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Health informatics — Medical waveform format —

Part 4: Stress test electrocardiography

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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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).

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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 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, SpO_2 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, SpO_2, 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)

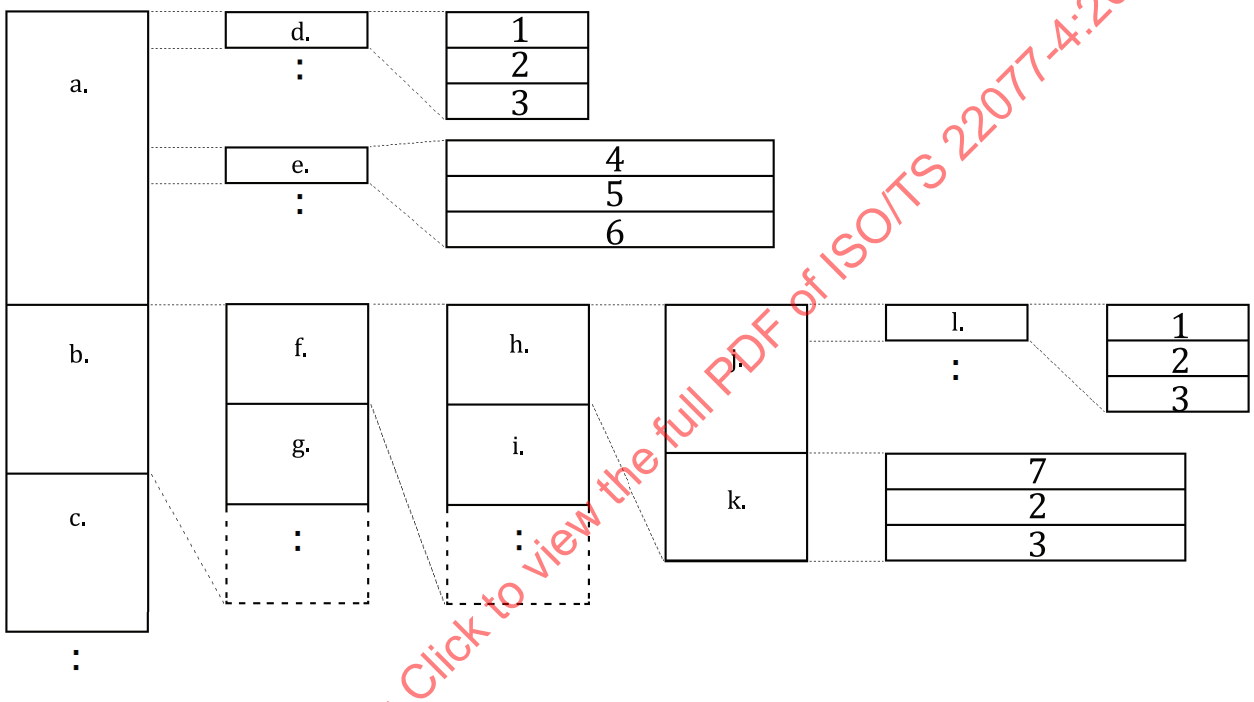
Medical waveform data described in accordance with the MFER is an aggregate of waveform frame data that consists of a header section (encoding detailed information about the waveform) and a waveform data section (main data of waveform). The header and waveform data are encoded based on the encoding rules 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
b. waveform (type #1)
c. waveform (type #2)
d. explanation about stress test
e. explanation (waveform class)
f. waveform #1 of type #1
g. waveform #2 of type #1
h. frame #1 of waveform #1
i. frame #2 of waveform #1
j. header
k. waveform data
l. explanation about frame

1 tag
2 length
3 value
4 tag: MWF_WFM(8)
5 length: 2
6 value: ECG_EXCER(4)
7 tag: MWF_WAV(30)

Figure 1 — Configuration of waveform data

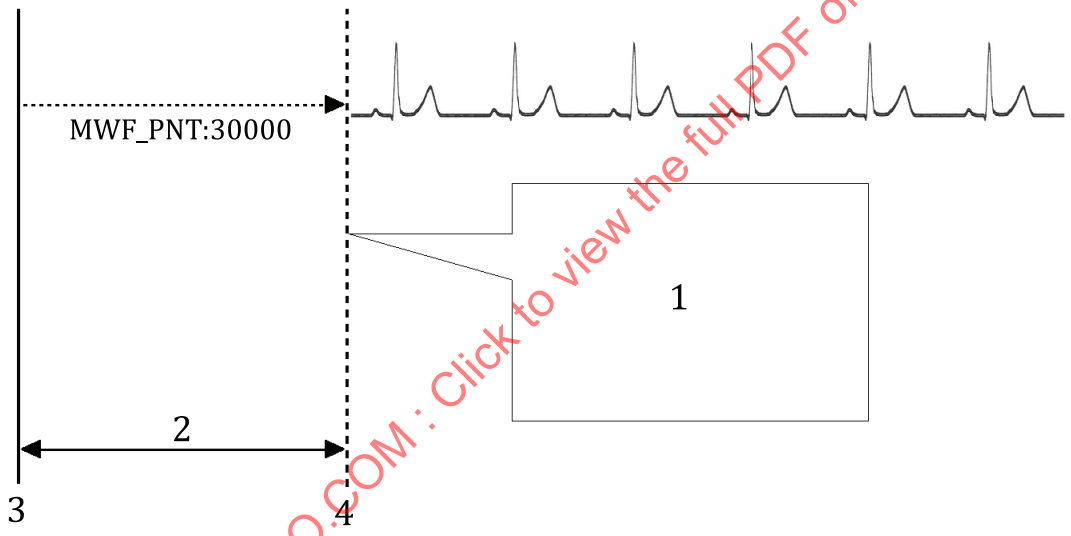
4.2 Time synchronization (see Figure 2)

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).

