14 or 13, to which ECG sequence or ECG reference beat the stored spike measurements / annotations correspond.

If ECG_DS = 14, then ECG_DBN shall store the block identification number "BN" (see 5.17.6.6) corresponding to the analysed ECG sequence, i.e. ECG_DBN = BN.

If ECG_DS = 13, then ECG_DBN shall store the metadata block ID "Bid" (see 5.16.3.3) corresponding to the analysed reference beat, i.e. ECG_DBN = BId.

In all other cases ECG_DBN shall be set to zero.

4 to 7   Analysis Time Window Starting Date (TWSD).

The value assigned to TWSD shall be the date of the acquisition of the first ECG sample of the ECG area of interest (also pinpointed by ECG_DS, ECG_DBN, TWST, TWSS and TWSL) corresponding to the Time Window for which the spike measurements and annotations stored hereafter have been computed or, in case ECG_DS = 0, the date of the acquisition of the first analysed ECG sample in the original, non-saved high bandwidth ECG recording.

In case ECG_DS = 13, the stored measurements are related to the reference beat identified by its metadata block Id BId and TWSD shall take the same value as BDR (see 5.16.3.3 bytes 4 to 7).

The format of TWSD shall be compliant with the "Date of Acquisition" format specified in the ECG metadata part of Section 1. (For the format details, refer to Table 2, Tag 25).

8 to 10   Analysis Time Window Starting Time (TWST).

The value assigned to TWST shall be the time of the acquisition of the first ECG sample of the ECG area of interest (also pinpointed by ECG_DS, ECG_DBN, TWSD, TWSS and TWSL) corresponding to the Time Window for which the spike measurements stored hereafter have been computed or, in case ECG_DS = 0, the time of the acquisition of the first analysed ECG sample in the original, non-saved high bandwidth ECG recording.

In case ECG_DS = 13, the stored measurements are related to the reference beat identified by its metadata block Id BId and TWST shall take the same value as BTR (see 5.16.3.3 bytes 8 to 10).

The format of TWST shall be compliant with the "Time of Acquisition" format specified in the ECG metadata part of Section 1. (For the format details, refer to Table 2, Tag 26).

NOTE 1   In case the analysis Time Window of the saved measurements and annotations is identical to the time window during which the analysed ECG signal has been acquired, then TWSD and TWST (defined above in bytes 4 to 10) respectively take the same values as the date and the time of the acquisition of the first ECG sample of the raw ECG recording or sequence pinpointed by ECG_DS and ECG_DBN.

11 to 14   Analysis Time Window Starting Sample number (TWSS).

This field contains the sample number (referred to a generic lead, all the leads having the same number of samples) of the first ECG sample of the ECG area of interest specified by the previously defined starting date (TWSD) and time (TWST) and by the analysis Time Window Length (TWSL, defined hereafter in bytes 15 to 18), in the raw ECG recording pinpointed by ECG_DS and ECG_DBN or, in case ECG_DS = 0, in the original, non-saved high bandwidth ECG recording.

In case ECG_DS ≠ 13 and TWSD and TWST are identical to the date and the time of the acquisition of the first ECG sample of the analysed ECG signal, then TWSS shall be set to 1.

In case ECG_DS = 13, the stored measurements are related to the reference beat identified by its metadata block Id BId and TWSS shall take the same value as SRB (see 5.16.3.3 bytes 18 to 21).

15 to 18   Analysis Time Window Length, in Samples per lead (TWSL).

This field contains the length (in number of samples) of the analysis Time Window in the raw ECG recording pinpointed by ECG_DS and ECG_DBN or, in case ECG_DS = 0, in the original, non-saved high resolution ECG recording.

In case ECG_DS = 13, the stored measurements are related to the reference beat identified by its metadata block Id BId and TWST should take the same value as LRB (see 5.16.3.3 bytes 22 to 23).

TWSL includes sample TWSS. The last sample of the specified area of interest will thus be sample number (TWSS + TWSL −1)

NOTE 2   If the value of ECG_DS is different from "0", then the number and definition of the leads, the sampling rate and the AVM to be considered here for extraction or display of the corresponding ECG area of interest are specified in the sections pinpointed by ECG_DS and ECG_DBN.

19 to 22   Sampling Rate, in samples per second (SR).

Semantically equivalent to MDC_ECG_CTL_VBL_SAMPLE_RATE and MDC_ATTR_SAMPLE_RATE.

This field shall replicate the sampling rate of the original ECG recording specified in the sections pinpointed by ECG_DS and ECG_DBN. It has been included here to make this section self-standing and to convert measurement time points (viz spike and paced beat locations) and durations expressed in sample numbers and in sample intervals, into physical time and duration.

In case the value of ECG_DS equals "0", then bytes 19 to 22 shall store the sampling rate of the original, high resolution ECG on which the spike measurements / annotations stored in this measurements array have been computed.

23   Measurement Array specific Filter Setting (MAFS).

The definition of the values taken by this byte are:

0   Unspecified.

No specific filter settings have been specified and the filter settings used by the spike measurement and annotation programs for processing the ECG signals corresponding to the spike measurements / annotations stored in this measurements array are unknown. This means that bytes 24 to 28 shall be discarded and that the users shall refer to the physician's guide to know which specific filtering has been used, if any.

If ECG_DS does not equal "0" (see above, byte 2), then the filter settings stored in Table 2, Tag 27, 28 and 29 and/or in the sections pinpointed by ECG_DS may be used to know if the ECG signals stored in the respective ECG signal data sections have been filtered, and how.

1   No specific filter settings used

No specific filters other than the ones specified in Table 2, Tag 27, 28 and 29 and/or in the sections pinpointed by ECG_DS have been used for processing the ECG signals corresponding to the spike measurements / annotations stored in this spike measurements array. The relevant filter settings initially stored in Table 2 and/or in the sections pinpointed by ECG_DS are replicated hereafter in bytes 24 to 28, to facilitate the retrieval of the corresponding information and thus make this section self-standing.

2   Specific filter settings used

The filter settings that have been used for processing the ECG signals corresponding to the spike measurements / annotations stored in this measurements array in this section are defined hereafter, regardless of the values stored in Table 2 or in the sections pinpointed by ECG_DS. The new settings only apply to this measurements array in this section, and are specified in bytes 24 to 28.

24 to 25   High-pass filter (HPF) [MDC_ECG_CTL_VBL_ATTR_FILTER_HIGH_PASS].

If MAFS = 2, this field contains the "cut-off" frequency (−3 dB) of the high-pass filter that has been used, if any, for computing the spike measurements and annotations stored in this measurements array, in units of (1/100) Hertz.

NOTE 3   A value of 0xFFFF in this field means that the filter setting was not specified.

NOTE 4   A value of zero in this field means that the recorded signals were DC-coupled and that no high-pass filtering was performed.

26 to 27   Low-pass filter (LPF) [MDC_ECG_CTL_VBL_ATTR_FILTER_CUTOFF_FREQ].

If MAFS = 2, this field contains the "cut-off" frequency (−3 dB) of the low-pass filter that has been used, if any, for computing the spike measurements and annotations stored in this measurements array, in units of Hertz.

Systems that do not perform any low-pass filtering for computing spike measurements and annotations shall replicate the low-pass filter setting of the recorded signal data.

NOTE 5   A value of 0xFFFF in this field means that the filter setting was not specified.

28   Filter bit map (FBM) (binary).

If MAFS = 2, this field indicates if other filters, which were not implicitly defined by the content of bytes 24 to 27, have been used during the processing of the ECG. The definition of the different bits of the FBM bit map are detailed in Annex A, Table A.6.

NOTE 6   If FBM = 0, no additional filtering than those implicitly specified in bytes 28 to 31 was used.

NOTE 7   If FBM = 255, then the FBM filter setting was not specified.

29 to 32   Number of stored spike Measurements Blocks (#Spikes).

33 to 62   Reserved for future use (shall always be set to zero).

63 to 64   Length, in bytes, of a Note field for this spike Measurements Array (LMAN).

The notes may be used for example to describe and document the different ECG processing steps and the particularities of the selected analysis time window or of the

manufacturer specific spike measurements / annotations stored in this particular array.

Variable (LMAN) Measurements Array Notes field explaining the particularities of the processing steps and/or of the non-standard spike measurements. This is a free text field that can also be filled in with annotations from the technician, cardiologist, etc. It shall be null terminated.

Variable Set of spike Measurements and annotations (Measurements Block) for the 1st Spike (MB1).

NOTE 8   The size of this field and of each of the following ones is (21 + #ASM x 2) bytes.

variable Set of spike Measurements and annotations for the 2nd Spike (MB2).

variable Set of spike Measurements and annotations for the 3rd Spike (MB3).

... etc.

To facilitate the retrieval of the spikes measurements and annotations metadata and thus make this section self-contained, none of the fields of this array header can be overlooked even if some of the values are the same as in Section 1 or in the signal sections. This section 17 header shall be filled up again.

NOTE   Unlike Section 6, where sample time interval in microseconds is adopted (an example is given in 5.9.3), in this Section the sample rate has been preferred, as in sections 12 (long-term ECG), 13 and 14.

5.20.4 (Single) Spike Measurements data Block (MB) structure

5.20.4.1 Description of the data content of each spike Measurements and annotations data Block

Byte   Contents

1 to 4   Spike ID (SID).

Sequential number. May be used to facilitate retrieval of the measurements and annotations of a specific spike when referenced in another section.

5 to 8   Spike Location Sample Number (SLSN), expressed as a sample number relative to TWSS, the Starting Sample number of the analysed ECG excerpt corresponding to the analysis Time Window.

Semantically equivalent to MDC_ECG_WAVP_ONSET.

This field contains the sample number SLSN (referred to the lead and the ECG sequence in which the spike has been detected and measured or annotated, or, in case the lead has not been specified, to a generic lead, all the leads having the same number of samples) of the onset (rising edge) of the spike pinpointed by SID, with reference to TWSS, the Starting Sample number of the analysis Time Window.

9 to 10   Spike Type, encoded using the CODE10 code corresponding to the most relevant REFID for pacemaker spike type, appropriateness and capture state defined in ISO/IEEE 11073-10102 [9] and/or in the running updates tables stored in the NIST RTMMS repository [59].

Semantically equivalent to MDC_ECG_WAVP_TYPE.

Examples of appropriate REFIDs are MDC_ECG_RHY_EPAXLO, MDC_ECG_RHY_EPVXLO, and all REFIDs listed in ISO/IEEE 11073-10102, Table A.8 "ECG WAVP pacemaker components" [9] synthetically described by MDC_ECG_WAVP_discrim_APPR_ASSN_AOI, where:

- "discrim" specifies the purpose (energy level) of the spike (i.e. antibradycardia, antitachycardia, cardioversion, and defibrillation) and the paced chamber (e.g. generic

pace, atrial, ventricular, and transthoracic),

- APPR indicates whether the pacemaker spike was unspecified, appropriate, inappropriate, or a transient/testing/manual exception,

- ASSN indicates whether the capture state relative to depolarization of the paced chamber of the heart was uncertain, not captured, captured, or fusion.

- Area of Interest (AOI) shall be left unspecified (NOS), i.e. coded as "0"

Isolated spike artefacts, i.e. spikes that look like a pacemaker pulse but that have not been produced by a pacing device, shall be encoded using the CODE10 code for MDC_ECG_WAVC_ARFCT.

Undefined spike types or spike types not yet defined in ISO/IEEE 11073-10102 [9] or in the NIST RTMMS repository [59] shall be encoded by 0xFFFF.

11   Lead Identification (Lead ID).

This discriminator shall be used to specify the ECG lead, if any, that has been used to detect and annotate the spike and for which the measurements specified hereafter in bytes 12–17 apply. The same SCP-ECG numbering scheme as in 5.6.4, Table 4, shall be used.

Semantically equivalent to MDC_ECG_Lead_xxx (see 5.6.4 Note).

NOTE   If the set of measurements and annotations does not explicitly refer to a given lead, e.g. if the spike detection and the spike duration measurements have been performed by means of a multilead approach (see Table 11, Footnote f) and if no spike amplitude measurement is provided, i.e. the value stored in bytes 14 to 17 is set to one of the special codes 29997 to 29999 defined in Clause 5.10.3.1, then Lead ID can be set to SCP-ECG code "199" (Global, Virtual lead). If a spike amplitude is provided in bytes 14 to 17, then the relevant lead can be specified in Lead ID, whatever the method used to detect and measure the spike duration.

12 to 13   Spike Duration, in µS (Unsigned Integer).

Semantically equivalent to MDC_ECG_WAVP_DURN (WAVP component Duration / width).

14 to 17   Spike Amplitude, in µV (4-byte Signed Integer).

18 to 21   Paced Beat location, if any, expressed as a sample number relative to TWSS, the Starting Sample number of the ECG excerpt pinpointed by the analysis Time Window.

In case no beat has been triggered by the spike identified by SID, such as for pacemaker pulse-like spike artefacts, non-captured pacemaker pulses and pulses only captured by the atrium without resulting in an associated QRS beat, then the Paced Beat location shall be coded 0xFFFFFFFF.

22 to 23   1st Additional Spike Measurement/annotation, if any (ASM1)

24 to 25   2nd Additional Spike Measurement/annotation, if any (ASM2)

26 to 27   3rd Additional Spike Measurement/annotation, if any (ASM3)

...   etc, up to "Additional Spike Measurement/annotation" ASMn, n = #ASM

The information on the type of pacing device shall be provided in Section 1 (Table 2, Tag 32 and Tag 36).

The recommended method to measure spike durations and amplitudes in high resolution recordings is to measure the amplitude at the rising edge of the pulse and the pulse width at 50 % of the amplitude points, see J Electrocardiol. 2012;45:663–669, Figure 4. Manufacturers who are using other methods specify which method they are using in the physician's guide.

The "Paced Beat Location" value stored in bytes 18 to 21 shall allow to easily localize the paced beat. The recommended method is to use the global onset of the paced QRS or a global and reliable intra QRS fiducial point viz a synchronisation point used for QRS complexes averaging. Manufacturers specify which method they are using in the physician's guide.

All additional spike measurements/annotations stored after byte 21 and computed as "Points-in-time" (i.e. for example the measurements results corresponding to measurements defined in Table A.8 "ECG WAVP pacemaker components" of ISO/IEEE 11073-10102 where _dSuffix is _TIME_POINT, _PEAK, _ONSET, _OFFSET, etc.), if any, shall be expressed in sample intervals with respect to the Spike Location Sample Number SLSN. Unlike Section 7, where wave time points are given in milliseconds (see 5.10.3.3), in this Section sample intervals have been preferred. Timings in milliseconds may be easily computed by multiplying the values in sample intervals by 1000 and then by dividing the result by the sampling rate SR stored in bytes 19 to 22 of the Spike-by-Spike Measurements Array Header (see 5.20.3.4).

These additional measurements values, if any, shall be stored as 2-byte signed integers. Care should be taken to limit "positive" values to a maximum of 32767 and to avoid using one of the special codes listed in 5.10.3.1, except if relevant. Annotations based on ISO/IEEE 11073-10102 REFIDs, if any, shall be stored as CODE10 values (2 byte unsigned integers). Unspecified annotations shall be coded 0xFFFF.

NOTE 1   Some typical examples of spike types are listed at the end of Table 11.

NOTE 2   Pacemaker pulse amplitudes recorded in surface ECGs exhibit large variations, depending on the recording equipment (high resolution vs standard electrocardiographs) and the type of implanted cardiac device. Values reported in the literature and in the requirements sections of the ad'hoc AAMI and IEC standards range from +- 30 µV up to +- 700mV. This explains why the present document encodes pacemaker pulse amplitudes as 4-byte signed integers instead of the usual 2-byte encoding. Note also that Spike amplitudes measurements are not yet defined in ISO/IEEE 11073-10102 [9].

5.20.4.2 Overview of the data content of a single spike Measurements and annotations Block (MB)

An overview of the data content of a typical spike Measurements and annotations Block (MB) is provided in Figure 23, where ASM stands for Additional Spike Measurement (see 5.20.3.3).

SID	SLSN	Spike Type	Lead ID	Spike Duration	Spike Amplitude	Paced Beat Location	1st ASM	2nd ASM	//	Last ASM
4	4	2	1	2	4	4	2	2	var	2

Figure 23 — Overview of the data content of a typical spike Measurements Block (MB)

5.20.5 Overview of the data part of the Pacemaker Spikes Measurements and Annotations section

An overview of the data part of section 17, Pacemaker Spikes Measurements and Annotations, is provided in Figure 24.

