
**Health informatics — Medical
waveform format —**

**Part 4:
Stress test electrocardiography**





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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation 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 Technical Committee ISO/TC 215, *Health informatics*.

A list of all parts in the ISO 22077 series can be found on the ISO website.

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

0.1 General

Stress test electrocardiography is an examination that is frequently used. It is used to check the changes in biological phenomena such as electrocardiogram or blood pressure that occur during cardiac stress. Cardiac stress can be seen via exercise or by intravenous pharmacological stimulation. The purpose of this examination is to find cardiac abnormalities, such as myocardial ischemia disease or arrhythmia during exertion, and to check the athletic capability of the cardiopulmonary function.

This document defines the detailed rules of stress test electrocardiogram waveform format that is encoded according to the Medical waveform Format Encoding Rules (MFER). In addition to basic rules defined in ISO 22077-1, there are rules for ECG waveforms electrocardiography (12lead ECG, etc.) and long-term electrocardiography (Holter ECG) that are contained in other MFER technical specifications, i.e. ISO/TS 22077-2 and ISO/TS 22077-3. Please refer to those specifications for additional information.

0.2 Information package added to the electrocardiogram

The stress test checks the changes in the electrocardiogram during exercise against the resting electrocardiogram. To correctly interpret the changes, we also need to capture other waveforms such as the blood pressure, respiration gas, SpO₂ and the load information. These should be put into a single package to be delivered to a third party such as a healthcare provider.

The purpose of this document is to describe waveforms of different nature in the package and how they can be synchronized in order to be interpreted simultaneously by the recipient of the package.

0.3 About electrocardiography waveform encoding in MFER

It is recommended to store the original waveforms as much as possible, i.e. waveforms are not irreversible compressed or filtered. This is to avoid losing the information contained in the original waveform when reusing the waveform in research, etc. It is desirable to perform the processing (e.g., Synthesized lead or filtering) needed for encoded waveforms. The configuration and condition of an electrocardiogram recording may be encoded with waveform data to assure reproduction of electrocardiographic representation when using a system such as electronic medical records. However, it is entrusted to the system whether those can or cannot be reproduced using this information. There are often large drift noises and EMGs on electrocardiograms during exercise stress tests. Some devices perform special signal processing to remove these noises. And the system might not be able to perform the same signal processing to reproduce the electrocardiogram that was recorded. In such a case, in addition to the original waveform, storing the waveform after signal processing is also an option.

Health informatics — Medical waveform format —

Part 4: Stress test electrocardiography

1 Scope

This document defines the application of Medical waveform Format Encoding Rules (MFER) to describe stress test electrocardiography, which is one of the outputs of exercise, pharmacological and cardiopulmonary stress test. MFER performed in physiological laboratories, healthcare clinics, etc.

This document covers not only the electrocardiogram waveform but also the description of related stress information and biological signals, e.g. blood pressure, respiration gas, SpO₂, etc..

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/TS 22077-2, *Health informatics — Medical waveform format — Part 2: Electrocardiography*

ISO/TS 22077-3, *Health informatics — Medical waveform format — Part 3: Long term electrocardiography*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1.1

abstract waveform

single beat ECG waveform which is extracted from all ECG waveform during examination period, including the waveform which did the signal processing such as averaging

3.1.2

intermittent recording

recording electrocardiogram for a given period of time at a preset interval of time

3.1.3

full disclosure waveform

electrocardiographic waveform covering the entire time from the *resting period* (3.1.4) to the *recovery period* (3.1.7) during cardiac stress test

3.1.4

resting period

phase before loading of stress (by exercise or medication) to the patient's heart

3.1.5

warm-up period

practise stage just before the start loading

3.1.6

loading period

phase immediately after the start loading with stress (by exercise or medication) to the patient's heart

3.1.7

recovery period

end of loading with stress (by exercise or medication) to the patient's heart

3.1.8

exercise stress test

examination procedure loaded to the heart to enable diagnosis of cardiac disease by exercise

Note 1 to entry: Ergometer and treadmill are representative methods for exercise stress loading.