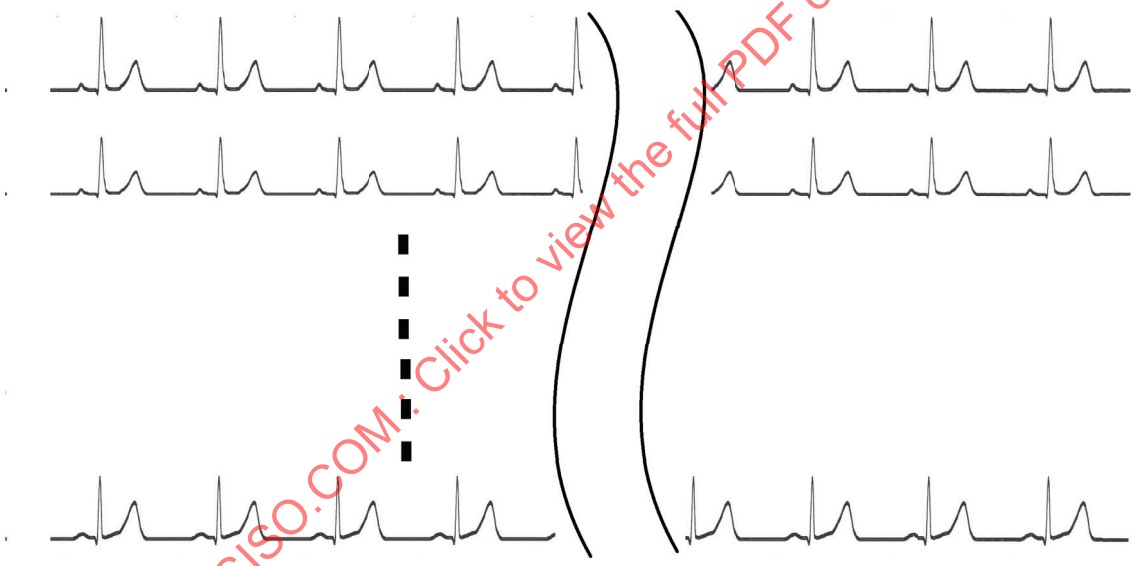


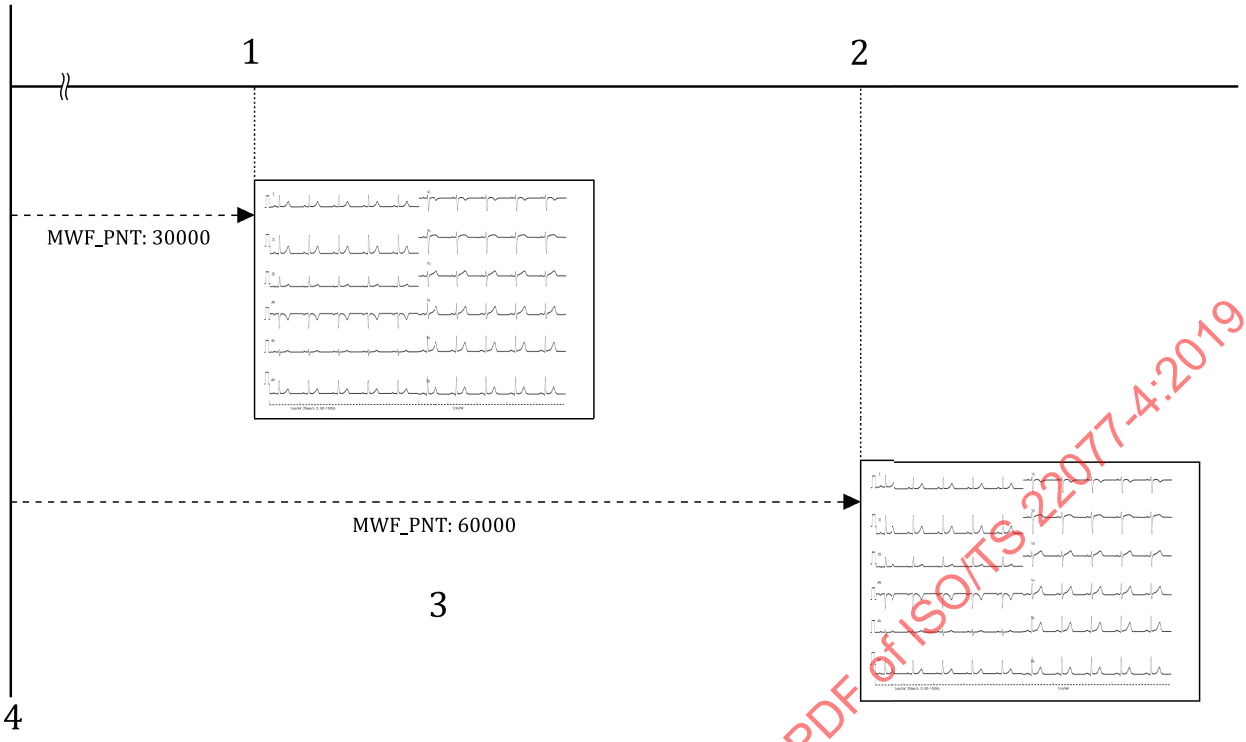
Figure 3 — Full disclosure waveform

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

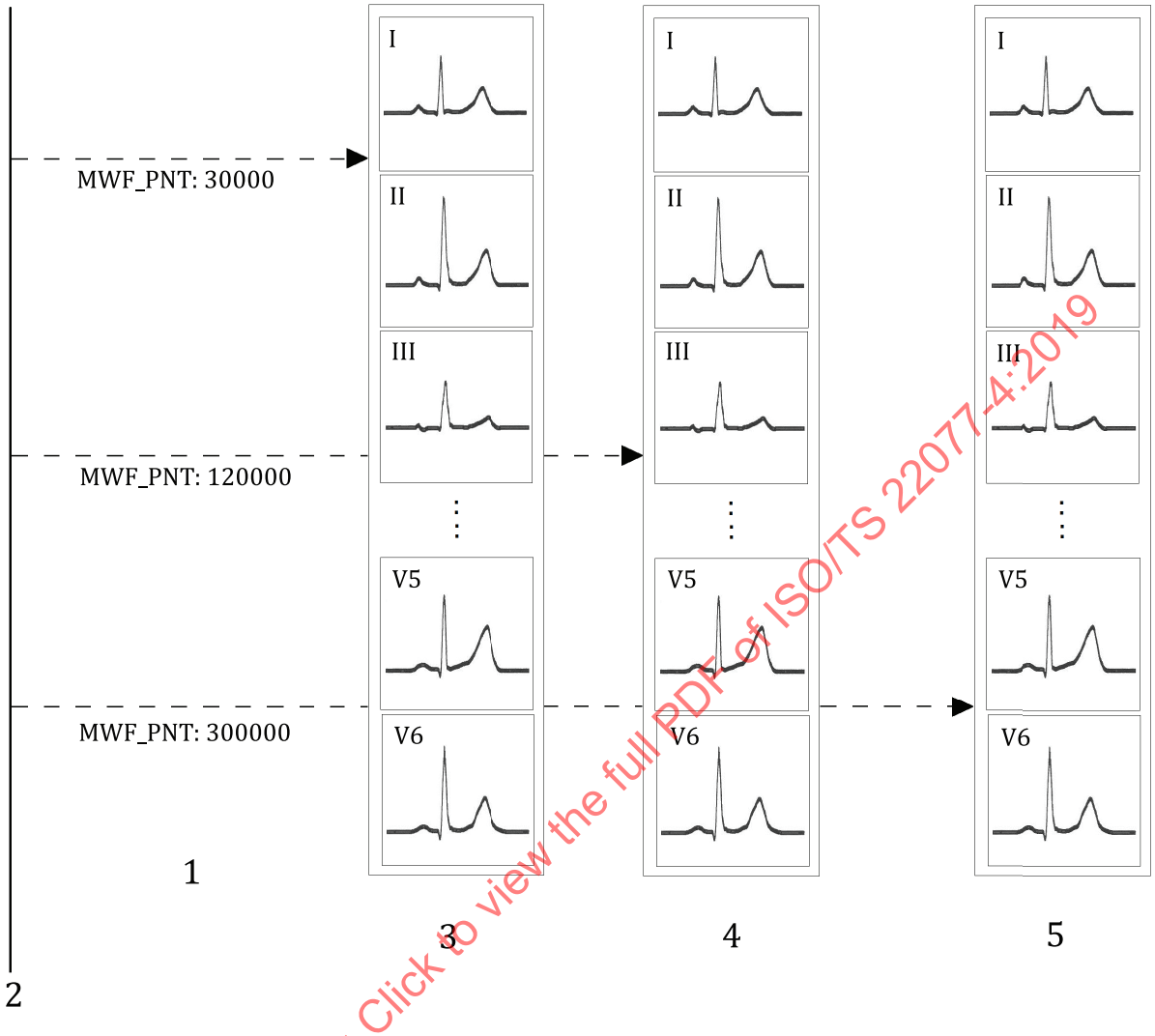
Figure 4 — Intermittent record waveform

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.



Key

1 sampling interval: 2 ms
2 start of examination
3 start of load (resting)
4 3 min after load
5 end of load (post exercise)

Figure 5 — Abstract waveform

5.2 Waveform class

5.2.1 General

The waveform class indicates that this waveform data is as stress test ECG. Furthermore, the waveform class indicates the kind of waveform that included in this data. The format is given in Table 1.

Table 1 — Waveform class

MWF_WFM		Data length	Default	Remarks	Duplicated definitions
08	08h	2	Non-specific waveform		Override
		Str ≤ 32	Waveform description		Override

5.2.2 Waveform class for stress test electrocardiography

A description of waveform class for stress test ECG shall be provided in the data. This description shall precede the description of the waveform class of the waveforms included in this data.

The type for this waveform is designated in Table 2.

Table 2 — Stress test ECG waveform

Classification	Type	Value	Waveform description	Remarks
Electrocardiogram	ECG_EXCER	4	Stress test ECG	Exercise stress test ECG Pharmacological stress test ECG Cardiopulmonary stress test ECG

5.2.3 Waveform class for full disclosure waveform

The waveform class for full disclosure waveform is "Long term ECG". Long term ECG waveform should be encoded in accordance with ISO/TS 22077-3.

The type for this waveform is designated in Table 3.

Table 3 — Full disclosure waveform

Classification	Type	Value	Waveform description	Remarks