Header	Add Spike Meas Def	1st Meas Array	2nd Meas. Array	...
var	*var*	*var*	*var*	

Status	D/T	TZ	#ASM	#SMA	Res.	LHN	LMI	Notes	MI
1	7	2	2	1	49	4	4	*var*	*var*

1st Meas RTC	1st Meas MIC	1st Meas LID	1st Meas Units	1st Meas MVM	...	...	Last Meas MVM
1	4	1	2	2			2

MAId	ECG_DS	ECG_DBN	TWSD	TWST	TWSS	TWSL	SR	MAFS	HPF	LPF	FBM	...
1	1	1	4	3	4	4	4	1	2	2	1	

...	#Spikes	Res	LMAN	MA Notes	1st Spike MB	2nd Spike MB	...	...	Last Spike MB
	4	30	2	*var*	*var*	*var*			*var*
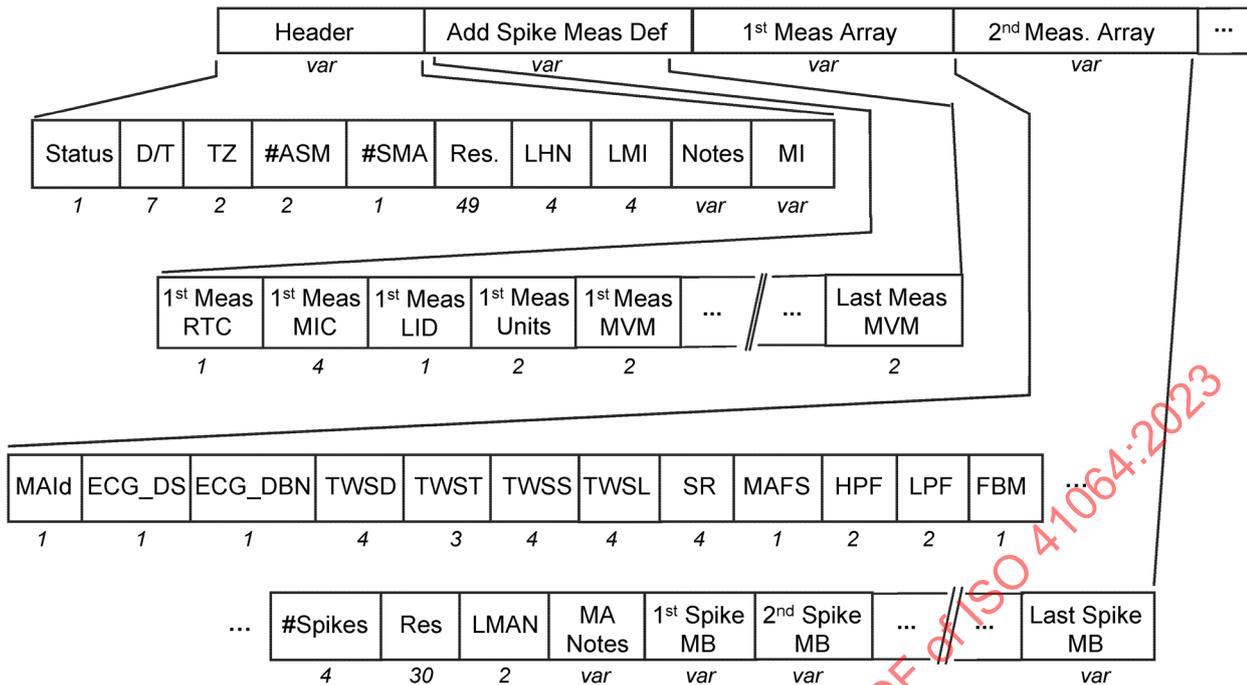
Figure 24 — Overview of the data part of Section 17

5.20.6 Example of encoded spike measurements and annotations

Table 11 below displays some of the coded content of a (Spike x Measurements/Annotations) Array for a few spikes from a 10 min duration ECG record, where we assume that the subject has been paced by a triple chamber device (DDD mode pacing with CRT at clinical settings), the pulses have been detected and measured thanks to a hi-fi recording system (sampling rate equal or higher than 32 000 samples/sec), the sampling rate of the signals stored in the SCP-ECG record is 1000 samples/sec and there are one or more Additional Spike Measurements and Annotations (ASMs) defined in the "Additional Spikes Measurements and Annotations Definition block" (not documented in this example).

Spike ID (SID), Spike Location Sample Number (SLSN), Spike Type, Lead ID, spike durations and amplitudes and Paced Beat Location have been encoded as specified in 5.20.4.1.

Spike Type values other than the value for spike #20 (spike artefact) have been encoded by the CODE10 values corresponding to the REFIDs "Wave components (paced)" listed in Table A.8 "ECG WAVP pacemaker components" of ISO/IEEE 11073-10102 [9].

For readability reasons, Lead IDs have been described by means of their standard SCP-ECG Name, except for spike #21, where the newly defined term "VIRT" has been used to indicate that this spike has not been detected on a per-lead basis, but by means of a multilead based method viz spatial velocity or spatial Vectorcardiography. As Lead IDs cannot be stored using their textual representation in the Spike Measurement Arrays, they shall be encoded using the corresponding one byte SCP-ECG code as specified in Clause 5.6.4, Table 4, "Lead Identification codes". Lead ID "VIRT" should be encoded as "Global, virtual lead", SCP-ECG code "199".

Spike durations are expressed in micro-seconds and spike amplitudes in micro-volts.

Measurements not computed by the program (viz some additional spike measurements) are coded 29 999 (see 5.10.3.1).

In this 10 min ECG record example, we hypothesize that the first beat located at time 0,47 s after the onset of the ECG recording is paced by respectively an atrioventricular (AV) and two biventricular (Bi-

V) pacemaker pulses (SID = 1 to 3, paced beat location = 470), spike #20 is an artefact, spike #21 has been detected and its pulse magnitude measured by means of a Vectorcardiographic method, and the last beat of the record has been paced by a unique ventricular pacemaker pulse.

Table 11 — Tabular representation of the coded content of a typical (Spike x Measurements/Annotations) Array

SID	SLSN (sample point)	Spike Type	Lead ID	Spike Duration (in µs)	Spike Amplitude (in µV)	Paced Beat Loc. (sample pt)	...	Last ASM
1	370	4704 [a]	V2	560	3000	470 [h]	...	...
2	455	5728 [b]	V1	590	- 20000	470 [h]		29999 [i]
3	457	5468 [c]	DII	600	- 15000	470 [h]		
...	...	...	...	...	...	...	...	...
20	6000	2176 [d]	V2	650	4500	0xFFFFFFFF [j]	...	29999 [i]
21	6300	6752 [e]	VIRT [f]	605	7200 [g]	6325	...	29999 [i]
...	...	...	...	...	...	...	...	...
M	59200	4704 [a]	V2	565	3000	59360	...	...

[a] CODE10 for MDC_ECG_WAVP_PACE_ATR_R_APPR_C

This REFID stands for: Pacing stimulus, Right atrial antibradycardial pace, appropriate, captured

[b] CODE10 for MDC_ECG_WAVP_PACE_V_L_APPR_C

This REFID stands for: Pacing stimulus, Left ventricular antibradycardial pace, appropriate, captured

[c] CODE10 for MDC_ECG_WAVP_PACE_V_R_APPR_C

This REFID stands for: Pacing stimulus, Right ventricular antibradycardial pace, appropriate, captured

[d] CODE10 for MDC_ECG_WAVC_ARFCT

This REFID stands for: Isolated QRS-like or pacemaker pulse like artefact

[e] CODE10 for MDC_ECG_WAVP_ATPACE_V_APPR_C

This REFID stands for: Pacing stimulus, Ventricular Antitachycardia pace, appropriate, captured

[f] VIRT is encoded by SCP-ECG code "199", which stands for "Global, virtual lead"

[g] Here we assume that the method used to detect and measure the pacemaker pulse is based on a vectorcardiographic method viz the one described in J Electrocardiol. 2011;44:275–281, and that the magnitude of the spatial pulse is 7200 µV. Alternatively, one could have also encoded the stored Spike Amplitude value as 29 999, which according to Clause 5.10.3.1 means "Measurement not computed by the program", for example in case the "global" method used to detect and localize the pacemaker pulse is based on a multilead approach viz computing a global detection function such as the spatial velocity without measuring the amplitude of the spike. Manufacturers using non-standard methods specify the method they are using in the physician's guide.

[h] To pinpoint that pacemaker pulses #1, 2 and 3 have contributed in pacing the same beat, it is of utmost importance to use identical sample values for localizing the paced beat.

SID	SLSN (sample point)	Spike Type	Lead ID	Spike Duration (in µs)	Spike Amplitude (in µV)	Paced Beat Loc. (sample pt)	...	Last ASM

ⁱ   Code 29999 is used to specify that, for the type of spikes listed in lines 2, 20 and 21 (the type of each spike is identified by the CODE10 value listed in column Spike Type), the kind of spike measurement/annotation called "Last ASM" is neither performed by the spike measurement program nor by a human reviewer.
^j   Code 0xFFFFFFFF is used to specify that no beat (i.e. no QRS complex) has been triggered by spike #20.

5.21 Additional ECG annotations – Section 18

5.21.1 General

The main objective of this section is to provide a solution to store 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/or end of a bigeminy 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 (retrograde ventriculoatrial conduction, LBBB aberrancy, etc.) and P waves (AV block or AV dissociation, etc.), noise annotations in a given lead, etc.

Annotation data shall be stored on an annotation-by-annotation basis. Ideally, each annotation should correspond to a basic concept, viz rhythm annotation or measurement annotation, although both types of annotation may be merged into only one annotation.

Each annotation consists in a variable number of entries. There are three types of entries possible:

— Coded entries based on CF_CODE10 (as specified hereafter in 5.21.4).

— XML document

— Full Text.

The three different coding schemes may coexist, i.e. annotations encoded according to CF_CODE10 based SCP-ECG Coding Rules may concomitantly also be encoded for example according to aECG XML encoding rules [17] and/or described in plain text.

The data contained in this section shall include the most recent annotation data and be consistent with the data stored in Sections 7-11 and Sections 15-17.

5.21.2 Section ID header

If present, the section shall start with a "Section ID Header" as defined in 5.2.7. In particular, in the Section ID Header, the protocol version number stored in the Header byte 10 shall reflect the current version of this document, since versions V1 and V2 do not support this additional ECG annotations section (section 18 does not exist in SCP-ECG versions V1 and V2).

5.21.3 Section Data part

The data part of this section includes a data header followed by a variable number of annotations. The layout of the data part is presented in 5.21.5, and its content is explained hereafter.

5.21.3.1 Data Header

The header of the data part of the section contains the status and the time and date of the storage and/or overreading of the annotations, and the number of stored annotations. Its format is as follows:

Byte   **Contents**

1   Annotations overreading Confirmation Status.

	Value	Type
	0	Original annotations (not overread).
	1	Confirmed annotations.
	2	Annotations (partially) overread, but not confirmed.

2 to 8   Date and time of annotations recording and/or overreading (D/T).

Semantically equivalent to MDC_ATTR_TIME_ABS.

The byte format is identical to the date and time formats specified in section 8 (see 5.11.4):

Byte

2 to 3   Binary: Year (Full integer notation, as in 2018) [MDC_DIM_YR]

4   Binary: Month (range 01 to 12; 01 = January) [MDC_DIM_MON]

5   Binary: Day (range 1 to 31) [MDC_DIM_DAY]

6   Binary: Hours (range 0 to 23) (time is always local time) [MDC_DIM_HR]

7   Binary: Minutes (range 0 to 59) [MDC_DIM_MIN]

8   Binary: Seconds (range 0 to 59) [MDC_DIM_SEC]

NOTE 1   The date and time information stored in this header indicates the date and time of the creation and/or storage of the latest annotation of this section (in case the value of byte 1 is 0), or the date and time of the latest overreading or confirmation (in case the value of byte 1 is 1 or 2). This information is usually different from the date and time of the signal recording.

NOTE 2   Time and date is expressed as local time in the Time Zone of the overreader and/or of the analysing device.

9 to 10   Date&Time Time Zone (TZ), specified as an offset from UTC in minutes. (Signed integer).

Semantically equivalent to MDC_ATTR_TIME_ZONE.

The content of this field shall identify the time zone related to the local time stored here above in bytes 2 to 8. The format shall be identical to the Time Zone format specified in bytes 1–2 of Tag 34 in Table 2. In case the local Time Zone is unknown, TZ shall be set to 0x7FFF.

11 to 12   Number of recorded Annotations (#ANN).

Allowed values range from1 to 65 535.

13 to 62   Reserved for future use (shall always be set to zero).

63 to 66   Length of the Header Notes field in bytes (LHN).

67 to 70   Length of the Manufacturer-specific additional Information field in bytes (LMI).

variable   General Header Notes on this section. This is a free-text field. It shall be NULL terminated.

variable   Manufacturer-specific Information field (MI).

The different annotations then follow, starting after the Manufacturer-specific Information field (MI), if any. The format for each single annotation is defined hereafter in 5.21.3.2 and 5.21.4.

5.21.3.2 (Single) Annotation (ANN) data block structure

Each annotation consists in a variable number of annotation entries and is identified by an incremental annotation number (ANN_ID).

Byte   Contents

1 to 2   Annotation ID (ANN_ID)

Sequential number. May be used to facilitate retrieval of the measurements and annotations of a specific beat or event when referenced in another section.

3 to 6   Annotation Size (ANN_SZ)

Length in bytes of this annotation data block, starting with Annotation ID (i.e. including the 2 bytes of ANN_ID and the 4 bytes of ANN_SZ).

7   Related SCP-ECG data section (ECG_DS).

This byte is used in combination with byte 8 to specify in which section one can find the raw ECG signal data or the beat or spike ID corresponding to the measurements / annotations stored in this specific annotations data block.

Value	Related ECG signal data and measurements localization
0	Unknown, or the raw ECG signals from which the measurements / annotations stored in this specific annotations data block have been derived are not saved in this SCP-ECG file
5	Rest ECG reference beat (Section 5)
6	Rest ECG rhythm data (Section 6)
12	Long-term ECG rhythm data (Section 12)
13	Selected ECG reference beats (Section 13)
14	Selected ECG sequences repository (Section 14)
15	Beat-by-Beat ECG measurements and annotations (Section 15)
16	Selected ECG beats measurements and annotations (Section 16)
17	Pacemaker Spikes measurements and annotations (Section 17)

8   Related ECG Data Block Number or Measurements Array Id (ECG_DBN).

This byte is used to specify, in case ECG_DS = 13 to 17, in which ECG sequence or meta-data block or in which ECG measurements / annotations array one can find the raw ECG signal data or the beat or spike ID corresponding to the measurements / annotations stored in this specific annotations data block.

If ECG_DS = 13, then ECG_DBN shall store the metadata block ID "BId" (see 5.16.3.3) corresponding to the analysed reference beat, i.e. ECG_DBN = BId.

If ECG_DS = 14, then ECG_DBN shall store the block identification number "BN" (see 5.17.6.6) corresponding to the analysed ECG sequence, i.e. ECG_DBN = BN.

If ECG_DS = 15, then ECG_DBN shall store the Measurements Array Identification number "MAId" (see 5.18.3.3) corresponding to the analysed ECG sequence, i.e. ECG_DBN = MAId.

If ECG_DS = 16, then ECG_DBN shall store the Beat ID "BID" (see 5.19.4.1) corresponding to the selected beat, i.e. ECG_DBN = BID.

If ECG_DS = 17, then ECG_DBN shall store the Measurements Array Identification number "MAId" (see 5.20.3.4) corresponding to the analysed ECG sequence, i.e. ECG_DBN = MAId.

In all other cases ECG_DBN shall be set to zero.

9 to 12   Related Beat or Spike Id (BSId).

This byte is used to further specify, in case ECG_DS = 15 or 17, to which specific beat or spike, if any, the additional measurements / annotations stored in this specific annotation data block correspond.

If ECG_DS = 15, then BSId shall store the Beat Identification number "BID" (see 5.18.4.1) corresponding to the annotated ECG beat, i.e. BSId = BID.