3.1.9

pharmacological stress test

medication administered as a stress to the heart to enable diagnosis of heart disease

3.1.10

cardiopulmonary stress test

exercise stress test ([3.1.8](#)) to evaluate exercise capacity and predict outcome in patients with heart failure and other cardiac conditions

3.1.11

borg scale

index used to express the exercise strength and to indicate the rating of perceived exertion

Note 1 to entry: The borg scale is generally used in exercise stress test.

3.2 Symbols and abbreviated terms

ECG	Electrocardiogram
MFER	Medical waveform Format Encoding Rules
SCP-ECG	Standard Communications Protocol for Computerized Electrocardiography
SpO ₂	Saturation of Peripheral Oxygen
$\dot{V}O_2$	oxygen consumption
$\dot{V}CO_2$	carbon dioxide output
$\dot{V}_E$	minute ventilation

4 Outline of stress test cardiography rules

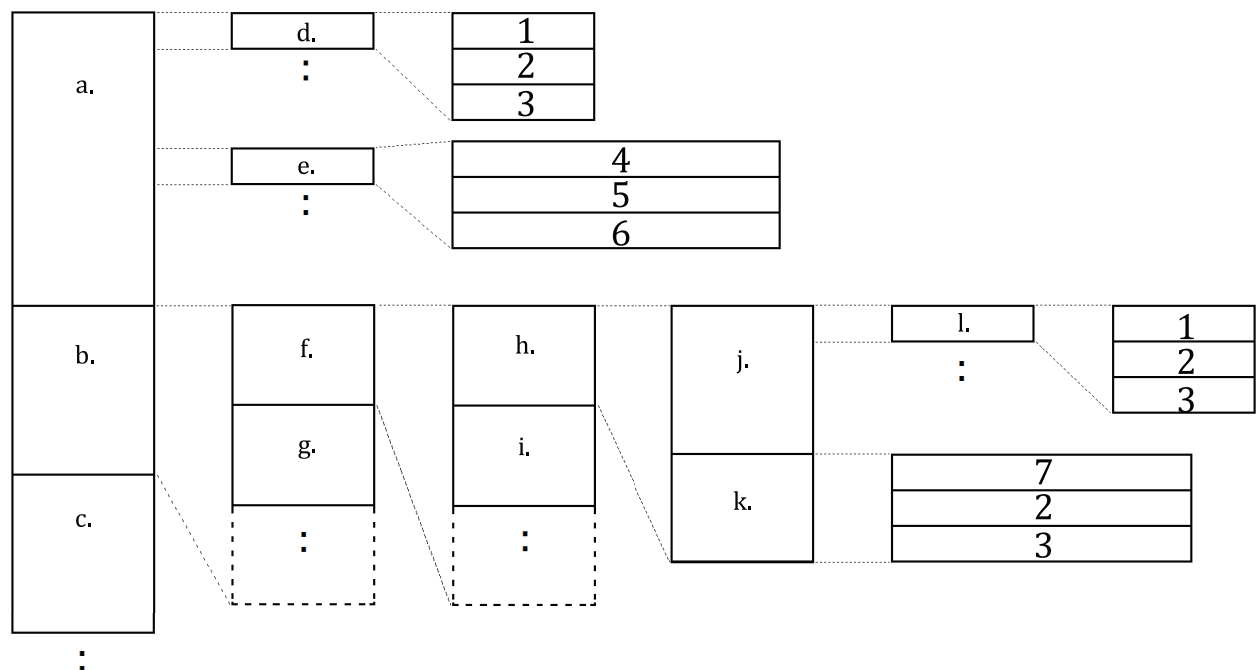
4.1 Configuration of waveform data (see [Figure 1](#))

Medical waveform data described in accordance with the MFER is an aggregate of waveform frame data that consists of a header section (encoding detailed information about the waveform) and a waveform data section (main data of waveform). The header and waveform data are encoded based on the encoding rules which are composed of TLV (Tag - Data length - Value). One MFER waveform file can include several waveforms. The definition of the MFER waveform file is sequentially interpreted

from the beginning of the file. As most definitions, multiple use is possible. The definition is used until another definition for the same tag is encountered. Then the new definition replaces the older definition.