Electrocardiogram	ECG_LTERM	2	Long term ECG	Full disclosure ECG

5.2.4 Waveform class for intermittent recorded waveform

The waveform class for intermittent record waveform is "Standard 12lead ECG", etc. This waveform should be encoded in accordance with ISO/TS 22077-2.

The type for this waveform is designated in Table 4.

Table 4 — Intermittent record waveform

Classification	Type	Value	Waveform description	Remarks
Electrocardiogram	ECG_STD12	1	Standard 12lead ECG	Standard 12lead ECG including general ECG in short term recording.
	ECG_SURF	6	Body surface ECG	Frank's lead, chest bipolar lead, Nehb lead, etc.
	ECG_DRV	12	Derived lead	Derived ECG from Frank vector leads, EASI lead, etc.

5.2.5 Waveform type for abstract waveform

The waveform class for abstract waveform is "QRS beat". This waveform should be encoded in accordance with ISO/TS 22077-2.

The type for this waveform is designated in Table 5.

Table 5 — Abstract waveform

Classification	Type	Value	Waveform description	Remarks
Electrocardiogram	ECG_BEAT	9	QRS beat	One heart beat waveform which the abstraction is made periodically during the examination. Average, median, dominant, etc.

5.3 Lead name (Waveform attributes)

Lead name means the waveform code that is one of waveform attributes. The format is as Table 6.

Table 6 — Definition of waveform attributes

MWF_LDN			Data length	Default	Remarks	Duplicated definitions
09	09h	Waveform code	2	undefined	Data length = 2, if waveform information is encoded	Override
		Waveform information	Str ≤ 32		—	Override

This is the waveform code used in stress test ECG. As the lead code is encoded by the number 0-127, extra attention would be required in the case of conforming with other rules such as SCP-ECG.