If ECG_DS = 17, then BSId shall store the Spike Identification number "SID" (see 5.20.4.1) corresponding to the analysed spike, i.e. BSId = SID.

For convenience reasons, in case ECG_DS = 13 or 16, BSId should repeat the information already stored in ECG_DBN, i.e. BSId = ECG_DBN.

In all other cases BSId shall be set to zero.

13   Lead Identification (LID).

This discriminator shall be used to identify to which specific ECG lead, if any, the additional measurements / annotations stored in this specific annotation data block apply. The same SCP-ECG numbering scheme as in 5.6.4, Table 4, shall be used to specify the lead that has been used.

Semantically equivalent to MDC_ECG_Lead_xxx, see 5.6.4 Note.

NOTE   As specified in 5.6.4 (Table 4), applicable codes are from 1 to 184 and 199. Codes 200 to 255 are reserved to specify manufacturer specific leads. SCP-ECG code "199" is used to specify that the measurement(s) / annotation(s) does not refer to a specific lead, but that it is the result of a global evaluation having taken all (or several) leads into account. This is distinguished from the case where the lead used to perform the measurements / annotations is unspecified, which is coded "0".

14 to 17   Sampling Rate, in samples per second (SR).

Semantically equivalent to MDC_ECG_CTL_VBL_SAMPLE_RATE and MDC_ATTR_SAMPLE_RATE.

This field shall replicate the sampling rate of the original ECG recording specified in the sections pinpointed by ECG_DS and ECG_DBN. It has been included here to make this section self-standing and to convert measurement time points (viz beat and wave locations) and durations expressed in sample numbers and in sample intervals, into physical time and duration.

In case the value of ECG_DS equals "0", then bytes 5 to 8 shall store the sampling rate of the original ECG on which the measurements / annotations stored in this annotation data block have been computed.

18 to 19   Number of annotation Entries (#Entries)

var   1st annotation entry

var   2nd annotation entry, if any

...		etc., up to annotation entry #Entries

5.21.3.3 Overview of the data content of a single additional annotations data block (ANN)

An overview of the data content of a typical annotation data block (ANN) is provided in Figure 25, where ANN stands for Annotation (see 5.21.3.2).

ANN_ID	Size	ECG_DS	ECG_DBN	BSId	LID	SR	#Entries	1st Entry	2nd Entry	//	Last Entry
2	4	1	1	4	1	4	2	var	var	var	var

Figure 25 — Overview of the data content of a single Annotation data block ANN

5.21.4 (Single) annotation Entry data format description

5.21.4.1 Entry data format

Each annotation Entry consists in a variable length entry data block and is identified by an incremental Entry ID.

Each entry data block consists in an Entry type specifier followed by a variable number of Entry data fields.

Each Entry data field either consists in one NULL terminated characters string (plain text or XML document) or in a (Code, Unit, Value) triplet, depending on the Entry type (see 5.21.4.2).

In the present version of this protocol, all text strings and XML documents are UTF-8 encoded.

The format of each single entry and its entry field(s) are as follows:

Byte	Contents
1	Entry ID (Binary). Each entry has been given a sequence number (starting with 1)
2 to 5	Entry data length (Binary). Length in bytes of this entry data block, starting with Entry Type ID (i.e. including the 1 byte of "Entry Type ID"), and including all NULL terminators, see Figure 26).
6 to ***	Entry data block

Byte	Contents
1	Entry Type ID (Binary)

Value	Type
1	Coded entry type, as described below in 5.21.4.2 Type 1
2	XML document
3	Full text type
4 to 99	Reserved

2 to ***	Data depending on the Entry Type ID specified in byte 1 of the Entry data block, eventually terminated by NULL (0).

5.21.4.2 Entry data field content specification in function of the Entry type

Type 1	This type of entry may contain one or more (Code, Unit, Value) triplets. Each triplet

represents an elementary measurement or annotation, viz the onset or the end of an atrial fibrillation. Its encoding is as follows:

Measurement / Annotation Identification Code (COD) (4-byte unsigned integer).

The measurement / annotation shall be identified by a unique code that shall allow to know what the measurement / annotation represents. COD shall store the CF_CODE10 value corresponding to the REFID of the measurement/annotation as defined in ISO 11073-10101 [8] and 11073-10102 [9], and/or in their running updates stored in the NIST RTMMS repository [59].

Measurement / Annotation Unit code (U) (2-byte unsigned integer).

These two bytes shall specify the physical unit (and its type, if dimensionless) of the value of the measurement/annotation identified by COD and stored hereafter in VAL. Physical units shall be identified by means of their UoM base code according to ISO/IEEE 11073-10101 [8] and the updates maintained in the corresponding units-of-measure table defined in the NIST RTMMS repository [59].

Table A.8 in Annex A points out the most useful units for the purpose of this additional ECG annotations section and defines the codes that shall be used for the measurement and annotation types not defined by the 11073-10101 standard.

Units of dimensionless annotations viz the QRS morphology class number or the ECG rhythm type, shall be encoded by 512, the UoM base code for MDC_DIM_DIMLESS.

In case no value "Val" shall be saved as for example for REFID "MDC_ECG_NOISE_CLEAN" or "MDC_ECG_NOISE_CLEAN_ANNOT", coded COD = 666575, then storing a Unit code is irrelevant and U shall be set to 0xFFFF (which allows to distinguish this case from the case where the Unit is not known, encoded as "Unspecified" (MDC_DIM_NOS), UoM base code = 0).

Measurement or Annotation Value (VAL) (4-byte integer)

VAL shall store the measurement value as a signed integer and use the CF_CODE10 for the annotation value.

In case no value is provided, then VAL shall be set to 0xFFFFFFFF.

Type 2:   This type has one data part containing an XML document, and is NULL (0) terminated.

Type 3:   This type has one data part containing only text characters, and is NULL (0) terminated.

5.21.4.3 Overview of the data content of a single annotation Entry

An overview of the data content of a single annotation Entry is provided in Figure 26.
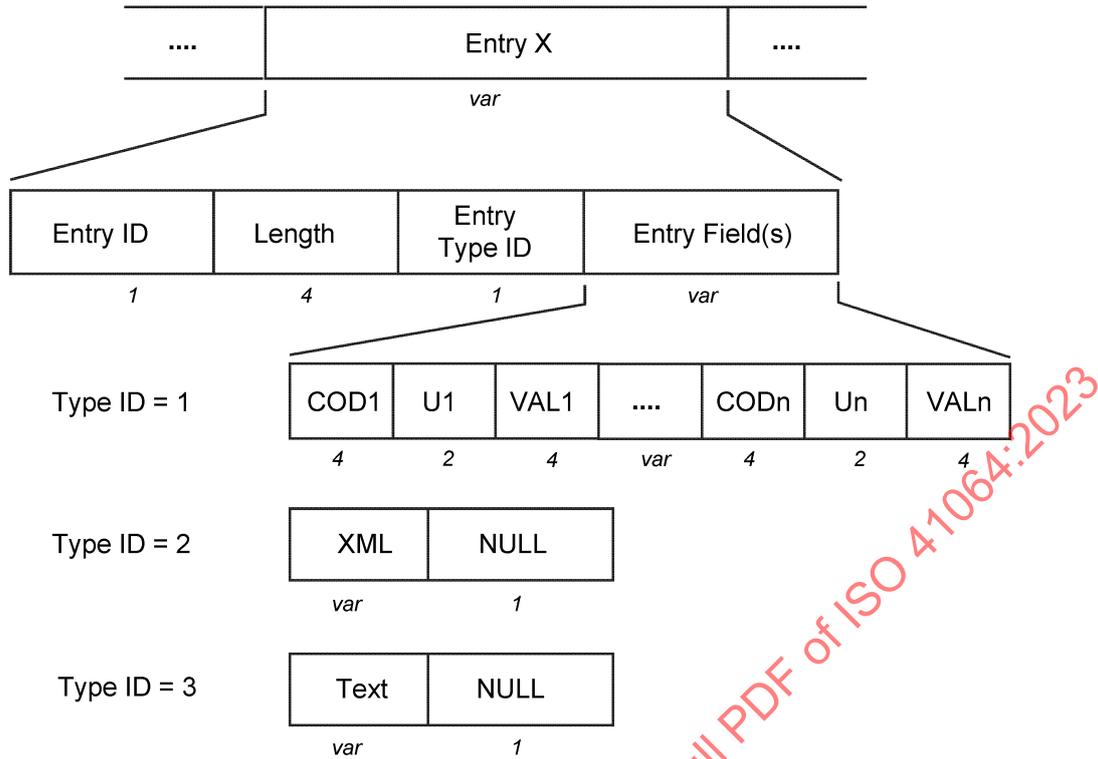
Figure 26 — Overview of the data content of a single annotation Entry

5.21.5 Overview of the data part of section 18 "Additional Measurements and Annotations"

An overview of the data part of section 18, Additional Measurements and Annotations, is provided in Figure 27.
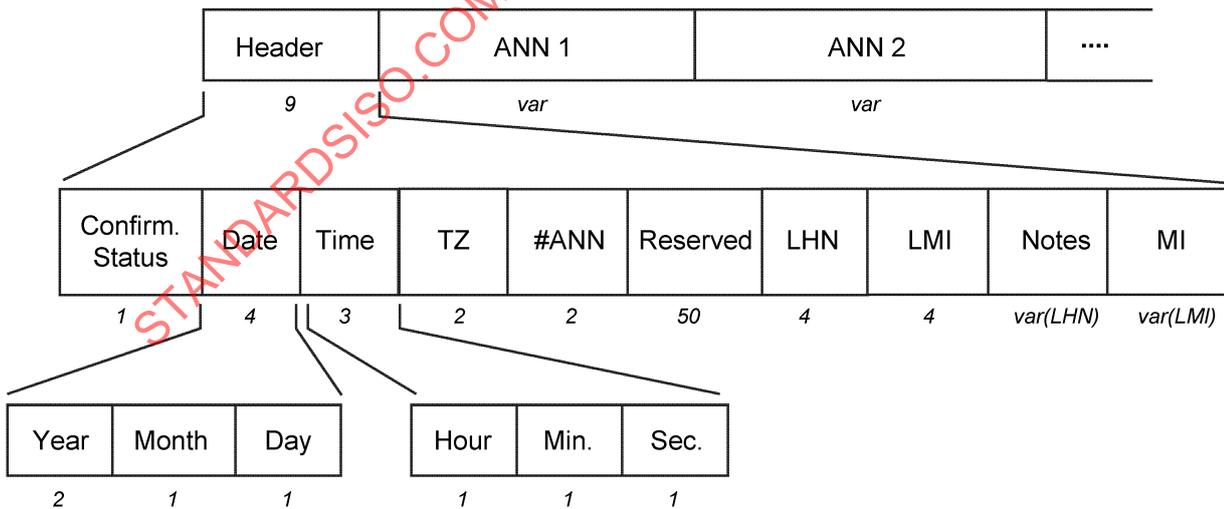
Figure 27 — Overview of the data part of Section 18

Annex A
(normative)

Supplementary information and additional encoding specifications

A.1 Supplementary information to Table 2, Clause 5.4.5

A.1.1 SCP-ECG specific drug class and drug sub class encoding

Tables A.1 and A.2 hereafter specify the drug class codes (DCC) and specific sub class codes (SBC) that shall be used to encode the content of Table 2, Tag 10 of the patient data area (see Clause 5.4.5), in case the SCP-ECG specific drug coding system is adopted to encode the patient's drugs.

Table A.1 — SCP-ECG Drug Class Codes (DCC)

0 - Unspecified	8 - Psychotropic
1 - Digitalis	9 - Calcium Blockers
2 - Antiarrhythmic	10 - Antihypotensive
3 - Diuretics	11 – Anticholesterol/lipid modifying agent
4 - Antihypertensive	12 - ACE- Inhibitors
5 - Antianginal	13 - Antistaminic
6 - Antithrombotic	14 - Sartans
7 - Beta Blockers	15 to 99 - Reserved
101 - Drugs, but unknown type	103 to 255 - Manufacturer specific codes
102 - Other medication	

Table A.2 — SCP-ECG Specific Drug Codes (SDC)

CLASS 1: DIGITALIS PREPARATION		
0 – Unspecified	3 – Acetyldigoxin	6 – Metildigoxin
1 – Digoxin	4 – Lanatoside C	7 – Gitoformate
2 – Digitoxin-Digitalis	5 – Deslanoside	9 – Other
CLASS 2: ANTIARRHYTHMIC		
0 – Unspecified	7 – Amiodarone	14 – Adenosine
1 – Disopyramide	8 – Tocainide	15 – Bretylium
2 – Quinidine	9 – Other	16 – Dofetilide
3 – Procainamide	10 – Encainide	17 – Dronedarone

4 – Lidocaine	11 – Mexiletine	18 – Ibutilide
5 – Phenytoin	12 – Flecainide	19 – Propafenone
6 – Fosphenytoin	13 – Lorcainide	20 – Sotalol

CLASS 3: DIURETICS

0 – Unspecified	3 – Potassium Chloride	6 – Torasemide
1 – Thiazide	4 – Bumetanide	7 – Other Sulfonamides
2 – Furosemide	5 – Piretanide	9 – Other diuretics

CLASS 4: ANTIHYPERTENSIVE

0 – Unspecified	10 – Diazoxide	20 – Moxonidine
1 – Clonidine	11 – Doxazosin	21 – Nitroprusside
2 – Prazosin	12 – Guanethidine	22 – Pinacidil
3 – Hydralazine	13 – Guanfacine	23 – Reserpine
4 – Ambrisentan	14 – Guanoxabenz	24 – Riociguat
5 – Betanidine	15 – Guanoxan	25 – Sitaxentan
6 – Bietaserpine	16 – Ketanserin	26 – Tolonidine
7 – Bosentan	17 – Macitentan	27 – Trimazosin
8 – Debrisoquine	18 – Methyldopa	28 – Trimetaphan
9 – Other	19 – Minoxidil	29 – Urapidil

CLASS 5: ANTIANGINAL

0 – Unspecified	2 – Calcium Blockers	9 – Other
1 – Isosorbide	3 – Nitrates	

CLASS 6: ANTITHROMBOTIC AGENTS

0 – Unspecified	4 – Warfarin	8 – Platelet aggr. inhibit. excl. heparin
1 – Acetylsalicylic acid (Aspirin)	5 – Streptokinase	9 – Other
2 – Vitamin K antag. excl. warfarin	6 – tPA enzymes	10 – Direct thrombin inhibitors
3 – Heparin group	7 – Other antithrombotic Enzymes	11 – Direct factor Xa inhibitors

CLASS 7: BETA BLOCKERS

0 – Unspecified	7 – Alprenolol	14 – Esmolol
1 – Propranolol	8 – Betaxolol	15 – Labetalol

2 – Nadolol

3 – Atenolol

4 – Metoprolol

5 – Pindolol

6 – Acebutolol

9 – Other

10 – Bisoprolol

11 – Carteolol

12 – Carvedilol

13 – Celiprolol

16 – Nebivolol

17 – Penbutolol

18 – Practololl

19 – Timolol

CLASS 8: PSYCHOTROPIC

0 – Unspecified

1 – Tricyclic antidepressant

2 – Phenothiazine

3 – Barbiturate

9 – Other

CLASS 9: CALCIUM BLOCKERS

0 – Unspecified

1 – Nifedipine

2 – Verapamil

3 – Amlodipine

4 – Bepridil

5 – Diltiazem

6 – Felodipine

7 – Isradipine

8 – Nicardipine

9 – Other

10 – Nimodipine

11 – Nisoldipine

CLASS 10: ANTIHYPOTENSIVE

0 – Unspecified

1 – Asthmatic drug

2 – Aminophylline

3 – Isoprenaline

4 – Sympathomimetic drug

9 – Other

CLASS 11: ANTICHOLESTEROL / LIPID MODIFYING AGENTS

0 – Unspecified

1 – Colestipol

2 – Lovastatin

3 – Simvastatin

4 – Fibrates

5 – Other bile acid sequestrants

6 – Other statins

7 – Nicotinic acid and derivatives

8 – MTTP inhibitors

9 – Other lipid modifying agents

CLASS 12: ACE- INHIBITORS

0 – Unspecified

1 – Captopril

2 – Benazepril

3 – Cilazapril

4 – Enalapril

5 – Fosinopril

6 – Imidapril

7 – Lisinopril

8 – Moexipril

9 – Other

10 – Perindopril

11 – Quinapril

12 – Ramipril

13 – Trandolapril

14 – Zofenopril

CLASS 13: ANTISTAMINIC

0 – Unspecified

CLASS 14: SARTANS

0 – Unspecified

Within each DCC class, if a patient takes a drug that has not been listed within the corresponding DCC class, then the SDC sub class drug shall be coded 9 which is the code to be used for "other".

