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An American National Standard

Standard Specification for Transferring Digital Neurophysiological Data Between Independent Computer Systems[1]

This standard is issued under the fixed designation E 1467; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers transmission of digitally recorded electrophysiologic waveform data and related textual annotations between laboratories or clinics, or between computer systems in a given laboratory or clinic. This includes all electroneurophysiology (EN) studies such as electroencephalograms (EEG) and magnetoencephalograms (MEG), polysomnograms (PSG) and multiple sleep latency tests (MSLT), evoked potentials (EP) and evoked magnetic fields (EMF), event-related potentials (ERP), electromyograms (EMG) and nerve conduction studies (NCS), and many others in either a clinical or research environment. Although this specification is concerned primarily with electroneurophysiology, the methods used for encoding waveform and related data would be suitable for other tests involving waveforms, such as electrocardiograms (EKG), vascular/intracranial pressure monitoring, oximetry, or gastrointestinal motility studies.

1.2 This specification defines a format for waveform data based on Specification E 1238 (developed in cooperation with HL7 (Health Industry Level 7)), with extensions to support the transmission of multichannel time-series waveforms.

1.3 This specification may be applied either to two-way transmission of data over medium- to high-speed data communication networks, or one-way transmission of data by recording on and later playback from magnetic or optical digital storage media. It defines the blocked stream of data, called a message, which is transmitted over a network connection or recorded on a storage medium. It does not define the hardware or software network protocols or storage media formats needed for message transmission (for example, see ISO 8072), or the formats used to store data internally by the sender or receiver.

1.4 Recognizing, however, that some standardization in storage media format and network protocols would help to promote exchange of data between computer systems with diverse hardware and software, it is suggested that readily available universal media and formats be used, when possible, for data exchange. An example suitable for transmission of large amounts of digital waveform data would be the use of industry-standard magnetic tape or digital audio tape (DAT), with ANSI standard tape labels, employing variable length blocked records (lines) with a maximum block size of 4092 bytes. Individual lines within the blocks would be terminated by carriage return characters, Code 13 in the American Standard Codes for Information Interchange (ASCII). As another example, for the transmission of moderate amounts of digital waveform data, floppy disks written in MS-DOS **(1)**[2] format (or another commonly used directory and file structure) would be appropriate; the data would be contained within a single sequential file on the disk, with lines within the file delimited by carriage return (ASCII 13) or carriage return followed by linefeed (ASCII 10) characters. An example of network hardware and software suitable for transmission of waveform data would be Ethernet **(2)** and the TCP/IP **(3)** protocol.

1.5 The major topics can be found in the following sections.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this specification.

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2. Referenced Documents

2.1 *ASTM Standards:*

E 1238 Specification for Transferring Clinical Observations Between Independent Computer Systems[3]

2.2 *ANSI Standards:*

X3.4-1986 Coded Character Sets—American National

[3] *Annual Book of ASTM Standards*, Vol 14.01.

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Standard Code for Information Interchange (7-Bit ASCII)[4]

X3.50-1986 Representations for U.S. Customary, SI, and Other Units to be Used in Systems with Limited Character Sets[4]

2.3 *ISO Standards:*

ISO 2022-1986 Information Processing—ISO 7-Bit and 8-Bit Coded Character Sets—Code Extension Techniques[5]

ISO 2955-1983 Information Processing—Representation of SI and Other Units in Systems with Limited Character Sets, 2nd Edition[5]

ISO 4217-1990 Codes for the Representation of Currencies and Funds[5]

ISO 8072-1986 Network Standards[5]

ISO 8859-1988 Information Processing—8-Bit Single-Byte Coded Graphic Character Sets[5]

ISO 10646-1993 Information Technology—Universal Multiple-Octet Coded Character Sets (UCS)—Part I: Architecture and Basic Multilingual Plane[5]

2.4 *Other Standard:*

Health Industry Level 7 Interface Standards[6]

3. Significance and Use

3.1 *General Approach*:

3.1.1 This specification defines a general and flexible mechanism for the formatting and transmission of digitized waveforms in order to facilitate portable exchange between dissimilar computer systems. This mechanism can serve for many different types of physiological signals. This specification also defines how associated identifying and other annotative textual data can be incorporated into the data stream. Such information in digital form provides the complete context necessary for interpretation of a test or study performed for clinical diagnosis or for basic or clinical research purposes.

3.1.2 Both primary and derived data comprising an electrophysiologic study may be transmitted using this specification. Primary data includes digitized waveforms for multiple channels; channel identifications, sensitivities, filter settings, and sampling frequency; averaging parameters (for averaged data); date and time-of-day labels; electrode or transducer locations and attributes; measured distances; stimulation parameters (when visual, auditory, electrical, or other stimulation is performed); calibration data; technical comments before or during the study; medications administered; special procedures performed; and instrument(s) used. This primary data represents everything that would be traditionally written on paper along with the waveforms at the time the study was performed.