Table 7 — Lead name 1

Code	Lead	Code	Lead	Code	Lead	Code	Lead
0	Config	32	CB4	64	aVF	97	—
1	I	33	CB5	65	(-aVR)[b]	98	—
2	II	34	CB6	66	V8	98	—
3	V1	35	—	67	V9	99	—
4	V2	36	—	68	V8R	100	—
5	V3	37	—	69	V9R	101	—
6	V4	38	—	70	Nehb-D	102	—
7	V5	39	—	71	Nehb-A	103	—
8	V6	40	—	72	Nehb-I	104	—
9	V7	41	—	73	—	105	—
10	(V2R)[a]	42	—	74	—	106	—
11	V3R	43	—	75	—	107	—
12	V4R	44	—	76	—	108	—
13	V5R	45	—	77	—	109	—
14	V6R	46	—	78	—	110	—
15	V7R	47	—	79	—	111	—
16	X	48	—	80	—	112	—
17	Y	49	—	81	—	113	—
18	Z	50	—	82	—	114	—
19	CC5	51	—	83	—	115	—

[a] Although V2R (10) is defined in other rules such as SCP-ECG, the definition shall not be used in MFER. V2R shall be used as V1.

[b] -aVR lead shall not be encoded according to MFER. The users (viewer) shall make a calculation to derive –aVR when required.

Table 7 *(continued)*

Code	Lead	Code	Lead	Code	Lead	Code	Lead
20	CM5	52	—	84	—	116	—
21	—	53	—	85	—	117	—
22	—	54	—	86	—	118	—
23	—	55	—	87	—	119	—
24	—	56	—	88	—	120	—
25	—	57	—	89	—	121	—
26	—	58	—	90	—	122	—
27	—	59	—	91	MCL	123	—
28	—	60	—	92	—	124	—
29	—	61	III	93	—	125	—
30	—	62	aVR	94	—	126	—
31	NASA	63	aVL	95	—	127	—

[a] Although V2R (10) is defined in other rules such as SCP-ECG, the definition shall not be used in MFER. V2R shall be used as V1.

[b] -aVR lead shall not be encoded according to MFER. The users (viewer) shall make a calculation to derive –aVR when required.

Table 8 — Lead name 2

Code	Lead	Remarks
175	SpO_2	
4160	Status	In case status including pacing and lead off. Status should be encoded in accordance with ISO/TS 22077-3.
4166	ECG1	These shall be used in case lead name is not definite.
4167	ECG2	
4168	ECG3	
4169	ECG4	
4224	VO_2	These signals about respiration gas are used in cardiopulmonary stress test.
4225	VCO_2	
4226	Tidal Volume	
4227	Respiratory Rate	
4228	V_E	

5.4 Sampling attributes

"Sampling interval (MWF_IVL)" and "Sampling resolution (MWF_SEN)" should be described in accordance with ISO 22077-1. If multiple types of waveform are present, the sampling attributes described immediately before description of their waveform data are used.

5.5 Frame attributes

"Data block length (MWF_BLK)", "Number of channels (MWF_CHN)" and "Number of sequences (MWF_SEQ)" should be described in accordance with ISO 22077-1. If multiple types of waveform are present, the frame attributes described immediately before description of their waveform data are used.

5.6 Pointer

This tag indicates the waveform data pointer, which is represented by the sampling rate of the root level, in the frame. If no pointer is designated, the pointer of the first frame is initialized as zero. The

pointer for the next frame is deemed to be a value adding the number of data length of the virtual root level channel in the previous frame.

In stress test ECG, the pointer may be used to indicate the position of waveform in the examination.

The format is provided in Table 9.

Table 9 — Pointer

MWF_PNT		Data length	Default	Remarks	Duplicated definitions
07	07h	≤4	Zero or pointer of previous frame		Override

5.7 Filter information

"Filter information (MWF_FLT)" should be described in accordance with ISO 22077-1. The format is provided in Table 10.

Stress test ECG often use special filters to eliminate the influence of various artifacts during examination. Because some filters cause distortion or delay of electrocardiogram waveform, a clear description of attenuation rate, delayed time, etc. is recommended if care is deemed necessary.

Table 10 — Filter information

MWF_FLT		Data length	Default	Remarks	Duplicated definitions
17	11h	Str ≤ 128	unused	—	Possible

Table 11 — Filter description example

Filter function	Abbreviation	Example	Meaning
Filter information only	None	Hum filter ON	Hum filter (characteristics, etc. not specified). Combining line frequency information can provide specific filter information.
High-frequency pass filter	HPF	HPF=0.5^delay time=1023ms	Indefinite characteristics 0,5 Hz low frequency cut-off (high-pass) filter used. Delay time is 1 023 ms.
Low-frequency pass filter	LPF	LPF=150^secondary Butterworth filter	Butterworth secondary characteristics 150 Hz high frequency cut-off (low-pass) filter used.
Band elimination filter	BEF	BEF=50^Hum filter	50 Hz Hum filter used. Cut-off characteristics not known.

6 Load information

6.1 General

The load information should be described using with "Event (MWF_EVT)" and "Value (MWF_VAL).

6.2 Loading related events

Loading-related events such as protocol name, starting load, stage of load, etc. is described as event. The format is Table 12. Events include those listed in Table 13.