A.1.2 Language support encoding in legacy SCP-ECG versions

SCP-ECG versions V1.x and V2.x used byte 17 of Tag 14 of Table 2, Clause 5.4.5, to specify the character set that is used to encode textual strings within the SCP-ECG record. Starting with SCP-ECG version V3.0, this byte shall be set to 0x37 to indicate that now only UTF-8 text string encoding is allowed.

Table A.3 hereafter displays for historical purposes the bit map table that was used to specify the assigned codes, including UTF-8. Codes other than UTF-8 shall no longer be used except for decoding legacy SCP-ECG files.

Table A.3 — Multilingual character sets encoding in legacy SCP-ECG files

Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Meaning
0	x	x	x	x	x	x	x	8-bit ASCII-only
1	0	x	x	x	x	x	x	ISO-8859–1 Latin-1
1	1	0	0	0	0	0	0	ISO-8859–2 Latin-2 (Central and Eastern European)
1	1	0	1	0	0	0	0	ISO-8859–4 Latin-4 (Baltic)
1	1	0	0	1	0	0	0	ISO-8859–5 Cyrillic
1	1	0	1	1	0	0	0	ISO-8859–6 Arabic
1	1	0	0	0	1	0	0	ISO-8859–7 Greek
1	1	0	1	0	1	0	0	ISO-8859–8 Hebrew
1	1	0	0	1	1	0	0	ISO-8859–11 Thai
1	1	0	1	1	1	0	0	ISO-8859–15 Latin-9 (update to Latin-1, also called "Latin-0")
1	1	1	0	0	0	0	0	ISO/IEC 10646
1	1	1	1	0	0	0	0	JIS X 0201–1976 (Japanese)
1	1	1	0	1	0	0	0	JIS X 0208–1997 (Japanese)
1	1	1	1	1	0	0	0	JIS X 0212–1990 (Japanese)
1	1	1	0	0	1	0	0	GB 2312-80 (Chinese)
1	1	1	1	0	1	0	0	KS C5601-1987 (Korean)
1	1	1	0	1	1	0	0	UTF-8
1	1	1	1	1	1	0	0	Reserved
x	x	x	x	x	x	0	1	Reserved

Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Meaning
x	x	x	x	x	x	1	0	Reserved
x	x	x	x	x	x	1	1	Reserved (except for following entry)
1	1	1	1	1	1	1	1	Manufacturer-Specific

A.1.3 Implanted cardiac devices functionalities encoding

Tag 36 in Table 2, Clause 5.4.5, may be used to identify the functionalities of the patient's implanted cardiac device (pacemaker, ICD, pacing ICD, CRT) thanks to a coded text string based either on the 5-letter NBG code [29] for a pacemaker or on the 4-letter NBD code [28] for an ICD. The meaning of these coding letters is summarized hereafter in Table A.4 and in Table A.5, where positions I to V stand for the respective position of the corresponding letter in the NBG or 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".

Table A.4 — NASPE/BPEG revised (2002) NBG pacemaker code

Position I *(Chamber Paced)*	Position II *(Chamber sensed)*	Position III *(Response to Sensed Event))*	Position IV *(Programmability, Rate Modulation)*	Position V *(Multisite Pacing)*
O = none	O = none	O = none	O = none	O = none
A = atrium	A = atrium	I = inhibited	R = rate modulation	A = atrium
V = ventricle	V = ventricle	T = triggered		V = ventricle
D = dual (A + V)	D = dual (A + V)	D = dual (T + I)		D = dual (A + V)
X = unspecified	*X = unspecified*	*X = unspecified*	*X = unspecified*	*X = unspecified*
S = (A or V)	*S = (A or V)*			
Note "NBG" stands for North American Society of Pacing and Electrophysiology (N) and British Pacing and Electrophysiology Group (B) generic (G) pacemaker code.				

NOTE 1   The last two lines of letter codes, X = unspecified and S = Single (A or V), are not part of the official NBG/NBD codes. Although not endorsed by the different rhythmology societies, they have been listed in both tables because they are used by some manufacturers.

NOTE 2   Some manufacturers expand the NBG code by specifying the polarity of the device in position VI: U = unipolar, B = bipolar, X = unspecified.

Table A.5 — NASPE/BPEG generic NBD defibrillator code

Position I	Position II	Position III	Position IV
(Shock Chamber)	*(Antitachycardia Pacing Chamber)*	*(Tachycardia Detection)*	*(Antibradycardia Pacing Chamber)*
O = none	O = none	E = electrogram	O = none
A = atrium	A = atrium	H = haemodynamic	A = atrium
V = ventricle	V = ventricle		V = ventricle
D = dual (A + V)	D = dual (A + V)		D = dual (A + V)
X = unspecified	*X = unspecified*	*X = unspecified*	*X = unspecified*
S = (A or V)	*S = (A or V)*		*S = (A or V)*
Note "NBD" stands for North American Society of Pacing and Electrophysiology (N) and British Pacing and Electrophysiology Group (B) generic defibrillator (D) code.			

NOTE 1   For robust identification, position IV can be expanded into its complete NBG code. For example, a biventricular pacing-defibrillator with ventricular shock and antitachcardia pacing functionality would be identified as VVE-DDDRV, assuming that the pacing section was programmed DDDRV. No haemodynamic sensors have been approved yet for tachycardia detection (position III).

NOTE 2   For the last two lines in italic, see Table A.4, NOTE 1.

A.2 Encoding of additional filtering methods used for ECG processing

Table A.6 hereafter specifies the different bits of the one byte filter bit map (FBM) that shall be used in different sections of SCP-ECG to further specify the filtering methods that have been applied for processing the stored ECG signals and/or for computing the different measurements and annotations, in addition to the usual low-pass and high-pass filter settings specifications.

Table A.6 — Filter bit map (FBM) to be used for encoding additional ECG filtering methods

Bit	Filtering method
0	60 Hz notch filter [MDC_ECG_CTL_VBL_ATTR_FILTER_NOTCH_FREQ]
1	50 Hz notch filter [MDC_ECG_CTL_VBL_ATTR_FILTER_NOTCH_FREQ]
2	Artefact filter
3	Unspecified baseline filter [MDC_ECG_CTL_VBL_BASELINE]
4	Adaptive mains filter [MDC_ECG_CTL_VBL_ATTR_FILTER_NOTCH]
5	Baseline correction by cubic spline [MDC_ECG_CTL_VBL_BASELINE_DESC]
6	Baseline correction by adaptive filter [MDC_ECG_CTL_VBL_BASELINE_DESC]
7	Reserved for future use (shall be set to zero, except for case specified hereafter in Note 2).

NOTE 1   If all bits are set to zero, no additional filtering than those implicitly specified in the low-pass and high-pass filter fields was used.

NOTE 2   If all bits are set to 1, then the additional filter method(s) used for processing the ECGs was not specified or the method(s) were different from the ones listed in Table A.6.

The use of FBM has been specified in Clauses 5.4.5 (Table 2, Tag 29), 5.15.4.1 (Long-term ECG rhythm data Header, byte 32), 5.16.3.3 (Stress tests, drug trials and protocol based Events Metadata Blocks, byte 29), 5.17.6.6 (Selected ECG sequences, byte 12), 5.18.3.3 (Beat-by-beat measurements array header, byte 28), 5.19.3.2 (Selected ECG beats measurements and annotations header, byte 20) and in 5.20.3.4 (Spike-by-spike measurements array header, byte 28).

A.3 Encoding of the units of measure of the workload level WL

Clause 5.16.3.3 provides means to store in the related stress tests, drug trials and protocol based events metadata blocks the Workload Level WL used during stress tests as well as the code for ULL, the Unit of measure of the work Load Level WL. The binary code used to represent the unit of measure ULL shall be the Unit of Measure (UoM) base code taken from ISO/IEEE 11073-10101, Table A.6.4.1: Vital signs units of measurements [8] and their updates maintained in the corresponding units-of-measure table defined in the NIST RTMMS repository [59].

Table A.7 hereafter lists the most relevant values of ULL for exercise ECG on treadmill, cycloergometer and stepper, both in decimal and in hexadecimal.

Table A.7 — Typical ULL unit codes for the measure of the workload level WL

ULL code		ULL units
Decimal	Hexadecimal	
0	0x0000	Unspecified [MDC_DIM_NOS]
544	0x0220	% (percentage) [MDC_DIM_PERCENT]
736	0x02e0	Angle Degree [MDC_DIM_ANG_DEG]
3968	0x0f80	J (units for Work, 1 Newton-meter = 1 J) [MDC_DIM_X_JOULES]
4032	0x0fc0	Watt [MDC_DIM_X_WATT]
8096	0x1fa0	rpm (rounds per minute) [MDC_DIM_X_ROTATIONS_PER_MIN]
11616	0x2d60	steps per minute [MDC_DIM_STEP_PER_MIN]
12003	0x2ee3	km/h [MDC_DIM_KILO_M_PER_HR]
12032	0x2f0	Mph [MDC_DIM_MPH]
65120	0xfe60	Nm (units for Torque in Newton-meter)

NOTE   The ULL codes are identical to the UoM base codes of the REFIDs defined in the ISO/IEEE 11073-10101 standard [8], except for the Nm units for Torque.

A.4 Encoding of the physical units and/or type of measurements and annotations

Sections 15 to 18 provide means to dynamically define for each SCP-ECG record additional beat and/or spike measurements and annotations that may be stored in the related measurements and annotations data blocks as well as the physical unit and/or the type of the stored measurement/annotation values. Physical units shall be identified by means of their UoM base code according to ISO/IEEE 11073-10101 [8] and its updates maintained in the corresponding units-of-measure table defined in the NIST RTMMS repository [59].

Units of dimensionless annotations viz the QRS morphology class number or the ECG rhythm type shall be encoded by 512, the UoM base code for MDC_DIM_DIMLESS.

Units of measurements expressed in sample numbers and sample intervals shall be distinguished from other dimensionless measurements and annotations by respectively using the special codes specified hereafter in Table A.8, unless explicitly defined in future versions of ISO/IEEE 11073-10101 [8] and/or in the NIST RTMMS repository [59].

Vector Azimuth and Elevation and electrical axes shall be expressed in signed angular degrees and measured according to the conventions shown in 5.1.3.3, Figure 10, and in 5.10.3.7, Figure 11.

Table A.8 hereafter points out the most useful units to be used for the additional measurements and annotations specified in sections 15 to 18 and defines the codes that shall be used for the measurement and annotation types not yet defined by the 11073-10101 standard [8].

Table A.8 — Typical units codes for ECG measurements and annotations

UoM base code		Type or physical unit
Decimal	Hexadecimal	
0	0x0000	Unspecified [MDC_DIM_NOS]
512	0x200	Dimensionless [MDC_DIM_DIMLESS]
544	0x0220	% (percentage) [MDC_DIM_PERCENT]
736	0x02e0	Angular degree [MDC_DIM_ANG_DEG]
2176	0x0880	s (second) [MDC_DIM_SEC]
2194	0x0892	ms (millisecond) [MDC_DIM_MILLI_SEC]
2195	0x0893	μs (microsecond) [MDC_DIM_MICRO_SEC]
2196	0x0894	ns (nanosecond) [MDC_DIM_NANO_SEC]
2464	0x09a0	s^{-1} [MDC_DIM_PER_X_SEC]
2496	0x09c0	Hz [MDC_DIM_X_HZ]
2720	0x0aa0	bpm [MDC_DIM_BEAT_PER_MIN]
4274	0x10b2	mV (millivolt) [MDC_DIM_MILLI_VOLT]
4275	0x10b3	μV (microvolt) [MDC_DIM_MICRO_VOLT]
4276	0x10b4	nV (nanovolt) [MDC_DIM_NANO_VOLT]
8244	0x2034	μV.ms [MDC_DIM_NANO_VOLT_SEC]
11648	0x2d80	Duration in sample intervals [MDC_DIM_TICK]
65280	0xff00	Time Point in sample number(s) (see Note 2)

NOTE 1   The REFIDs listed in the rightmost column and all UoM base code values except 65280 are defined in the ISO/IEEE 11073-10101 standard [8].

NOTE 2   Dimensionless Time Point measurements and/or annotations values (viz wave onset, time of peak, point in time, etc.) expressed as sample numbers relative to the beginning of the ECG signals recording or of the analysed beat (see for example 5.18.1.6) use UoM base code 65280.

Annex B
(informative)

Universal ECG interpretation statements codes

B.1 General

Universal ECG interpretive statement codes may be used, in addition to free text, to transfer interpretive statements between various ECG analysis systems, but also between such systems and clinical workstations and hospital information systems.

A common set of statement codes is of utmost importance in order to exchange interpretive ECG messages in a multilingual environment, and is also an important asset for data compression.

These codes can also be used for storage of the overreading trail. Storage of overreading results is necessary for legal reasons. Changes made to the computer interpretation by a cardiologist need to be stored, and should be retrievable for transfer to general practitioners or other specialists, and to other third parties.

B.2 Constraints

The coding scheme presented below provides a "pragmatic" approach to the problem of mapping computer statements onto a common and understandable lexicon. Simple, basic mnemonics, modifiers and conjunctives are proposed which can be used to compose and reflect simple but also rather complex ECG interpretive statements.

It should clearly be understood that it is not assumed that ECG computer programs should attempt to make all the statements listed in this annex. This is beyond the reach of current technology and even the desire of cardiologists. Indeed, based on the ECG alone several statements listed in this annex are hard to make on an objective basis. The present document does not want to provide a value judgment on the usefulness or limitations of standard electrocardiography. However, this annex attempts to provide a fair representation of the electrocardiographic terminology and ECG reporting used in current practice.

B.3 Composition of the code and general syntax rules

B.3.1 General principle

Mnemonics which are as far as possible widely used in the literature, and which can possibly be remembered by physicians overreading ECGs, have been used. These mnemonics can be converted into numeric codes such as the so-called categorized AHA statement codes [21] or the CDISC C-Code [30], or for "internal" program use. The electrocardiographer who only occasionally reviews computerized ECG interpretations cannot be expected to familiarize himself with a set of code numbers or the sometimes rather complex mnemonics used in the programs of different manufacturers.

Through the use of a flexible, but unique code structure, the computer can be made to gain at least a general understanding about the changes made by readers without forcing them into a strict use of numbers. Vice versa, rather complex statements hidden in the free text of computer interpretive reports can, by means of acronyms and simple syntax rules, be converted into universal understandable statement codes.

B.3.2 Basic composition of the code

The universal SCP-ECG interpretation code consists of one or more fields. In principle there is no limit to the number of different fields, except that the parsing and phrasing of the interpretive statement may become too long.

The first field (maximum 5 bytes long) defines the basic (or primary) diagnostic interpretation or descriptive statement.

The second field (one or two bytes) is primarily used to indicate an estimated probability that a statement is correct or to define the certainty degree of the corresponding statement.

e.g.   A or DE = definite   D or CE = rule out/cannot exclude

B or PR = probable   SS = strongly suggestive

C or PS = possible   CO = consider

U or UN = unknown   CW = consistent with

The second field can also be used for other purposes (see below).

The third and other fields (two bytes) are used for other modifiers.

B.3.3 Modifiers

The following modifiers can be used:

1) to indicate the age of an infarction or ischaemic ST-T changes

OL = old   EV = evolving

RE = recent   XO = probably old

AC = acute   XA = probably acute (recent)

SU = subacute   YO = possibly old

AI = age indeterminate   YA = possibly acute (recent)

AU = age undetermined

2) to indicate the location of ST-T and other abnormalities

AN = anterior   BA = basal

AS = anteroseptal   AF = antero-inferior

AL = anterolateral   SE = septal

IN = inferior   PL = posterolateral

IL = inferolateral   SN = subendocardial

PO = posterior   SP = subepicardial

LA = lateral   EX = extensive

HL = high lateral   WI = widespread

IP = inferoposterior   DI = diffuse

AP = apical   ML = mid (level)

3) to indicate the severity of the abnormality e.g. hypertrophy, conduction defect or ST-depression

MA = major, MO = moderate, MI = minor, MK = marked and PM = prominent.