When there are several waveforms in a MFER waveform file, each waveform may be located anywhere in the file. However, in the specification of stress test electrocardiography, waveform should be located as follows for usability and to avoid erroneous interpretation.

- The information about stress test should be described before description of waveform. And the value of waveform class definition (MWF_WFM) for the information should be ECG_EXER (stress test ECG).
- The same type waveforms should be described in a mass and that should be located chronological.



Key

- | | | | |
|----|-------------------------------|---|---------------------|
| a. | stress test information | 1 | tag |
| b. | waveform (type #1) | 2 | length |
| c. | waveform (type #2) | 3 | value |
| d. | explanation about stress test | 4 | tag: MWF_WFM(8) |
| e. | explanation (waveform class) | 5 | length: 2 |
| f. | waveform #1 of type #1 | 6 | value: ECG_EXCER(4) |
| g. | waveform #2 of type #1 | 7 | tag: MWF_WAV(30) |
| h. | frame #1 of waveform #1 | | |
| i. | frame #2 of waveform #1 | | |
| j. | header | | |
| k. | waveform data | | |
| l. | explanation about frame | | |

Figure 1 — Configuration of waveform data

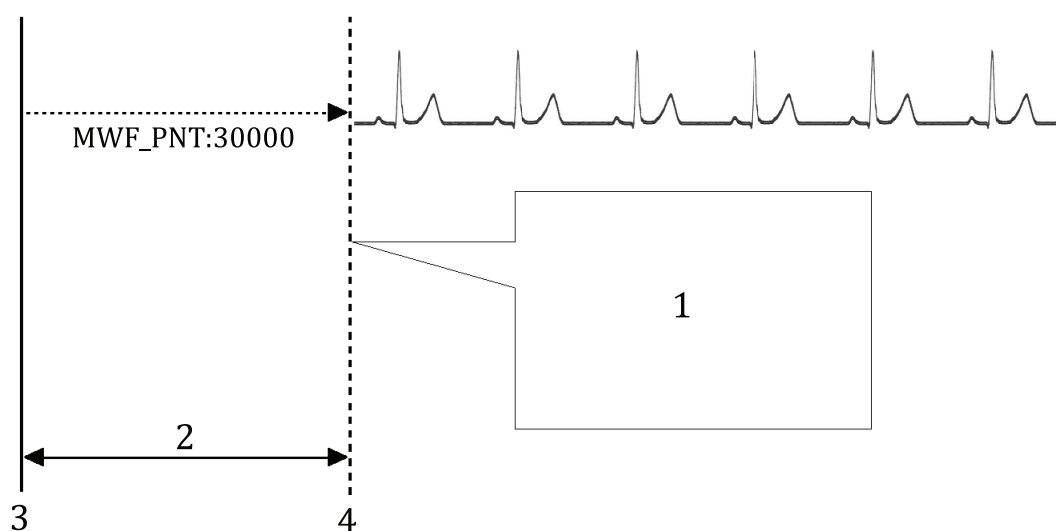
4.2 Time synchronization (see [Figure 2](#))

In the data of stress test electrocardiography, several types of electrocardiogram and biomedical data, such as blood pressure, are described together. In addition, it is necessary to grasp the state of the load at the time the data was acquired.

The reference time of description starts counting from examination beginning. The provider shall describe the acquisition time which is defined using the reference time for each data. The user can get the synchronization between data by collating the acquisition time for each data.

The reference time of waveform such as electrocardiogram is described using the pointer tag (MWF_PNT). The reference time of events such as load information (loading period, recovery period, stage period, etc.) is described using "starting time" item of the event tag (MWF_EVT). The reference time of measurements such as blood pressure and the amount of load such as treadmill speed are described using the "time point" item of the value tag (MWF_VAL). The reference time is indicated as a data pointer which depend on the sampling rate of the frame. The user may get the synchronization using pointer of different sampling rate.