Table 12 — Loading-related events

MWF_EVT			Data length	Encoding range/Remarks	Duplicated definitions
65	41h	Event code	2	See Table 13	Multiple definitions available
		Starting time (point)	4	Number of samples acquired at the sampling interval defined in the root definition.	
		Duration	4		
		Event information	Str ≤ 256	See Table 13	

Table 13 — Loading-related event code

Reference ID	CODE		Event	Explanation/ Event information
	DEC	HEX		
MWF_LOAD_EXAM_TYPE	4608	1200	Type of examination	Type of examination is described as event information. Starting time is –1, duration is 0. Example: Exercise stress test Pharmacological stress test Cardiopulmonary stress test
MWF_LOAD_DEVICE	4609	1201	Loading device name	Loading device name is described as event information. Starting time is –1, duration is 0. Example: Treadmill Ergometer
MWF_LOAD_PROTOCOL	4610	1202	Protocol name	Protocol name is described as event information. Starting time is –1, duration is 0. Example: Bruce
MWF_LOAD_EXAM_PERIOD	4624	1210	Examination period	Starting time is 0, duration is examination period.
MWF_LOAD_RESTING	4625	1211	Resting period	Set starting time and period of resting phase.
MWF_LOAD_WU	4626	1212	Warm-up period	Set starting time and period of warm-up phase.
MWF_LOAD_LOADING	4627	1213	Loading period	Set starting time and period of loading phase.
MWF_LOAD_RECOVERY	4628	1214	Recovery period	Set starting time and period of recovery phase.
MWF_LOAD_STAGE	4629	1215	Stage period	Set starting time and period of each stage. Event information is encoded with "phase^stage number". Example: loading^1 (It means stage 1 of loading phase)

Table 13 *(continued)*

Reference ID	CODE		Event	Explanation/ Event information
	DEC	HEX		
MWF_LOAD_HOLD	4630	1216	Hold loading period	Set starting time and period of hold loading.
MWF_LOAD_PAUSE	4631	1217	Pause loading period	Set starting time and period of pause loading. Event information is encoded reason of pause. Example: Lead off
MWF_LOAD_MAX_LOAD	4640	1220	Maximum load time	Starting time is the time in maximum load, duration is 0. Event information is encoded with " load value^unit". Example: 120^W
MWF_LOAD_MAX_HR	4641	1221	Maximum HR time	Starting time is the time in maximum heart rate, duration is 0. Event information is encoded with "HR value^unit". Example: 140^/min
MWF_LOAD_MAX_ST	4642	1222	Maximum ST displacement time	Starting time is the time in maximum ST displacement, duration is 0. Event information is encoded with "ST level value^unit^lead name". Example: -0.1^mV^V5
MWF_LOAD_END_REASON	4648	1228	Reason of load ending	Reason of load ending is described as event information. Starting time is –1, duration is 0. Example: Target HR
MWF_LOAD_CONTROL	4652	122C	Time of control wave	Starting time is the beginning time of control abstract wave, duration is 0. Event information is encoded with “phase” or “phase^elapsed time of phase”. Example: resting loading^0:00

6.3 Amount of load

Amount of load such as ergometer power, treadmill speed, and treadmill gradient are described as value. The format is given in Table 14.

Table 14 — Amount of load

MWF_VAL			Data length	Encoding range/Remarks	Duplicated definitions
66	42h	Value code	2	See Table 15	Multiple definitions available
		Time point	4	Number of data values sampled is encoded.	
		Value	Str ≤ 32	Value is encoded with a character string with unit ("^").	

Table 15 — Amount of load code

Reference ID	CODE		Value	Explanation
	DEC	HEX		
MWF_LOAD_ERGO_WATT	4672	1240	Power (watt) of ergometer	Example: 50^W
MWF_LOAD_ERGO_RPM	4673	1241	Rotate per minute of ergometer	Example: 60^r/min
MWF_LOAD_TREAD_SPEED	4674	1242	Speed of treadmill	Example: 2.7^km/h
MWF_LOAD_TREAD_GRADE	4675	1243	Gradient of treadmill	Example: 10^%
MWF_LOAD_PHARM_DOSE	4676	1244	Pharmacological stress agent dose rate	Example: 0.001^mg/kg/min

7 Measurement information

7.1 General

Information generated during measuring stress test ECG, information that would exert effect on the authenticity of ECG and validity of waveforms are encoded. For example, it is possible to encode waveform display information and power supply frequency that do not exert effect on generation of ECG waveform measurement but that are required to reproduce the condition at the time of measurement. The descriptions in this chapter are recommended to be implemented in accordance to local conventions whenever possible.

7.2 Examination date/time

This tag encodes the examination date/time (Table 16).

The date/time is an important object stored using MFER. Care should be taken to ensure it is accurate.

Table 16 — Examination date/time

MWF_TIM			Data length	Default	Remarks	Duplicated definitions
133	85h	Year	2	None	1900-2100	Override
		Month	1		1-12	
		Day	1		1-31 (1-30, 1-28,29)	
		Hour	1		0-23	
		Minute	1		0-59	
		Second	1		0-59	
		Milli-sec	2		0-999	
		Micro-sec	2		0-999	

7.3 Rating of perceived exertion

Rating of perceived exertion (RPE) is described as event (MWF_EVT) is given in Table 17. Borg scale is often use.

Table 17 — Rating of perceived exertion

MWF_EVT			Data length	Encoding range/Remarks	Duplicated definitions
65	41h	Event code	2	See Table 18	Multiple definitions available
		Starting time (point)	4	Number of samples acquired at the sampling interval defined in the root definition.	
		Duration	4	0	
		Event information	Str ≤ 256	Binary rating of perceived exertion is converted into letters and described with Borg scale (Table 18) using separator (^) for distinction. Example: 9^Very light	

Table 18 — RPE event

Reference ID	Code		Value
	DEC	HEX	
MWF_LOAD_BORG	4704	1260	Borg scale (see Table 19)
MWF_LOAD_BORG_CR10	4705	1261	Modified Borg Scale (CR10:2010) (see Table 20)

Table 19 — Borg scale

Scale	Explanation
20	
19	Very very hard
18	
17	Very hard
16	
15	Hard
14	

Table 19 *(continued)*

Scale	Explanation
13	Somewhat hard
12	
11	Fairly light
10	
9	Very light
8	
7	Very very light
6	

Table 20 — Modified Borg scale (CR10)

Scale	Explanation
10	Extremely strong (Maximal)
9	
8	
7	Very strong
6	
5	Strong (Heavy)
4	
3	Moderate
2.5	
2	Weak (Light)
1.5	
1	Very weak
0.7	
0.5	Extremely weak (Just noticeable)
0.3	
0	Nothing at all

7.4 R wave position

The R wave position, needed for deriving the abstract waveform from full disclosure waveform by means of averaging, is described. It is given in Table 21. This information is described as value (MWF_VAL). In the case of heartbeat used for averaging, the value is 1. And, in the case of heartbeat that is not used for averaging such as arrhythmia, the value is –1.