Another coding scheme, e.g. S1 to S5, may be used, where grade S1 is used to define light and grade S5 represents very prominent.

4) to indicate the evolving nature or time course of some abnormalities, where:

— SE: serial changes consistent with...

— CC: continuing changes of...

— X1: one   — TR: transient   — UF: unifocal

— OC: occasional   — FR: frequent   — MF: multifocal

— IM: intermittent

— PD: predominant

— TE: temporary

— EV: evolving

— NE: new

— MU: multiple

5) to indicate the physiopathological nature of ST-T changes

— LV: compatible with left ventricular strain

— MD: compatible with myocardial ischaemic damage

— PE: compatible with pericarditis

— EL: compatible with electrolyte abnormalities

6) to indicate the normality or abnormality of a finding

— NO: within normal limits

— NV: may be normal variant

— BO: borderline

— AB: abnormal

— BN: borderline normal

— BA: borderline abnormal

7) rhythm modifiers / anatomic locations

— SI: sinus

— AT: atrial

— SV: supraventricular

— ND: nodal

— VE: ventricular

8) arrhythmia and tachyarrhythmia modifiers

— COU: couplets

— BIG: in a bigeminal pattern

— TRI: in a trigeminal pattern

— MON: monomorphic

— RAP: with a rapid ventricular response

— SLO: with a slow ventricular response

— CAP: with capture beat(s)

— ABR: with aberrancy

— POL: polymorphic

— INT: interpolated

9) miscellaneous

— IC: incomplete

— CP: complete

— TY: typical

— YT: atypical (Note: AT means "atrial"; see 7) above)

— NON: non specific (shall be used only before some statements, see AHA [21])

B.3.4 Separation delimiters

1) The different fields within a statement code are separated by an underscore, e.g. LVH_PR.

2) The main diagnostic code is put first. The modifier indicating the certainty or probability of a code is put as second (as shown in (1) LVH_PR). In case the program or the reader is uncertain about a modifier such as the phase of an infarction or of ischaemic ST-T changes, then a certainty modifier should be added to this modifier, as demonstrated in the following examples:

AMI_PR_AC: means Probable acute anterior infarction.

AMI_AC_PR: means Anterior infarction, probably acute.

AMI_PR_AC_PR: means Probable anterior infarction, probably acute.

In the second case, there is assumed (definite) certainty about the infarction, but uncertainty about its phase.

3) Various statement codes are separated from each other by semicolons. Statements are preceded by sequence numbers during the transmission of the data (see section 11, Clause 5.14.4.2, byte 1). These sequence numbers can be used to link various statements, but also conjunctive terms can be used to this end.

B.3.5 Conjunctive terms

Conjunctive terms may be used to link statements or to create composite statements.

1) The classical Boolean operators can be used as conjunctives, i.e.: AND, OR, NOT, XOR, EOR.

   The conjunctive NOT can be used to indicate that the leading statement is true "in absence of" or "without" the subsequent statement.

2) The following arithmetic and relational operators can be used as conjunctives:

— ADD: add (+)

— SUB: subtract (-)

— MPY: multiply (*)

— DIV: divide (/)

— EXP: exponent

— SQR: square root of

— ABS: absolute value of

— MAX: maximum value of

— MIN: minimum value of

— EQU: equals

— ILT: is less than

— IGT: is greater than

— INE: is not equal to

— IGE: is greater than or equal to

— ILE: is less than or equal to

3) Conjunctive terms with respect to serial comparison, such as:

— SER: serial changes of

— DEC: decreased (in comparison to the previous recording)

— INC: increased (in comparison to the previous recording)

— UNC: unchanged/has not changed (in comparison to the previous recording)

— CHG: changed/has changed (in comparison to the previous recording)

— DIS: (now) disappeared (in comparison to the previous recording)

— REP: (now) replaced ((statement) reported previously)

— IMP: improved (compared to)

— WRS: worse (compared to)

— SRO: since record of

— CRU: comparison record unavailable

— SPE: since previous ECG

— NEW: new since previous ECG

— RSV: resolved

4) Other conjunctive terms can also be used, such as:

— RES: to indicate that the leading statement "results" in (or "causes") the next statement

— SEC: to indicate that the leading statement is "secondary to" the subsequent statement

— ASS: is associated with

— EXC: exclude, rule out, or consider also the next statement

— WTH: with

— ALT: alternating with

— VRS: versus

The conjunctive terms can be maximum 3 bytes long and are given between two semicolons to link separate statements.

Linkage of the conjunctive terms within a composite statement is performed with the underscore (_) sign.

B.4 Acronyms for ECG interpretive statements

B.4.1 References used for the elaboration of this proposal

Lists with interpretive statements of different ECG computer programs have been consulted to elaborate the current proposal. These lists can be found in the 5th to 8th CSE Progress Reports, as well as in the Physicians Handbook of several manufacturers.

In addition, three reports on "Standardization of terminology and interpretation", on "Definitions and classification of cardiac arrhythmias" and on "Recommendations for the standardization and interpretation of the electrocardiogram. Part II: Electrocardiography diagnostic statement list" have largely been used. These reports have been published respectively in the Am. Cardiol. (1978;41:130-145) [42], in the Am. Heart J. (1978;95:796-806) [40], and in Circulation 2007 Mar 13;115(10):1325-32 [21].

The list of interpretive statements has also been crosschecked and amended with reference to the interpretive statements defined or used by AHA [21], aECG [9], HL7 aECG [17], CDISC [30] and DICOM [19].

B.4.2 Acronyms

B.4.2.1 Normal/Abnormal

NORM or NLECG	normal ECG
NLQRS	normal QRS
NLP	normal P wave
NLSTT	normal ST-T
NLST	normal ST segment
WHNOR	ECG within normal limits for age and sex
POSNL	possibly normal ECG
BOECG	borderline ECG
ABECG	abnormal ECG
POSAB	possibly abnormal ECG
ABQRS	abnormal QRS
ABSTT	abnormal ST-T
ABRST	abnormal resting ST (non diagnostic abnormalities)
NFA	normal for age
NFB	normal for build
ABFA	abnormal for age
ABFB	abnormal for build
UFB	unusual for build
ONL	otherwise normal ECG
UNINT	uninterpretable ECG
NV	consider normal variant

B.4.2.2 Ventricular Hypertrophy

LVH	left ventricular hypertrophy
LVHWS	left ventricular hypertrophy with strain
VCLVH	voltage criteria (QRS) for left ventricular hypertrophy
RVH	right ventricular hypertrophy

VCRVH   voltage criteria (QRS) for right ventricular hypertrophy

BVH   biventricular hypertrophy

SEHYP   septal hypertrophy

PRANT   prominent anterior forces

LVHST   LVH with ST-T changes

B.4.2.3 Myocardial Infarction

(The infarct location is preferentially defined within the basic acronym, but can also be defined with a location modifier)

MI   myocardial infarction

AMI   anterior myocardial infarction

EAMI   extensive anterior myocardial infarction

ASMI   anteroseptal myocardial infarction

ALMI   anterolateral myocardial infarction

LMI   lateral myocardial infarction

HLMI   high-lateral myocardial infarction

APMI   apical myocardial infarction

IMI   inferior myocardial infarction

ILMI   inferolateral myocardial infarction

IPMI   inferoposterior myocardial infarction

IPLMI   inferoposterolateral myocardial infarction

PMI   posterior myocardial infarction

SEPMI   septal myocardial infarction

RVMI   right ventricular myocardial infarction

NQWMI   non Q wave myocardial infarction

MILBBB   MI in presence of left bundle-branch block (same as MI_AND_LBBB)

B.4.2.4 Intraventricular and intra-atrial conduction disturbances

BBB   unspecified bundle branch block - MDC_ECG_BEAT_BB_BLK

LBBB or CLBBB   (complete) left bundle branch block - MDC_ECG_BEAT_LBB_BLK_COMP

ILBBB   incomplete left bundle branch block - MDC_ECG_BEAT_LBB_BLK_INCOMP

ALBBB   atypical left bundle branch block

LVCD   left ventricular conduction delay

RBBB or CRBBB   (complete) right bundle branch block - MDC_ECG_BEAT_RBB_BLK_COMP

IRBBB   incomplete right bundle branch block - MDC_ECG_BEAT_RBB_BLK_INCOMP

RVCD   right ventricular conduction delay

IVCD   non-specific intraventricular conduction disturbance -

	MDC_ECG_BEAT_BLK_IVCD
IVCD >	intraventricular conduction disturbance (QRS > 120 ms)
IVCD <	minor intraventricular conduction disturbance (QRS < 120 ms)
WPW	Wolf-Parkinson-White syndrome - MDC_ECG_RHY_WPW_UNK
WPWA	Wolf-Parkinson type A - MDC_ECG_RHY_WPW_A
WPWB	Wolf-Parkinson type B - MDC_ECG_RHY_WPW_B
PREEX	pre-excitation - MDC_ECG_RHY_PREX
DELTAW	Delta Wave
LAFB	left anterior fascicular block - MDC_ECG_BEAT_BLK_ANT_L_HEMI
LPFB	left posterior fascicular block - MDC_ECG_BEAT_BLK_POS_L_HEMI
BIFAS	bifascicular block (its two components shall always be listed separately) - MDC_ECG_BEAT_BLK_BIFAS
TRFAS	trifascicular block - MDC_ECG_BEAT_BLK_TRFAS
BILAT	bilateral bundle-branch block beat - MDC_ECG_BEAT_BLK_BILAT
PMIB	possible peri-infarction block
PISB	peri-ischaemic block
ACSB	aberrant conduction of supraventricular beat(s)
IACD	intra-atrial conduction delay
RAA	right atrial conduction abnormality
LAA	left atrial conduction abnormality
EPSI	epsilon wave

B.4.2.5 Other QRS morphology or general descriptive statements

COPD	suggests chronic obstructive pulmonary disease
PD	consider pulmonary disease
PE	suggests pulmonary emphysema
QWAVE	Q waves present
POORR	poor R-wave progression in precordial leads
ABRPR	abnormal R-wave progression
ERWT	early R wave transition
LRWT	late R wave transition
NRW	notched R wave
PROMR	prominent R waves in right precordial leads
DXTRO	consider dextrocardia
DEXP	consider dextroposition
LOWV	low voltage
LVOLT	low QRS voltages in the frontal and horizontal leads

HVOLT	high QRS voltage
LVOLF	low voltage in frontal leads
LVOLH	low QRS voltages in the horizontal leads
HVOLF	high QRS voltages in the frontal leads
HVOLH	high QRS voltage in the horizontal leads
S1S23	S1 S2 S3 type QRS pattern
RSR1	rSr' type in V1 or V2
TRNZL	transition zone in precordial leads displaced to the left
TRNZR	transition zone in precordial leads displaced to the right
MYOPA	suggests hypertrophic cardiomyopathy
MYOCA	compatible with myocarditis
CRIMA	criteria for
CRIMO	moderate criteria for
CRIMI	minimal criteria for
HIPL	consider high precordial lead placement

B.4.2.6 Rhythm Statements

Statements related to impulse formation (abnormalities)

SR	sinus rhythm - MDC_ECG_RHY_SINUS_RHY
NSR	normal sinus rhythm - MDC_ECG_RHY_SINUS_NORMAL_RHY
SARRH	sinus arrhythmia - MDC_ECG_RHY_SINUS_ARRHY
RSAR	respiratory sinus arrhythmia - MDC_ECG_RHY_RESP_ARRHY
NRSAR	nonrespiratory sinus arrhythmia - MDC_ECG_RHY_NON_RESP_ARRHY
MSAR	marked sinus arrhythmia
SSWAVB	sinus slowing with AV block
SVARR	supraventricular arrhythmia
STACH	sinus tachycardia - MDC_ECG_RHY_SINUS_TACHY
ETACH	extreme tachycardia
SBRAD	sinus bradycardia - MDC_ECG_RHY_SINUS_BRADY
MSBRAD	marked sinus bradycardia
EBRAD	extreme bradycardia
JTACH	junctional tachycardia - MDC_ECG_RHY_JUNC_TACHY
SVTAC	supraventricular tachycardia - MDC_ECG_RHY_SV_TACHY
SSVT	sustained supraventricular tachycardia
NSSVT	nonsustained supraventricular tachycardia
SVTACR	supraventricular run

JBRAD	junctional bradycardia
SVBRA	supraventricular bradycardia
WQTAC	wide QRS tachycardia
NQTAC	narrow QRS tachycardia
TACHO	tachycardia, origin unknown or not specified
BNS	bradycardia, nonsinus
BRADO	bradycardia, origin unknown or not specified - MDC_ECG_RHY_BRADY
VBRADY	slow ventricular rate, beats likely of ventricular origin, but existence of P-waves is unknown - MDC_ECG_RHY_V_BRADY
ARRHY	arrhythmia, origin unknown
IRREG	irregular rhythm - MDC_ECG_RHY_IRREG
REGRH	regular rhythm
LHRV	low heart rate variability - MDC_ECG_RHY_LHRV
JESCR	junctional escape rhythm - MDC_ECG_RHY_JUNC_ESC_BEATS
VESCR	ventricular escape rhythm
ACAR	accelerated atrial rhythm
ACVR	accelerated ventricular rhythm
ACJR	accelerated junctional rhythm - MDC_ECG_RHY_JUNC_ACCEL
AVJR	AV-junctional rhythm
ARHYT	atrial rhythm
SVRHY	supraventricular rhythm - MDC_ECG_RHY_SV_ECT_RHY
JRHYT	junctional rhythm - MDC_ECG_RHY_JUNC_RHY
VRHYT	ventricular rhythm - MDC_ECG_RHY_V_RHY
UNRHY	undetermined rhythm
EAR	ectopic atrial rhythm - MDC_ECG_RHY_ATR_ECT_RHY
LAR	left atrial rhythm
MAR	multifocal atrial rhythm
NODRH	nodal rhythm
RAR	low right atrial rhythm
LGL	Lown-Ganong-Levine syndrome - MDC_ECG_RHY_LGL
SHTPR	Short PR-interval
LPR	Prolonged PR interval
AFIB	atrial fibrillation - MDC_ECG_RHY_ATR_FIB
PAF	paroxysmal atrial fibrillation
PERAF	persistent atrial fibrillation
AFLT	atrial flutter - MDC_ECG_RHY_ATR_FLUT

ATACH   atrial tachycardia - MDC_ECG_RHY_ATR_TACHY

AUTOAT   Automatic atrial tachycardia (with warmup) - MDC_ECG_RHY_ATR_TACHY_AUTO

ATWAVB   atrial tachycardia with AV block

PSVT   paroxysmal supraventricular tachycardia - MDC_ECG_RHY_SV_TACHY_PAROX

PAT   paroxysmal atrial tachycardia - MDC_ECG_RHY_ATR_TACHY_PAROX

NSAT   non-sustained atrial tachycardia

MFAT   multifocal atrial tachycardia - MDC_ECG_RHY_ATR_TACHY_MF

RATAC   run of atrial tachycardia

RJTAC   run of junctional tachycardia

AVNRT   atrioventricular nodal re-entrant tachycardia - MDC_ECG_RHY_AV_TACHY_REENTRANT

AVRT   atrioventricular reciprocating tachycardia - MDC_ECG_RHY_AV_TACHY_RECIP

IDIOR   idioventricular rhythm - MDC_ECG_RHY_V_IDIO_RHY

VFIB   ventricular fibrillation - MDC_ECG_RHY_V_FIB

VTACH   ventricular tachycardia - MDC_ECG_RHY_V_TACHY

RVTAC   run of ventricular tachycardia

SVT   sustained ventricular tachycardia - MDC_ECG_RHY_V_TACHY_MONO

NSVT   non-sustained ventricular tachycardia - MDC_ECG_RHY_V_TACHY_PAROX

TORSA   torsade de pointes ventricular tachycardia - MDC_ECG_RHY_V_TACHY_TDP

MTACH   multifocal tachycardia (multiform), supraventr. or ventricular -
             MDC_ECG_RHY_V_TACHY_POLY