For example, if the sampling interval of load information event is 1 second (s) and the sampling interval of ECG waveform is 2 ms, then the point of load information event becomes 60 and the point of ECG waveform becomes 30 000 at the time of the start of the load.



Key

- 1 load information
tag: MWF_EVT
code: <Start of Load>
starting time: 60 s
- 2 60 s
- 3 start of examination
- 4 start of load

Figure 2 — Time synchronization

5 Waveform encoding

5.1 General

This set of rules is aimed at ensuring that the waveforms collected serially during stress test electrocardiography are encoded together with the information of the stress test. The waveforms involved in stress test electrocardiography include “full disclosure waveform” (waveform in all segments during the test), “intermittent record waveform” (waveform records in some short segments during the test) and “abstract waveform” (waveform for a single heart beat extracted periodically during the test).

5.1.1 Full disclosure waveform (see [Figure 3](#))

This form is used when encoding all waveforms of electrocardiogram, etc., covering the resting period (pre-loading), the loading period and the recovery period (post-loading). This includes not only encoding of waveforms of all leads used in the test but also encoding of only the waveform for selected one or multiple leads. It is a simpler description of full disclosure waveform to encode the waveform of the entire period of the examination within one frame.

Encoding of full disclosure waveform shall be done in accordance with ISO/TS 22077-3. The waveform class of this waveform is ECG_LTERM (2).