Table 21 — R wave position

MWF_VAL			Data length	Encoding range/Remarks	Duplicated definitions
66	42h	Value code	2	4736(DEC) / 1280(HEX)	Multiple definitions available
		Time point	4	Number of data values sampled is encoded.	
		Value	Str ≤ 32	Used for averaging: 1 Not used for averaging: –1	

7.5 Interpretation and beat annotation

Interpretation and beat annotation shall be encoded with the event tag in accordance with ISO/TS 22077-3.

Table 22 — Interpretation and beat annotation

MWF_EVT			Data length	Remarks	Duplicated definitions
65	41h	Event code	2	See Figure 6	Multiple definitions available
		Starting time (point)	4	Number of samples acquired at the sampling interval defined in the root definition.	
		Duration	4		
		Event information	Str ≤ 256	Event code and event information shall be used simultaneously. Alternatively, event code = 0 and event information shall be encoded. Event information shall be encoded with "interpretation text^code system (manufacturer name)^abbreviation or code" (in case of encoding plurality of event information, use "&"). Example: ventricular premature complex^ SCP-ECG^VPC	

Interpretation code format shall be defined as follows:

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0	0	0	Interpretation code (see Table B.2)											Possibility	

Figure 6 — Interpretation code format

Each possibility bit code means as follows:

— 0: Undesignated (No need to be defined or specified)

— 1: In case the possibility of the applicable finding is unlikely

— 2: Suspicious

— 3: Strongly suspicious

7.6 ST segment recognition points

ST segment recognition points (Reference point, STj point, ST level point, etc.) are described as event (MWF_EVT). The format is as Table 24.

When the ST segment recognition point of ECG waveform is shown Figure A.1, it is encoded by the event code.

When the ST segment recognition point in an ECG waveform is encoded by the root definition, it applies to all leads. When it is in a channel definition (each channel), the ST segment recognition point shall only apply to that channel. By specifying the lead inside the channel definition, the ST segment recognition point of each lead may be encoded. If the waveform is not encoded using MFER, then the lead should be specified in the channel definition.

Starting time of event tag indicates ST segment recognition point from the beginning of waveform frame.

Event information may describe the information about ST segment recognition point.

Table 24 — ST segment recognition points

MWF_EVT			Data length	Remarks	Duplicated definitions
65	41h	Event code	2	See Figure A.2	Multiple definitions available
		Starting time (point)	4	Number of samples acquired at the sampling interval defined in the root definition.	
		Duration	4	0	
		Event information	Str ≤ 256	Example: "ST level measurement point is J point plus 80ms"	

7.7 ST segment measurement value

ST segment measurement values (ST level, ST slope, etc.) are described as value (MWF_VAL).

Table 25 — ST segment measurement value

MWF_VAL			Data length	Encoding range/Remarks	Duplicated definitions
66	42h	Value code	2	See Figure A.3	Multiple definitions available
		Time point	4	Number of data values sampled is encoded.	
		Value	Str ≤ 32		

7.8 Other measurement value

The following measured values acquired during the examination except the electrocardiogram are described as value (MWF_VAL).

— NIBP

— Heart rate

— Double product

— SpO_2

— etc.

Table 26 — Other measurement value

MWF_VAL			Data length	Encoding range/Remarks	Duplicated definitions
66	42h	Value code	2	See Figure B.1	Multiple definitions available
		Time point	4	Number of data values sampled is encoded.	
		Value	Str ≤ 32	Value is encoded with a character string with unit ("^"). Example: Systolic BP: 120^mmHg Heart rate: 60^/min	

Annex A
(informative)

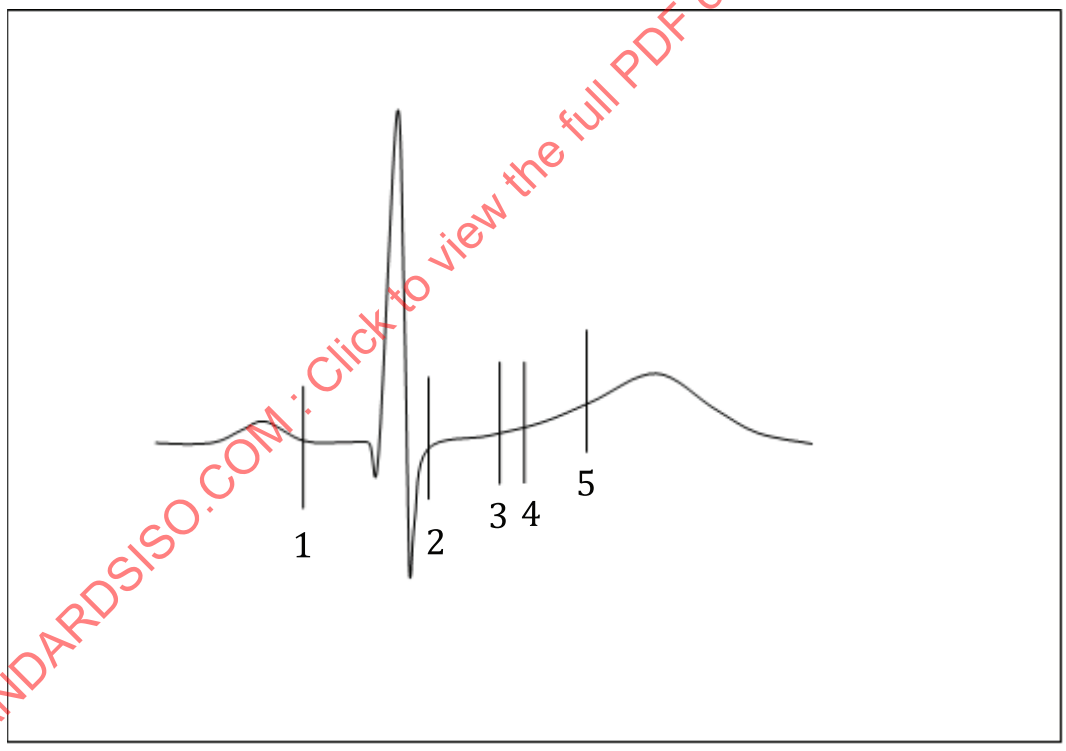
Encoding of ST segment recognition point and measurement value

A.1 General

ST segment recognition points (classification point) may be encoded with event tag (MWF_EVT), which is categorized as Level 2 as defined in ISO 22077-1.