VFLT   ventricular flutter - MDC_ECG_RHY_V_FLUT

ASYST   asystole - MDC_ECG_RHY_ASYSTOLE

USR   uncertain supraventricular rhythm

UNSVT   undetermined supraventricular rhythm

FAST   fascicular tachycardia

FASR   fascicular rhythm

AIVR   accelerated idioventricular rhythm - MDC_ECG_RHY_V_AIVR

SLOVTACH   slow ventricular tachycardia (idioventricular tachycardia) -
             MDC_ECG_RHY_V_IDIO_TACHY

MOVT   ventricular tachycardia, monomorphic

PVT   paroxysmal ventricular tachycardia

EVT   ectopic ventricular rhythm

IPVC   premature ventricular interpolated complex(es)

MPVC   multifocal premature ventricular complexes

UPVC   unifocal premature ventricular complexes

Sinus node dysfunction, atrial and AV-conduction defects

1AVB   first degree AV block - MDC_ECG_RHY_AV_HEART_BLK_DEG_1

2AVB   second degree AV block - MDC_ECG_RHY_AV_HEART_BLK_DEG_2

3AVB   third degree AV block - MDC_ECG_RHY_AV_HEART_BLK_DEG_3

AGAVB   advanced/high grade AV block

PAVB   paroxysmal AV block

I2AVB   intermittent second degree AV block

A2AVB   alternating second degree AV block

AVDIS   AV-dissociation - MDC_ECG_RHY_AV_DISSOC

AVDISINT   AV dissociation with interference - MDC_ECG_RHY_AV_DISSOC_INT

AVDISISO   isorhythmic AV dissociation - MDC_ECG_RHY_AV_DISSOC_ISO

AVDISCMP   complete AV dissociation - MDC_ECG_RHY_AV_DISSOC_COMP

AVBA   AV block, advanced (high-grade)

WENCK   Wenckebach phenomenon - MDC_ECG_RHY_AV_HEART_BLK_DEG_2_I

MOBI2   Mobitz type 2 second-degree AV block - MDC_ECG_RHY_AV_HEART_BLK_DEG_2_II

SABLK   sino-atrial block

1SAB   first-degree SA block - MDC_ECG_RHY_SA_HEART_BLK_DEG_1

2SABI   second-degree SA block type I (Wenckebach) - MDC_ECG_RHY_SA_HEART_BLK_DEG_2_I

2SABII   second-degree SA block type II - MDC_ECG_RHY_SA_HEART_BLK_DEG_2_II

3SAB   third-degree SA block (complete SA block) - MDC_ECG_RHY_SA_HEART_BLK_DEG_3

SAB21   2:1 sinoatrial block

SAR   sinus arrest

SARA   sinus arrest with atrial escape

SARSV   sinus arrest with supraventricular escape

SARJ   sinus arrest with junctional escape

SARV   sinus arrest with ventricular escape

SPAUS   sinus pause

MISSB   pause or missing beat (due to any reason) - MDC_ECG_RHY_MISSB

WANDP   wandering pacemaker - MDC_ECG_RHY_WANDPAV_ARRHY

WANDSP   wandering sinus pacemaker - MDC_ECG_RHY_WANDP_ARRHY

LRR   long R-R interval measured

OCAP   occasional capture

Statements related to ectopic rhythm abnormalities

PRC(S)   premature complex(es)

PAC or APC (APB)   atrial premature complex (beat) - MDC_ECG_BEAT_ATR_P_C (use of APB is not recommended)

BPAC	blocked premature atrial contraction
MAPCS	multiple atrial premature complexes
MFAPCS	multifocal premature atrial complexes
UFMAPCS	unifocal premature atrial complexes
PVC or VPC (VPB)	ventricular premature complex (beat) - MDC_ECG_BEAT_V_P_C (use of VPB is not recommended)
RONT	R-on-T premature ventricular beat - MDC_ECG_BEAT_V_P_C_RonT
MVPCS	multiple premature ventricular complexes
RVPCS or RPVCS	run of ventricular premature complexes - MDC_ECG_RHY_V_P_C_RUN
RAPCS	run of atrial premature complexes
RJPCS	run of junctional premature complexes
VIC	ventricular interpolated complexes
MVICS	multiple ventricular interpolated complexes
MICS	multiple interpolated complexes
SVPC	supraventricular premature complex - MDC_ECG_BEAT_SV_P_C
SVPCS	(multiple) supraventricular premature complexes
SVIC(S)	supraventricular interpolated complex(es)
ABER(S)	aberrantly conducted complex(es)
ABPCS	aberrant premature complexes, origin unknown
ABSVC	aberrant complex, possibly supraventricular origin
ABSVS	aberrant complexes, possibly supraventricular origin
ABASH	aberrant supraventricular complexes of the Ashman type - MDC_ECG_BEAT_ATR_P_C_ABERR
JPC(S)	junctional premature complex(es) - MDC_ECG_BEAT_JUNC_P_C
MJPCS	multiple junctional premature complexes
PVPCS or PPVCS	paired ventricular premature complexes
PAPCS	paired atrial premature complexes
PJPCS	paired junctional premature complexes
OVPAC	occasional ventricular paced complexes
ONPAC	occasional non-paced complexes
VBIG	ventricular bigeminy - MDC_ECG_RHY_V_BIGEM
ABIG	atrial bigeminy - MDC_ECG_RHY_ATR_BIGEM
SVBIG	supraventricular bigeminy BIGU bigeminal pattern (unknown origin, SV or Ventricular)
FUSC(S)	fusion complex(es) - MDC_ECG_BEAT_V_P_C_FUSION
CAPT(S)	capture complex(es)
VEC(S)	ventricular escape complex(es) - MDC_ECG_BEAT_V_ESC

AEC(S)	atrial escape complex(es) - MDC_ECG_BEAT_ATR_ESC
SVEC(S)	supraventricular escape complex(es) - MDC_ECG_BEAT_SV_ESC
JEC(S)	junctional escape complex(es) - MDC_ECG_BEAT_JUNC_ESC
ESCUN	escape complex, origin unknown
VPARA	ventricular parasystole - MDC_ECG_RHY_V_PARA
APARA	atrial parasystole
VTRIG	ventricular trigeminy - MDC_ECG_RHY_V_TRIGEM
ATRIG	atrial trigeminy
SVTRI	supraventricular trigeminy
TRIGU	trigeminal pattern (unknown origin, SV or Ventricular)
VQUAG	ventricular quadrigeminy
RECIP	reciprocal or re-entrant impulse
APCN	atrial premature complexes, nonconducted
VCPLT	ventricular couplet - MDC_ECG_RHY_V_P_C_CPLT
ACPLT	atrial couplet
NAPC	Nonconducted P-wave (blocked) - MDC_ECG_BEAT_ATR_PWAVE_BLK

Statements related to (predominant) conduction and block

B2T1	(predominant) 2:1 block
B3T1	(predominant) 3:1 block
B4T1	(predominant) 4:1 block
B5T1	(predominant) 5:1 block
VARBL	variable block
EXIBL	exit block
ENTBL	entrance block
VABL	ventriculo-atrial block
BLOCK	unspecified delay or failure of impulse propagation
C2T1	(predominant) 2:1 conduction
C3T1	(predominant) 3:1 conduction
C4T1	(predominant) 4:1 conduction
C5T1	(predominant) 5:1 conduction
VARCO	variable conduction
SVR	slow ventricular response
IVR	irregular ventricular response
RVR	rapid ventricular response
WRV	wide rate variation
AAVCO	accelerated AV conduction

RETCO	retrograde conduction
ANTCO	anterograde conduction
ORTCO	orthograde conduction
ABBCO	aberrant conduction
CONCO	concealed conduction
AVREN	AV nodal re-entry
AVRE	AV re-entry
CONRE	concealed re-entry
RENTR	re-entry phenomenon
AECHO	return of impulse to its chamber of origin: the atrium
VECHO	return of impulse to its chamber of origin: the ventricle
FCOUP	fixed coupling interval
VCOUP	variable coupling interval
AVRATIO	AV conduction ratio N:D

Other rhythm related statements

ARATE	atrial rate
VRATE	ventricular rate
RATE	rate, not specified ventricular or atrial (but mostly ventricular)
RHY(T)	rhythm
LOWHR	low heart rate

B.4.2.7 Pacemaker types and pacemaker function

PACE	normal functioning artificial pacemaker
PACEA	artificial pacemaker rhythm with 100 % capture
PACEP	artificial pacemaker rhythm with partial capture
PACEF	artificial pacemaker rhythm with underlying atrial fib or flutter
PACED	demand pacemaker rhythm
PACEM	malfunctioning artificial pacemaker
EPAVS	electronic pacemaker AV sequential, normal capture
EPVC	electronic pacemaker, ventricular capture - MDC_ECG_RHY_EPVC
EPDM	electronic pacemaker, demand mode
EPFC	electronic pacemaker, failure to capture
EPFS	electronic pacemaker, failure to sense
EPARV	bipolar electronic pacemaker at the apex of the right ventricle
EPU	unipolar electronic pacemaker
EPURV	unipolar electronic pacemaker at the apex of the right ventricle

PAA   electronic atrial pacing

PAD   dual chamber electronic pacing

PAVA   electronic ventricular pacing with atrial sensing

PADEM   demand pacing, analysis based upon intrinsic complexes

OVPAC   occasional ventricular paced complexes

ONPAC   occasional non-paced complexes

VPR   ventricular-paced complex(es) or rhythm

VPNON   ventricular pacing of non–right ventricular apical origin

EPAFC   failure to capture, atrial - MDC_ECG_RHY_EPAFC

EPVFC   failure to capture, ventricular - MDC_ECG_RHY_EPVFC

FIA   failure to inhibit, atrial

FIV   failure to inhibit, ventricular

FPA   failure to pace, atrial

FPV   failure to pace, ventricular

EPADM   atrial demand mode pacing - MDC_ECG_RHY_EPADM

EPAC   atrial capture - MDC_ECG_RHY_EPAC

EPAFS   atrial failure to sense - MDC_ECG_RHY_EPAFS

EPVDM   ventricular demand mode - MDC_ECG_RHY_EPVDM

EPVFS   ventricular failure to sense - MDC_ECG_RHY_EPVFS

EPAVT   antitachycardia pacing - MDC_ECG_RHY_EPAVT

EPAX   atrial spike expected, but missing - MDC_ECG_RHY_EPAX

EPAXLO   inadequate atrial spike, not capturable (loss of output) - MDC_ECG_RHY_EPAXLO

EPAXFO   atrial spike expected, but missing (failure to output) - MDC_ECG_RHY_EPAXFO

EPVX   ventricular spike expected, but missing - MDC_ECG_RHY_EPVX

EPVXLO   inadequate ventricular spike, not capturable (loss of output) - MDC_ECG_RHY_EPVXLO

EPVXFO   ventricular spike expected, but missing (failure to output) - MDC_ECG_RHY_EPVXFO

International classification of pacemaker types

The following six NASPE compliant acronyms (see Table A.4) are proposed for coding the pacemaker type:

PAVVI   VVI pacemaker

PAAAI   AAI pacemaker

PAVAT   VAT pacemaker

PAVDD   VDD pacemaker

PADVI   DVI pacemaker

PADDD   DDD pacemaker

where the three last characters "xyz" of acronym "PAxyz" respectively code:

— "x" : the chamber paced: V = ventricle; A = atrium; D = dual (A + V)

— "y" : the chamber sensed: V = ventricle; A = atrium; D = dual (A + V); O = no sensing

— "z" : the response of the pacemaker to a sensed beat: T = triggered; I = inhibited; D = dual (atrial triggered + ventricular inhibited or atrial triggered/inhibited + ventricular inhibited)

B.4.2.8 Descriptive axis statements

LAD	left axis deviation of QRS in frontal plane (<-30)
RAD	right axis deviation of QRS in frontal plane (>+90)
AXL	leftward axis (i.e. not severe enough to be called LAD)
AXR	rightward axis (i.e. not severe enough to be called RAD)
AXNW	northwest axis
AXIND	QRS axis indeterminate
AXSUP	axis shifted superiorly
AXPOS	axis shifted posteriorly
AXVER	axis vertical in frontal plane
AXHOR	horizontal axis in frontal plane
TRSLT	transition in horizontal leads shifted leftward
TRSRT	transition in horizontal leads shifted rightward
CCWRT	counter clockwise rotation
CWRT	clockwise rotation

B.4.2.9 ST-T descriptive statements

The following basic roots are proposed:

ISC_	ischaemic ST-T changes
INJ_	subendocardial injury
EPI_	epicardial injury
STT_	ST-T change
NST_	non-specific ST changes - MDC_ECG_RHY_STHILOST
STE_	non-specific ST elevation - MDC_ECG_RHY_STELVATION
STD_	non-specific ST depression
RST_	reciprocal ST-T changes
TAB_	T-wave abnormality
NT_	non-specific T-wave changes

Two solutions can be used to define the location of the ST-T changes - either by using a location modifier - or by extending the root with 2 more characters to define the region, as follows:

Ischaemic ST-T changes

ISCAN   - in anterior leads

ISCAL   - in anterolateral leads

ISCIN   - in inferior leads

ISCAS   - in anteroseptal leads

ISCLA   - in lateral leads

ISCPO   - in posterior region

ISCIP   - in inferoposterior region

ISCIL   - in inferolateral leads

ISCAF   - in antero-inferior leads

ISCWI   widespread ischaemic ST-T changes

ISCDI   diffuse ischaemic ST-T changes

Ischaemic ST-T changes compatible with subendocardial injury

INJAN   - in anterior leads

INJAL   - in anterolateral leads

INJIN   - in inferior leads

INJAS   - in anteroseptal leads

INJLA   - in lateral leads

INJPO   - in posterior region

INJIP   - in inferoposterior region

INJIL   - in inferolateral leads

INJAF   - in antero-inferior leads

INJWI   widespread subendocardial injury

INJDI   diffuse subendocardial injury

ST-T changes compatible with subepicardial injury

EPIAN   - in anterior leads

EPIAL   - in anterolateral leads

IPIIN   - in inferior leads

EPIAS   - in anteroseptal leads

EPILA   - in lateral leads

EPIPO   - in posterior region

EPIIP   - in inferoposterior region

EPIIL   - in inferolateral leads

EPIAF   - in antero-inferior leads

EPIWI   widespread subepicardial injury

EPIDI   diffuse subepicardial injury

Non-specific ST-T changes   Alternative

NSTAN   - in anterior leads   STNAN

NSTAL   - in anterolateral leads   STNAL

NSTIN   - in inferior leads   STNIN

NSTAS   - in anteroseptal leads   STNAS

NSTLA   - in lateral leads   STNLA

NSTPO   - in posterior region   STNPO

NSTIL   - in inferolateral leads   STNIL

NSTAF   - in antero-inferior leads   STNAF

NSTWI   widespread non-specific ST-T changes   STNWI

NSTDI   diffuse non-specific ST-T changes   STNDI

Non-specific ST elevation

STExx   and replace xx by the corresponding lead or location, e.g. AN

Non-specific ST depression

STDxx   and replace xx by the corresponding lead or location, e.g. AL

ST descriptive statements related to Stress ECG

STDHO   ST depression - horizontal

STDUP   ST depression - upsloping

STDDO   ST depression -downsloping

Other ST-T descriptive statements

REPA   repolarization abnormality

NSTT   non-specific ST-T changes

NDT   non-diagnostic T abnormalities

TNOR   normal T-wave variations

STNOR   normal ST-T variant

JUV   juvenile T waves

STDJ   junctional ST depression

HTVOL   high T-voltages

HIGHT   high amplitude T-waves

LOWT   low amplitude T-waves

INVT   inverted T-waves

NTW   notched t waves

PTW   T wave peaked

BTW   T waves biphasic

FTW   T waves flat

JPE	J point elevation
LNGQT	long QT-interval
PQTC	QTc prolongation
PQTCB	QTcB prolongation
PQTCF	QTcF prolongation
BQTCB	borderline QTcB
BQTCF	borderline QTcF
SHTQT	short QT-interval
SHTQTCB	short QTcB
SHTQTCF	short QTcF
PST	prolonged ST segment
SHTST	short ST segment