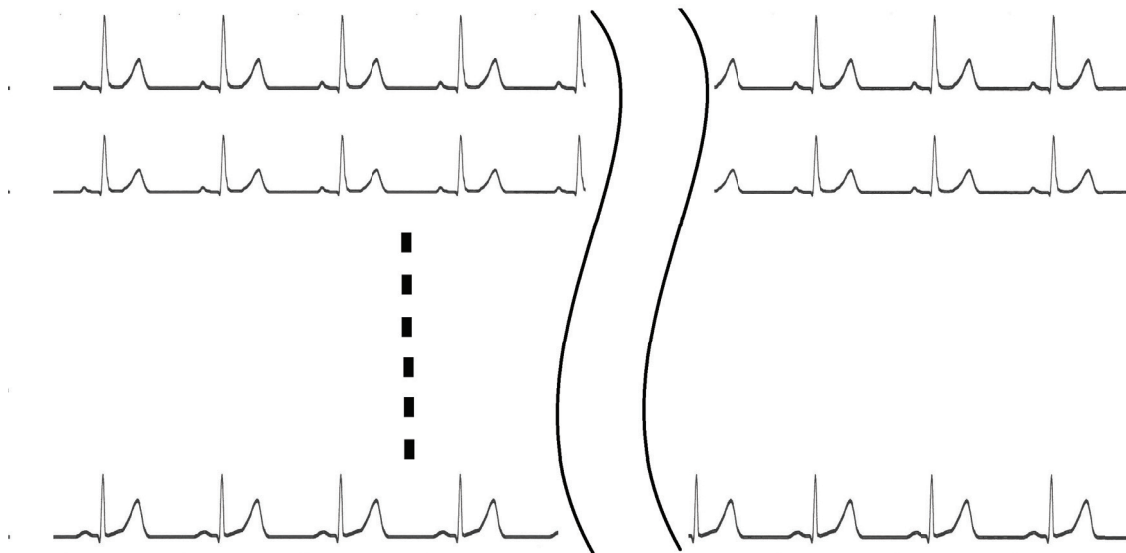


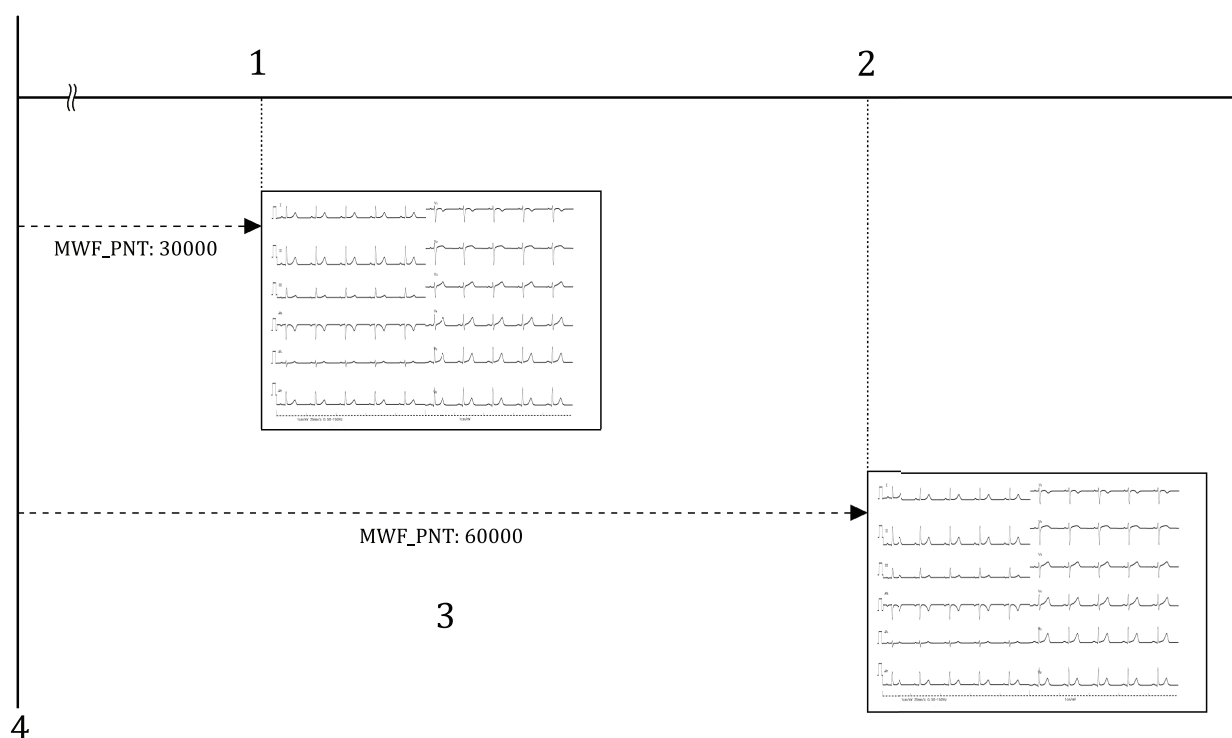
Figure 3 — Full disclosure waveform

5.1.2 Intermittent record waveform (see [Figure 4](#))

This form is used when encoding the waveforms of electrocardiogram, etc., using the interval records at the resting, the loading and the recovery periods or one-shot records taken at random during the test.

Encoding of intermittent record waveform shall be done in accordance with ISO/TS 22077-2. The waveform class of this waveform is ECG_STD12 (1), ECG_SURF (6) or ECG_DRV (12), etc.

The point of time when the record concerned was taken during the test is encoded with using the pointer tag (MWF PNT).



Key

- 1 60 s after examination starting
- 2 120 s after examination starting
- 3 sampling interval: 2 ms
- 4 start of examination

Figure 4 — Intermittent record waveform

5.1.3 Abstract waveform (see [Figure 5](#))

This form is used when encoding a group of electrocardiograms for individual heart beats extracted at the resting, the loading and the recovery periods to evaluate changes in the characteristics of electrocardiogram waveforms during the test.

The abstract waveform includes not only the extracted waveform which is one beat during a certain period but also the average waveform which averaged several beats during a certain period. In addition, it includes a derived waveform which is made by a special signal processing. Encoding of an abstract waveform is done in accordance with ISO/TS 22077-2. The waveform class of this waveform is ECG_BAET (9).

The abstract waveforms at the same time are encoded as one frame, and there are frames of abstract waveforms which are extracted each time. The pointer tag (MWF_PNT) of frame indicates the time of an abstract waveform.