A.2 ST segment recognition point

ST segment recognition points are shown in Figure A.1, and each point is encoded with the event tag of MFER coding. In the case that the recognition point is encoded in the root definition, the recognition points affect all leads of the beat. On the other hand, if the recognition points are in the channel definition, they only apply to beats in that channel.



Key

1 reference point
2 STj point
3 ST level measurement point
4 ST slope measurement start point
5 ST slope measurement end point

Figure A.1 — ST segment recognition point

ST segment recognition code format shall be defined as follows:

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
ST segment recognition point code (see Table A.1)							0	0	Lead code						

Figure A.2 — ST recognition point code format

Table A.1 — ST segment recognition point code

Reference ID	CODE		Explanation
	DEC	HEX	
MWF_ECG_ST_REFERENCE	57856	E200	Reference point
MWF_ECG_STJ	50688	C600	STj point
MWF_ECG_ST	51200	C800	ST level measurement point
MWF_ECG_ST_SLOPE_START	58368	E400	ST slope measurement start point
MWF_ECG_ST_SLOPE_END	58880	E600	ST slope measurement end point

A.3 ST segment measurement value

ST segment measurement value code format shall be defined as follows:

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
ST segment measurement value (see Table A.2)									Lead code						

Figure A.3 — ST segment measurement value code format

Table A.2 — ST segment measurement value code

Reference ID	CODE		Explanation
	DEC	HEX	
MWF_ECG_AMPL_STJ	58624	E500	STj amplitude
MWF_ECG_AMPL_ST	58752	E580	ST amplitude
MWF_ECG_AMPL_ST_SLOPE	59684	E900	ST-slope
MWF_ECG_AMPL_ST1	60672	ED00	ST-amplitude at the J-point plus 20 ms
MWF_ECG_AMPL_ST2	60800	ED80	ST-amplitude at the J-point plus 40 ms
MWF_ECG_AMPL_ST3	60928	EE00	ST-amplitude at the J-point plus 60 ms
MWF_ECG_AMPL_ST4	61056	EE80	ST-amplitude at the J-point plus 80 ms

Annex B
(informative)

Encoding measurement value and interpretation

B.1 Measurement value (with no lead designation)

Measurement value code format shall be defined as follows:

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Measurement value code (see Table B.1)															

Figure B.1 — Measurement value (no lead designation) code format

Table B.1 — Measurement value (no lead designation) code

Reference ID	CODE		Explanation
	DEC	HEX	
MWF_ECG_HEART_RATE	32769	8001	Heart rate
MWF_ECG_VPC_MIN	32778	800A	VPC rate per min
MWF_ECG_VPC_HOUR	32780	800C	VPC rate per hour
MWF_ECG_SYS_BP	32800	8020	Systolic blood pressure
MWF_ECG_DIA_BP	32801	8021	Diastolic blood pressure
MWF_ECG_MEAN_BP	32802	8023	Mean blood pressure
MWF_ECG_DOUBLE_PRODUCT	32803	8024	Double product
MWF_ECG_TARGET_HR	32804	8025	Target heart rate
MWF_ECG_MAXIMUM_HR	32805	8026	Maximum heart rate

B.2 Interpretation

Interpretation code shall be defined as follows:

Table B.2 — Interpretation code

Reference ID	CODE		Explanation
	DEC	HEX	
MWF_ECG_UNDFD	4224	1080	Unclassified
MWF_ECGL_NOR_BEAT	4228	1084	Normal beat
MWF_ ECGL_WPW _BEAT	4232	1088	Wolff-Parkinson-White syndrome type beat
MWF_ECGL_BBB_BEAT	4236	108C	Bundle branch block beat
MWF_ECGL_JUC_BEAT	4240	1090	Junctional beat
MWF_ECGL_SUP_BEAT	4244	1094	Supraventricular beat
MWF_ECGL_SBBB_BEAT	4248	1098	Supraventricular beat with Bundle branch Block
MWF_ECGL_SWPW_BEAT	4252	109C	Supraventricular beat with WPW
MWF_ECGL_AVC_BEAT	4256	10A0	Aberrant Ventricular Conduction