Secondary statements

QUIN	ST-T changes due to quinidine-effect
PERIC	ST-T changes compatible with pericarditis
STVAG	ST-elevation V1-V3 possibly due to enhanced vagal tone
REPOL	ST-T changes compatible with early repolarization
ANEUR	ST-T changes compatible with ventricular aneurysm
CNS	T-wave abnormality compatible with CNS disease
DIG	suggests digitalis-effect
DIGTOX	suggests digitalis toxicity
PEFF	suggests pericardial effusion
HPOCA	consider hypocalcemia
HPOK	consider hypokalemia
HPRCA	consider hypercalcemia
HPRK	consider hyperkalemia
LOTEMP	consider hypothermia
GRA	consider genetic repolarization abnormality
POSTO	post-operative ST-T changes
PULM	compatible with pulmonary embolism
ACET	related to pacemaker activity
NDOC	compatible with endocrine disease
METAB	possibly due to metabolic changes
IBP	compatible with hypertension
SSTT	secondary ST-T abnormality
CONG	secondary to congenital heart disease

VALV	secondary to valvular heart disease
RESP	secondary to respiratory disease
COTHY	consider hypothyroidism
CLIN	interpret with clinical data
MYOIN	suggests myocardial infarction (no location specified)
ISDIG	compatible with ischemia / digitalis effect
STPAC	review ST-T analysis for the effects of pacing
STPVC	post-extrasystolic T-wave changes
STTLVH	ST-T change due to ventricular hypertrophy

Other repolarization phase related statements

EALT	electrical alternans
TWA	T-wave alternans - MDC_ECG_RHY_TALT
OSB	Osborn wave
BRU	Brugada abnormality
AISCH	acute ischemia
ENDIS	CV end points ischaemic ECG changes

B.4.2.10 U wave descriptive statements

PU	prominent U waves
IU	inverted U waves
TUF	TU fusion
UWA	U wave abnormality

B.4.2.11 Atrial statements

LAO/LAE	left atrial overload/enlargement
RAO/RAE	right atrial overload/enlargement
BAO/BAE	bi-atrial overload/enlargement
HPVOL	high P-voltages
NSPEP	non-specific P wave abnormalities
ABPAX	abnormal P-axis
UNPAX	unusual P-axis
PWA	P wave abnormality
NPW	notched P wave
PRD	PR segment depression
SND	suggests sinoatrial disorder

B.4.2.12 Statements related to paediatric ECG analysis

PED	paediatric interpretation
RVD	right ventricular dominance
ASD	changes compatible with atrial septal defect (ostium secundum)
ECD	compatible endocardial cushion defect (ASD ostium primum)
EBSTA	compatible with Ebstein's anomaly
TCA	compatible with tricuspid atresia
ACA	compatible with anomalous location of the coronary artery

B.4.2.13 Statements related to stress ECG analysis

WPOS	weakly positive
POS	positive
SPOS	strongly positive
SPOSST	strongly positive - ST elevation

B.4.2.14 Statements related to serial ECG analysis

COMPI	New or worsened ischemia or infarction
COMPR	Significant change in rhythm
COMPQ	Significant repolarization change
COMPS	Change in clinical status
COMPD	Change in interpretation without significant change in waveform

B.4.2.15 Statements related to the ECG calibration

HSCAL	all leads half standard calibration (i.e. 5 mm/mV)
HSPRE	precordial leads half standard calibration
HSLIM	limb leads half standard calibration
DSCAL	all leads double standard calibration (i.e. 20 mm/mV)
DSPRE	precordial leads double standard calibration
DSLIM	limb leads double standard calibration
NSCAL	non-standard calibration

B.4.2.16 Technical conditions and problems

ARMRE	suspect arm leads reversed
LMISP	lead misplacement
MLEAD	missing lead(s)
RPEL	right-sided precordial electrode(s)
PEL	posterior electrode(s)

FAULT   faulty lead

QCERR   poor data quality, interpretation may be adversely affected

AHERR   acquisition/hardware error

MEASE   possibly measurement error

NOISE   noisy recording

WANDR   baseline wander

ARTEF   artefacts

SIMUL   input is from simulator or test pattern

CALS   calibration signal (sustained) - MDC_ECG_RHY_CALS

PINFO   inconsistent or erroneous patient demographic data

INCAN   incomplete or no analysis (by the program)

NODAT   missing or no data

B.4.3 Examples

B.4.3.1   The statements "Probable old anterior infarction and atrial fibrillation" shall be coded as follows: AMI_OL_PR; AFIB. The statement AFIB has no direct relation to AMI, therefore the AND conjunction is not used. There are in fact 2 independent statements, one on QRS contour and one on cardiac rhythm.

B.4.3.2   The statement "Probable left ventricular hypertrophy with ST-T changes compatible with left ventricular strain" is coded as follows: LVH_PR_AND_STT_LV. The underscore signs before and after the AND indicates that the conjunction is made within a single statement.

B.4.3.3   If the same statement had been made on 2 separate lines, and one wants to link them logically, i.e.:

– Probable left ventricular hypertrophy

– ST-T changes compatible with left ventricular hypertrophy

then coding is done as follows: LVH_PR;AND;STT_LV

B.5 Overreading of measurement results

B.5.1 Waveform and interval designations

P   P-wave

P+   P-wave, positive component

P-   P-wave, negative component

PA   the atrial repolarization wave

Q   Q-wave, i.e. the first negative deflection of QRS

R   R-wave, i.e. the first positive deflection of QRS

S   S-wave, i.e. first negative deflection after first positive deflection in QRS

R2   second R-wave, i.e. the first positive deflection in QRS after the S-wave

S2	second S-wave
R3	third R-wave in QRS
S3	third S-wave in QRS
J	the J-point
ST	the ST-interval
ST20	the amplitude of ST 20 ms after the J-point
ST60	the amplitude of ST 60 ms after the J-point
ST80	the amplitude of ST 80 ms after the J-point
STO	the amplitude of ST at the onset of ST, i.e. the J-point
STM	the amplitude of ST at the middle of ST
STE	the amplitude of ST at the end of ST, i.e. the beginning of the T-wave
T	the T-wave
T+	the (maximal) positive component of the T-wave
T-	the (maximal) negative component of the T-wave
U	the U-wave
QRS	the QRS complex
QR	QR type of QRS complex
QS	QS type of QRS complex
RS	RS type of QRS complex
RSR	RSR2 type of QRS complex
PR	the PR-interval
PP	the P-P interval
RR	the R-R interval
QT	the QT-interval
JT	the interval between the J-point and the end of the T-wave
TP	the interval between the end of the T-wave and the succeeding P-wave
ARP	absolute refractory period
ERP	effective refractory period
RRP	relative refractory period
FRP	functional refractory period

B.5.2 Lead denominators

a) For the abbreviations of the leads, see Section 3, Table 4 – "Lead Identification codes" and 5.6.4 Note.

b) The following conventional lead-labels shall most often be used:

D1   aVR   V1   V4   X

| D2 | aVL | V2 | V5 | Y |
| D3 | aVF | V3 | V6 | Z |

c) Further abbreviations:

LEAD	lead
INN	indication of location, for example in lead D3: translated as INN_D3
AXIS	axis
ELEC	electrode(s)

NOTE   INN used instead of IN which has been reserved for "Inferior".

B.5.3 Units of measurement

DUR	duration
MSEC	milliseconds
SEC	second(s)
AMP	amplitude
MVOLT	millivolt
MUVLT	microvolt
DEGR	degrees
RATIO	ratio of e.g. Q/R amplitude
UNIT	unsigned units

B.5.4 Examples

Most of the time rather simple single or composite ECG interpretive statements, such as listed in B.4.3 will be generated, but more complex statements can also be created such as listed in the examples shown below. It should be noted that these abbreviations and conventions for creating statements are to be used for communication between heterogeneous systems and that each system manufacturer can continue to use its own abbreviations for internal use.

P_AMP_INN_LEAD_V1_EQU_120_MUVOLT
The P-amplitude in lead V1 equals 120 microvolts

Q_DUR_INN_LEAD_D3_EQU_40_MSEC
The Q-wave in lead D3 equals 40 ms

RATIO_Q_AMP_DIV_R_AMP_INN_D2_IGT_0.5
The Q/R ratio in lead D2 is greater than 0,5

(S_AMP_INN_V1_ADD_R_AMP_INN_V5)_IGT_3.5_MVOLT
The sum of the S amplitude in V1 and the R amplitude in V5 is greater than 3,5 millivolt (i.e. the Sokolov index is positive)

(MAX_R_AMP_ADD_MAX_S_AMP)_INN_V_LEADS_IGT_4.5_MVOLT
The sum of the maximal R amplitude and the maximal S amplitude in the V-leads is greater than 4,5 millivolt

Annex C
(informative)

Definition of compliance with the SCP ECG standard

C.1 General

The SCP-ECG standard specifies means by which ECG devices and systems may exchange information. The ways in which ECG data may be encoded are well defined, but are also flexible. In implementing this document, a manufacturer may choose to implement only a subset of all possible ways of encoding the ECG data. Therefore, C.3 defines a testing procedure that shall be followed by manufacturers who state SCP-ECG compliance. Because of the flexibility allowed in information content and encoding, the user/purchaser shall determine the suitability of a device and/or software or system for a particular application.

Manufacturers who state SCP-ECG compliance for their devices and/or systems or software shall follow the specifications and definitions of this annex. Data format includes those items specified in Clause 5 and in the referenced annexes of this document. Compliance for communication support and query messages1) are not part of this document. However, if different communication supports are used (i.e. Bluetooth, wireless, LAN, etc.), the query messaging and the data transport should be clearly described and made freely available to the cart/system potential user/purchaser upon request.

At this time, there is no general purpose tool/method to allow testing compliance with the specifications of this document. At best such a tool would be useful to manufacturers in their efforts to ensure compatibility of their devices and systems. Because of the flexibility allowed in information content and encoding, compatibility between devices and systems made by different manufacturers shall be determined in each case, even if both devices and systems could be shown to be compliant with the SCP-ECG standard. A statement of compliance with the standard alone would be of little use to a user/purchaser. Therefore, a statement of compliance with the SCP-ECG standard shall be made with an accompanying statement of compatibility with a device or devices and/or systems/software of another manufacturer or manufacturers, uniquely identified by manufacturer trade name, model description and SCP implementation software identifier.

NOTE   SCP-ECG version V2.x included two informative Annexes respectively specifying a minimum set of control and query messages for the interchange of ECG data and a standard enhanced XMODEM based low-level ECG-Cart to host protocol. These two annexes are no longer part of this document.

C.2 Compliance specification

C.2.1 Data Format Categories

In former SCP-ECG versions, compliance was tested for so-called "categories" that represent a set of sections. In SCP-ECG V3, conformance testing is more fine-grained and based on individual SCP-ECG sections.

All devices stating SCP-ECG compliance for standard 12-lead ECG shall import at minimum data sections 0, 1, 3, 6, 7, and 8. Manufacturer specific data shall be optionally included only in manufacturer specific fields, bytes and data blocks that have been defined in the document. Reserved, unspecified and undefined fields, bytes or data blocks shall not be used for manufacturer specific data.

C.2.2 Data Exchange Functions

C.2.2.1   Export

The ability to make available to a communications channel an SCP-ECG version V3.x record with a specified list of sections. The SCP-ECG record is created from raw ECG data as per SCP-ECG specification, optionally with lossless, Huffman encoded redundancy reduction in case of wearable devices.

C.2.2.2   Import

The ability to accept from a communications channel, extract and make available to the user information from a SCP-ECG version V3.x record with a specified list of sections. A device or system importing standard 12-lead ECG shall minimally import data sections 0, 1, 3, 6, 7, and 8 (e.g. data from a standard 10-s, 12-lead ECG usually coded as I, II, V1, V2, V3, V4, V5, V6) and make available to the user the extracted information. If differences calculation and Huffman encoding are used, the reconstruction errors (RMS and absolute errors) (except the quantization error) have to be 0 (see C.3.2 and C.5).

NOTE   Import of legacy SCP-ECG version V1.x and V2.x records is out of the scope of this document.

C.2.2.3   Transfer

The ability to export of a previously imported SCP-ECG version V3.x record, at the same SCP-ECG version V3.x data format, with or without modification to the individual sections. ECG records stored in formats other than SCP-ECG version V3.x can be converted into a SCP-ECG version V3.0 compliant format. Waveform data imported in a SCP-ECG format shall not be subjected to losses during the decompression processes (if any), nor during the compression processes (viz differences calculation and Huffman encoding, if any) for transfer.

The purpose of the transfer definition is to preserve components in the record (for example, a manufacturer specific section) that the importing device/system is unable to process. The requirement that ECG waveform data shall not be subjected to further losses during transfer implies that either the original compressed data be sent, or that further compression be without loss. Editing by the user of demographic data, measurements and interpretations, or user chosen data reduction/losses (viz compressing the entire SCP-ECG record or removing some non-mandatory sections), are beyond the scope of this document.

NOTE 1   Import of legacy SCP-ECG version V1.x and V2.x records is out of the scope of this document. See C.2.2.2

NOTE 2   Starting with SCP-ECG version V3.0, data compression is limited to optional lossless data reduction (e.g. differences calculation and/or Huffman encoding) of the signal waveforms stored in section 5 and/or in section 6.

C.2.2.4   Communication Channel

Any mechanism capable of making the SCP-ECG record available externally (e.g. file transfer via LAN, wireless links, Internet, USB key, etc.).

NOTE   An example of legacy communication channel using RS-232 and ad hoc query messaging is described in Annex D and Annex E of the previous versions of SCP-ECG, viz ISO 11073-91064:2009 and EN 1064:2005.

C.2.3 SCP-ECG Messaging/transport protocol

The manufacturer shall disclose the mechanism(s) by which SCP-ECG data formatted files may be accessed.

In case a given device or system can only be accessed via a specific communication link (RS-232, Bluetooth, wireless, Lan, USB key, etc.), then the manufacturer shall state that the communication protocol information for the query messaging and data transport, if any, are available upon request.

C.2.4 Specification for Statement of Compliance

A statement of SCP-ECG compliance shall have the following form and contents:

The specified device/system/software is compliant with SCP-ECG Standard Version 3.x as follows:

Device:
Manufacturer's trade name.

Model description.

SCP-ECG implementation software identifier.

Export:
List of exported data sections, or "Not supported."

Data sections with content description.

List of manufacturers (and devices) specifying categories and optional sections with which export compatibility has been verified by testing for each device, or the following statement: "A list of manufacturers (and devices or systems or software) specifying sections with which SCP-ECG export compatibility has been verified by testing for each device (or system/software) is available on request".

Import:
List of imported data sections, or "Not supported".

Data sections with content description.

List of manufacturers (and devices) specifying sections with which import compatibility has been verified by testing for each device, or the following statement: "A list of manufacturers (and devices or systems or software) specifying sections with which SCP-ECG import compatibility has been verified by testing for each device (or system/software) is available on request".

Transfer:
"Supported" or "Not Supported".

Communication Channel:

The Communication Support for export, or transmit and/or receive shall be described, or the following sentence should be added: "The communication protocol information for the query messaging and data transport is available upon request" or "The mechanism(s) by which SCP-ECG data formatted files may be accessed is (are) available upon request".

C.2.5 Hypothetical Examples:

C.2.5.1 Cardiograph

SCP-ECG Standard Version 3.x Statement of Compliance

Device:
MyECG Company

Model Top1

SCP-ECG implementation MyECG SCP-ECG version 3.0

Export:
Data Sections 0, 1, 2, 3, 5, 6, 7, 8, 10, containing demographics, short-term ECG rhythm data, type 0 reference beat, global ECG measurements, per-lead ECG

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measurements and interpretation.

Export compatibility of sections … has been verified by testing with:

- Xzq Manufacturing, Inc. Models LB1577, LB1755 and ZM922 (SCP-ECG version 3.0, software implementation version 6.1)

- BestECG, LTD. Model PQRST2 (SCP-ECG version 3.0, software implementation version 3.0)

Import:	Data Sections 0, 1, 2, 3, 6, 7, 8, 10, containing demographics, short-term ECG rhythm data, global ECG measurements, per-lead ECG measurements and interpretation.
	A list of Manufacturers (and devices) specifying sections with which SCP-ECG import compatibility has been verified by testing for each device is available on request.

C.2.5.2 Management System

SCP-ECG Standard Version 3.x Statement of Compliance

Device:	MyECG Company.
	Model Top2.
	SCP-ECG implementation version MyECG SCP-ECG version 3.0.
Export:	Not Supported.
Import:	Data Sections 0, 1, 2, 3, 5, 6, 7, 8, 10, containing demographics, short-term ECG rhythm data, type 0 reference beat, global ECG measurements, per-lead ECG measurements and interpretation.
	A list of Manufacturers (and systems/devices) specifying sections with which SCP-ECG import compatibility has been verified by testing for each system/device is available on request.