Table B.2 *(continued)*

Reference ID	CODE		Explanation
	DEC	HEX	
MWF_ECGL_VENT_BEAT	4260	10A4	Ventricular beat
MWF_ECGL_FUS_BEAT	4264	10A8	Fusion beat
MWF_ECGL_VENTESP_BEAT	4268	10AC	Ventricular escape beat
MWF_ECGL_IDORHM_BEAT	4272	10B0	Idioventricular rhythm
MWF_ECGL_UNDFD_BEAT	4276	10B4	Undefined beat
MWF_ECGL_UNDFD_L_BEAT	4280	10B8	Learning beat
MWF_ECGL_UNDFD_C_BEAT	4284	10BC	Calibration beat
MWF_ECGL_A_PACE_BEAT	4288	10C0	Atrial paced beat
MWF_ECGL_V_PACE_BEAT	4292	10C4	Ventricular paced beat
MWF_ECGL_D_PACE_BEAT	4296	10C8	Dual paced beat
MWF_ECGLPAC_F_BEAT	4300	10CC	Paced fusion beat
MWF_ECGL_ART_HF	4304	10D0	Artifact High Frequency Noise
MWF_ECGL_ART_LF	4308	10D4	Artifact Low Frequency Noise
MWF_ECGL_BRADY	4480	1180	Bradycardia
MWF_ECGL_TACHY	4484	1184	Tachycardia
MWF_ECGL_PAUSE	4488	1188	Pause
MWF_ECGL_PROLONG	4492	118C	Prolong
MWF_ECGL_VE_ISO	4496	1190	VE Isolated
MWF_ECGL_VE_COU	4500	1194	VE Couplet
MWF_ECGL_VE_RUN	4504	1198	VE Run
MWF_ECGL_VT	4508	119C	Ventricular Tachycardia
MWF_ECGL_RONT	4512	11A0	R on T
MWF_ECGL_VENT_BIGE	4516	11A4	Ventricular Bigeminy
MWF_ECGL_VENT_TRI	4520	11A8	Ventricular Trigeminy
MWF_ECGL_SVE_ISO	4524	11AC	SVE Isolated
MWF_ECGL_SVE_COU	4528	11B0	SVE Couplet
MWF_ECGL_SVE_RUN	4532	11B4	SVE Run
MWF_ECGL_PARO_S_TACHY	4536	11B8	Paroxysmal Supraventricular Tachycardia
MWF_ECGL_SUP_BIGE	4540	11BC	Supraventricular Bigeminy
MWF_ECGL_SUP_TRI	4544	11C0	Supraventricular Trigeminy
MWF_ECGL__A_FIB	4548	11C4	Atrial Fibrillation
MWF_ECGL_A_FLUTTER	4552	11C8	Atrial Flutter
MWF_ECGL_A_F_F	4556	11CC	Atrial Flutter/ Fibrillation
MWF_ECGL_ST_ELE	4560	11D0	ST Elevation
MWF_ECGL_ST_DEP	4564	11D4	ST Depression
MWF_ECGL_CAP_FAIL	4568	11D8	Capture Failure
MWF_ECGL_UNDER_SENS	4572	11DC	Under-sensing
MWF_ECGL_OVER_SENS	4576	11E0	Over-sensing
MWF_ECGL_V_FIB	4580	11E4	Ventricular Fibrillation
MWF_ECGL_V_FLUTTER	4584	11E8	Ventricular Flutter

Annex C
(informative)

Example of waveform coding

Table C.1 below shows an example of the encoding of stress test ECG using the treadmill. In this example, the ECGs are recorded for 4 min at resting period, and for 16 min from the 1st stage to the 4th stage of Bruce protocol at loading period, and for 5,5 min at recovery period. The progress of the stress test is described by event tags and measurement tags. This example describe full disclosure waveform and abstract waveform every one minute.

Table C.1 — Example of encoding stress ECG

Tag name		Code				Descriptions
		Tag No (HEX)	Length (DEC)	Data (HEX)		
1	MWF_PRE	40	32	4d 46 52 20		MFR
				53 74 72 65 73 73 20 74 65 73 74 20 45 43 47 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20		Stress test ECG
2	MWF_BLE	01	1	00		Big endian
3	MWF_WFM	08	2	00 04		Waveform: Stress test ECG
4	MWF_EVT	41	30	Event code	12 00	Type of examination: Exercise stress test
				Starting time	ff ff ff ff	
				Duration	00 00 00 00	
				Event information	45 78 65 72 63 69 73 65 20 73 74 72 65 73 73 20 74 65 73 74	
5	MWF_EVT	41	19	Event code	12 01	Loading device: Treadmill
				Starting time	ff ff ff ff	
				Duration	00 00 00 00	
				Event information	54 72 65 61 64 6d 69 6c 6c	
6	MWF_EVT	41	31	Event code	12 02	Protocol name: Bruce
				Starting time	ff ff ff ff	
				Duration	00 00 00 00	
				Event information	42 72 75 63 65	
7	MWF_NTE	16	47	54 68 69 73 20 65 78 61 6d 69 6e 61 74 69 6f 6e 20 75 73 65 64 20 4d 61 73 6f 6e 2d 4c 69 6b 61 72 20 6c 65 61 64 20 73 79 73 74 65 6d 2e 00		Comment: This examination used Mason-Likar lead system.

Table C.1 *(continued)*

Tag name		Code				Descriptions
		Tag No (HEX)	Length (DEC)	Data (HEX)		
8	MWF_TIM	85	11	Year	07 e3	The examination date and time: 2019/05/15 13:31:20, 0, 0
				Month	05	
				Day	0f	
				Hour	0d	
				Minute	1f	
				Second	14	
				Milli-second	00 00	
				Micro-second	00 00	
9	MWF_AGE	83	7	Years	23	Age: 35 years old Age by day: 12 797 days old Date of birth: 1984/05/01
				Days	4d 55	
				Birth date [y]	07 c0	
				Birth date[M]	05	
				Birth date[D]	01	
10	MWF_SEX	84	1	01		Male
11	MWF_DTP	0a	1	01		Data type: Unsigned 16 bits integer
12	MWF_IVL	0b	4	Unit	01	Sampling interval: 1 sec
				Exponent	00	
				Mantissa	00 01	
13	MWF_PNT	07	4	00 00 00 00		Pointer: 0 sec
14	MWF_EVT	41	10	Event code	12 10	Examination period Starting time: 0 sec Duration: 1 290 sec
				Starting time	00 00 00 00	
				Duration	00 00 05 0a	
15	MWF_EVT	41	10	Event code	12 11	Resting period Starting time: 0 sec Duration: 240 sec
				Starting time	00 00 00 00	
				Duration	00 00 00 f0	
16	MWF_EVT	41	10	Event code	12 13	Loading period Starting time: 240sec Duration: 720 sec
				Starting time	00 00 00 f0	
				Duration	00 00 02 d0	
17	MWF_EVT	41	10	Event code	12 14	Recovery period Starting time: 960 sec Duration: 330 sec
				Starting time	00 00 03 c0	
				Duration	00 00 01 4a	
18	MWF_EVT	41	19	Event code	12 15	Stage 1 period Starting time: 240 sec Duration: 180 sec "loading^1"
				Starting time	00 00 00 f0	
				Duration	00 00 00 b4	
				Event information	6c 6f 61 64 69 6e 67 5e 31	
19	MWF_EVT	41	19	Event code	12 15	Stage 2 period Starting time: 420 sec Duration: 180 sec "loading^2"
				Starting time	00 00 01 a4	
				Duration	00 00 00 b4	
				Event information	6c 6f 61 64 69 6e 67 5e 32	