C.2.5.3 Defibrillator 12-lead ECG

SCP-ECG Standard Version 3.x Statement of Compliance

Device:	MyECG Company.
	Model Top3.
	SCP-ECG implementation version MyECG SCP-ECG version 3.0.
Export:	Data Sections 0, 1, 2, 3, 6 containing demographics and short-term ECG rhythm data.
	Export compatibility has been verified by testing with:

- Xzq Manufacturing, Inc. Models LB1577, LB1755 and ZM922 (SCP-ECG version 3.0, software implementation version 6.1).

- BestECG, LTD. Model PQRST2 (SCP-ECG version 3.0, software implementation version 3.0).

C.3 Testing/validation of SCP-ECG data format compatibility

C.3.1 Overview

Testing/validation of SCP-ECG data format compliance/compatibility may be done by individual manufacturers. The requirements for testing/validation are shown in Figure C.1 and are detailed in C.3.2. In brief, each manufacturer that states export compliance makes publicly and freely available example SCP-ECG formatted records for each device/system/software generating an SCP-ECG record and for each data format level claimed, and additional supporting data files to allow an Importing manufacturer to validate accurate decoding of the SCP-ECG records. By reading Manufacturer A's files, Manufacturer B can validate that A's files could be imported. If in a SCP-ECG compliance statement, Manufacturer B states validation of import compatibility with A, then Manufacturer A is notified in writing by Manufacturer B. Manufacturer A may then state export validation with B. Manufacturers therefore "cooperatively self-validate" compatibility with each other.

Import validation may be diagrammed as displayed in Figure C.1.
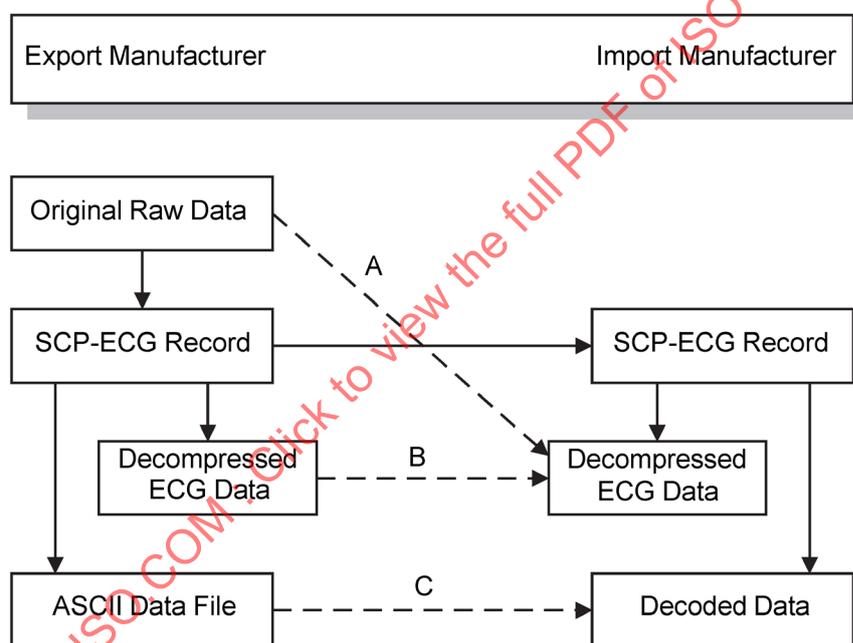
Figure C.1 — Import validation diagram

C.3.2 Requirements

An Export Manufacturer shall make five file types publicly and freely available for each test case provided, for each exporting device (or system/software) type, and for each compliance level:

1) An SCP-ECG formatted binary file (***.ECG).

2) An original ECG raw data file from which the SCP-ECG file was compiled, and in the binary format defined in C.3.3 (***.EC0).

3) A decompressed ECG data file from the SCP-ECG file using the Export Manufacturer's decompression process, and in the binary format defined in C.3.3. (***.EC1).

4) A text file as defined in C.3.3 specifying the data in the original and the decompressed ECG binary files (***.EC2).

5) An ASCII data file (for non-waveform data) containing all demographic, measurement and interpretation data (***.EC3).

An Export Manufacturer shall provide test cases consisting of the required five file types for at least those cases specified in Annex D.6 and its accompanying Table D.13. The Export Manufacturer may also provide additional test cases in the required file formats. The set of test cases provided by the Export Manufacturer shall include files with data content at the limits implemented by the Export Manufacturer.

For all test cases provided by the Export Manufacturer, the Import Manufacturer shall import the SCP-ECG records, then decode and decompress them (if compression is used). For each test case, the decompressed ECG data shall be compared to the original ECG data (comparison "A" in the diagram). This comparison shall be exact for all ECG signal samples. Comparisons "B" between the Export Manufacturer's decompressed data and the Import Manufacturer's decompressed data are to aid the Import Manufacturer in evaluating differences seen in comparisons "A". Comparison "B" is optional.

For each test case, the Import Manufacturer shall compare the decoded demographic, measurement and interpretation data with the data in the ASCII file provided by the Export Manufacturer (comparison "C" in the diagram). This comparison shall be exact for all data fields decoded by the Import Manufacturer.

A manufacturer may state import compatibility for each of its own devices/systems/software and for each data section that has been validated. If import compliance is stated for another manufacturer's exported files, then the exporting manufacturer shall be notified in writing, and the exporting manufacturer shall be allowed to state export compatibility with the importing manufacturer.

C.3.3 ECG Binary File Format (***.EC0, ***.EC1)

Each test ECG shall be provided with the following information:

1) A text file (***.EC2) containing:

   i) comma delimited descriptors for each lead of ECG data (which may be more leads or less leads than the typical 8 stored for a resting 12-lead ECG),

   ii) the total number of samples for each lead,

   iii) the sample rate (per second) or the sample time interval (microseconds),

   iv) the number of nanovolts per least significant bit.

2) Binary files (***.EC0, ***.EC1) with ECG data stored as 16 bit signed words, stored in Intel little-endian format (low-byte, high-byte). The sequence of the samples (S1, S2 ... Sn) for leads (L1, L2 ... Lm) is:

   S1L1, S1L2 ... S1Lm, S2L1, S2L2 ... SnL1, SnL2 ... SnLm

EXAMPLE   The following example is for 8 ECG leads, all identical to each other, with alternating samples of ± 1,0 mV for each lead. In this case, ± 1 000, hexadecimal values of 03E8 and FC18.

   ***.EC2 - Text file contains the following:

   Leads: I, II, V1, V2, V3, V4, V5, V6

   5 000 samples per lead; 500 samples per second; 1 000 nanovolts per LSB.

***.EC0 or ***.EC1 - Binary file (in Hexadecimal for each byte):

Table C.1 — Example for the first 6 samples for 8 ECG leads

		Leads								
		I	II	V1	V2	V3	V4	V5	V6	
Bytes	00 to 0F	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	Sample 1
	10 to 1F	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	Sample 2
	20 to 2F	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	Sample 3
	30 to 3F	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	Sample 4
	40 to 4F	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	E8 03	Sample 5
	50 to 5F	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	18 FC	Sample 6

C.4 Coding of SCP-ECG compliance

Previous versions of SCP-ECG provided means to encode, in Section 1, the SCP-ECG protocol compatibility level of an acquiring or analysing device (see 5.4.5, Tag 14 "Machine ID Acquiring Device", byte 16 "SCP-ECG Protocol Compatibility Level" and Tag 15 "Machine ID Analyzing Device").

This field is deprecated. It is recommended to set its value to 0xff, as we assume that only valid SCP-ECG v3 data will be generated. The real capabilities and support of features will be identified by parsing the files according to the rules specified in this document.

C.5 Minimum requirements for SCP-ECG versions V1.x and V2.x ECG data compression

This part of Annex C is an excerpt of SCP-ECG Clause 6.5.3 "Minimum requirements for ECG data encoding and compression" included in the previous versions of SCP-ECG, viz ISO 11073-91064:2009 and EN 1064:2005+A1. It has been reproduced in the present document to support decoding of legacy SCP-ECG version 1.x and 2.x files and conversion into SCP-ECG version V3.0 files. The requirements were listed in the previous versions of SCP-ECG to support conformance testing of lossless high redundancy reduction and lossy bimodal compression schemes.

C.5.1 General

In SCP-ECG versions V1.x and V2.x, it is left open to the manufacturers in which way they do the data compression. However, reference beat type 0 and the residual record shall be provided if reference beat subtraction is applied. The reconstruction RMS error and the absolute errors shall be verifiable on the SCP test set. Error measures shall be calculated from the beginning of the first subtraction to the end of the last subtraction. For pure redundancy reduction, the reconstruction errors (RMS and absolute errors) (except the quantization error) have to be 0 with reference to a 500 samples/s and 5 µV/LSB record.

C.5.2 Minimum requirements for ECG data encoding and compression

C.5.2.1 If reference beat subtraction is used for data compression, all leads of an ECG record shall be recorded simultaneously.

C.5.2.2 Digitization: SR ≥ 500 samples/s; LSB ≤ 5 μV

C.5.2.3 Reference Beat: SR ≥ 500 samples/s; LSB ≤ 5 μV

C.5.2.4 Residual Record: Truncation Error ≤ ± 15 μV

C.5.2.5 Residual Record: Sampling Interval ≤ 8 ms
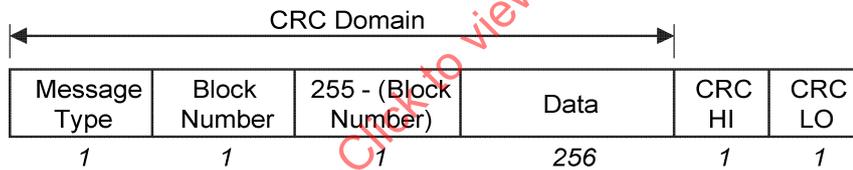
C.5.2.6 Reconstruction Error: RMS ≤ 10 μV

C.5.2.7 Absolute Error: ≤ 100 μV in a single sample outside P-QRS-T

C.5.2.8 Absolute Error within QRS: ≤ 15 μV in a single sample

C.6 CRC error detection algorithm

The CRC is based on CRC-CCITT ($X16 + X12 + X5 + 1$). The CRC is a 16-bit quantity and should be preset to all 1's (FFFF hex) at the start of the calculation for each block of data. The CRC is calculated over the entire data block up to the CRC itself:

		CRC Domain			
Message Type	Block Number	255 - (Block Number)	Data	CRC HI	CRC LO
1	*1*	*1*	*256*	*1*	*1*

Figure C.2 — CRC-CCITT error detection

The algorithm for the CRC-CCITT is below described. Note that all operations are on bytes.

A = new byte

B = temp byte

CRCHI = High byte (most significant) of the 16-bit CRC

CRCLO = Low byte (least significant) of the 16-bit CRC

START

FOR A = FIRST_BYTE TO LAST_BYTE IN BLOCK DO

    A = A XOR CRCHI

    CRCHI = A

    SHIFT A RIGHT FOUR TIMES   (ZERO FILL)

    A = A XOR CRCHI   { I J K L M N O P }

    CRCHI = CRCLO   { swap CRCHI, CRCLO }

```
                    CRCLO = A
                    ROTATE A LEFT 4 TIMES        { M N O P I J K L }
                    B = A                        { temp save }
                    ROTATE A LEFT ONCE           { N O P I J K L M }
                    A = A AND $1F                { 0 0 0 I J L L M }
                    CRCHI = A XOR CRCHI
                    A = B AND $F0                { M N O P 0 0 0 0 }
                    CRCHI = A XOR CRCHI          { CRCHI complete }
                    ROTATE B LEFT ONCE           { N O P 0 0 0 0 M }
                    B = B AND $ E0               { N O P 0 0 0 0 0 }
                    CRCLO = B XOR CRCLO          { CRCLO complete }
            DOEND

    FINISH
```

Final check on the CRC is accomplished by adding or concatenating CRCHI and CRCLO at the end of the data stream. Calculating the CRC of the resulting data stream will result in a zero CRC if the data was correctly received.

Annex D
(Informative)

Methodology of the recommended ECG signal compression technique

D.1 General

This Annex was previously normative and is now only informative. It has been partly deprecated because, starting with SCP-ECG version V3.0, there is no longer the need for performing in depth signal error verification of formerly recommended "High" SCP-ECG data compression techniques as only lossless, redundancy compression methods are allowed in the new version of this document. The remaining of Annex D has been kept for educational reasons, to support understanding of Huffman encoding and decoding and conversion of high compressed ECGs from legacy SCP-ECG version 1.x and 2.x files into SCP-ECG version V3.0 files.

D.2 Introduction

The methodology of the formerly recommended SCP-ECG signal data compression techniques is explained in this annex. The principles of the methodology are exposed first in general in various diagrams (D.3). Subsequently, a detailed description is given of the recommended data compression and decompression methodology (reference beat subtraction, bimodal compression, computation and storage of difference data, Huffman encoding), with corresponding mathematical definitions (see D.4). Then, a few numerical examples for SCP-ECG compression are presented in D.5, and the test set that was recommended for use by SCP-ECG version V2.x to assess the reconstruction errors of ECG compression methods and to test the absolute accuracy of an ECG compression implementation is described in D.6. Finally, some background information and minimum requirements for encoding and compression of the ECG signal data are presented in D.7.

D.3 Principles of "HIGH" SCP-ECG data compression

D.3.1 Original ECG - "raw data"

a)   Locate a reference point inside all ECG complexes, e.g. the time of QRSmax or any other marker:

— Fiducials for Reference Beat subtraction (see fc1 to fc7 in Figure D.1)

b)   Identify ECG complex types, i.e. normal type, different extrasystoles:
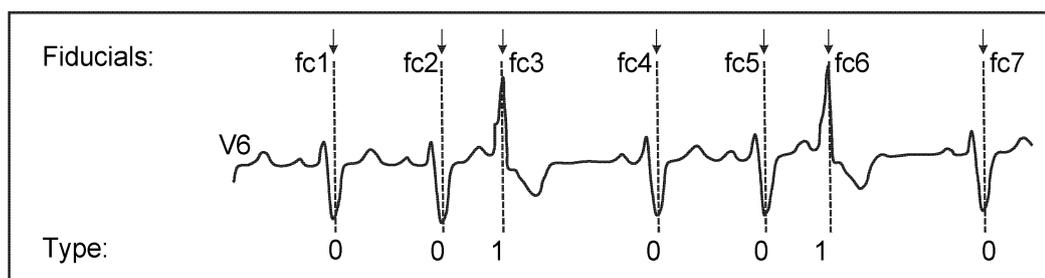
— QRS-type 0, 1, etc.

Figure D.1 — Example of raw data, fiducials and QRS typing

D.3.2 Reference Beat type 0

a) Compute the "Reference Beat Type 0", e.g. representative Average Cycle, Median Cycle, Modal Beat, etc.

b) Identify the wave onsets and offsets of the Reference Beat type 0 (see Figure D.2):

— length of the Reference Beat type 0 to be subtracted;

— pointers for QRS data segments p (see Figures D.3 and D.4) to be protected from filtering and decimation.
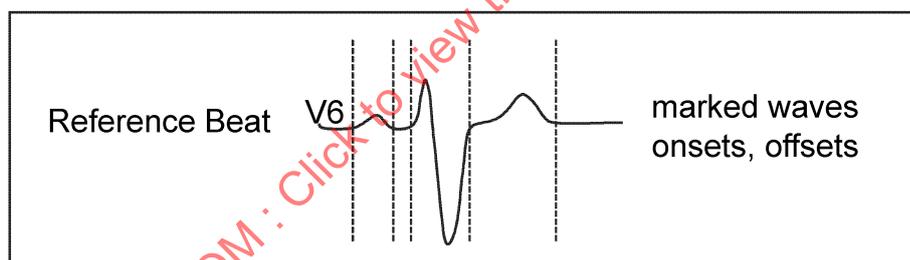

Figure D.2 — Example of a reference beat

D.3.3 Residual Record after beat subtraction

Subtract the Reference Beat Type 0 from all ECG complexes of type 0 using the fiducial locations.