3.1.3 Derived data includes measured feature or peak latencies, amplitudes, and other characteristics (which may be detected and generated by automatic algorithms or by a technician or physician scan of the data), or results of computer processing of the primary data (for example, spectral analyses). It also includes the quantitative or qualitative results which are reported to the ordering physician and which may be compared with the laboratory's normal ranges for these quantities, and text reports, interpretations, diagnoses, and recommendations which are sent back to the ordering physician.

3.1.4 This specification further defines how the general mechanisms for formatting and transmitting these data are to be applied specifically for electroneurophysiologic study data. Applications for EKG and other electrophysiologic studies can be developed using the same general mechanisms.

3.2 *Levels of Implementation*:

3.2.1 In order to facilitate the use of this specification over a wide range of applications, various levels of implementation are defined. Applications of this specification may range from simple embedded controllers in instrumentation at the most basic level, to integrated laboratory information systems at the higher levels. Simple implementations may evolve into more fully featured systems as needs arise. Three levels are defined, according to the scope and nature of data to be transmitted, as follows:

3.2.1.1 *Level I–Waveforms Only*—This most basic level of implementation specifies the mechanism for transmission of digitized, multichannel, time-series waveforms. A Level I transmission includes the information required for proper decoding of the digital waveform data and labeling of channels. It further includes an *envelope*, formatted in accordance with Specification E 1238 (or, alternatively, HL7) standard message structure, which provides the information required by a deformatting program in a system receiving the transmission. A Level I implementation of a receiving system would only need to recognize those types of data defined as required in Level I, but it must be designed to accept, without generating an error condition, any additional data included in a transmission produced by a higher level system; the additional information which is irrelevant to the Level I receiving system may be ignored or merely logged without interpretation.

3.2.1.2 *Level II–Waveforms or Procedure Annotations, or Both*—This level may include waveform data, but in addition it specifies the mechanism for embedding in the data transmission various identifying, annotative, and interpretive information associated with the study. This information constitutes a digital representation of the entire study. Level II defines the required data elements and their format, as well as optional data elements (with provision for site-specific data). Much of the data consists of free format text, such as labels and annotations which may be displayed on a screen (usually in association with the waveforms) or printed on a report form. A Level II implementation need not necessarily handle actual digital waveform data; it may, for example, deal only with the final interpretive report for transmission between computers comprising a hospital information system. All Level II receiving systems must, nevertheless, be designed to accept digital waveform data incorporated in a Level I, II, or III transmission without generating an error condition, even if the waveform information is merely ignored.

3.2.1.3 *Level III–Coded Information*—Level III has the same scope of data as Level II but, in addition, associates standard alphanumeric codes with several of the textual data

[4] Available from American National Standards Institute (ANSI), 11 West 42nd St., 13th floor, New York, NY 10036.

[5] Available from International Standards Organization (ISO), 1 Rue de Varembe, Case Postale 56, CH1211, Geneve, Switzerland.

[6] Health Level 7, Mark McDougall, Executive Director, 900 Victors Way, Suite 122, Ann Arbor, MI 48108.

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elements. For example, in Level II implementations, a diagnostic impression which applied to a particular study or portion thereof would be transmitted as a text string of arbitrary contents; in Level III implementations, it could alternatively be transmitted as an alphanumeric code such as an ICD-9-CM code **(4)** which the receiving system would translate into a defined text string by means of an internal table of diagnoses. The intent is to create a more structured and standardized medical record and thereby facilitate automated machine processing. For example, codification of the possible responses in a data field would allow a receiving system to make decisions regarding printing or display, automatic routing, etc., more easily based on the information contained in the transmission. Furthermore, the use of alphanumerically coded data would increase the uniformity of the medical record within an institution or laboratory and among different institutions, and misinterpretation or misapplication of information would not be as likely as with free text.

3.2.2 This version of the specification introduces a system of universal codes (based on CPT-4 **(5)**) for classifying the standard electrophysiologic studies, for grading quantitative or classifying qualitative test results, for specifying anatomic localizations, and for specifying diagnostic impressions for electrophysiologic tests (see Appendix X2). These codes should be used whenever appropriate by Level I and II implementations, in association with a text description, but only Level III implementations would be required to include a code table and thus be able to translate the alphanumeric code into a text description (or vice versa) when needed. Instead of, or in addition to, using these universal codes, an institution or laboratory may use a locally defined coding system, if available. The format defined by this specification for those data items which may be coded is flexible enough that a transmitting system may always elect to send either an alphanumeric code or a text string, or both. If both were transmitted, for example, a receiving system of any implementation level could simply display the textual data as received, possibly ignoring the alphanumeric code; only a Level III receiving system would be required to maintain code tables and could therefore generate the text string automatically if only an alphanumeric code were sent.

3.3 *Direction of Information Exchange*—Some systems will be producers of information (also referred to as acquisition systems, transmitters or senders, formatters), while some will be consumers of information (display systems, receivers, deformatters). A given system may be both a producer and a consumer; an example is a digital machine that had the capability to transmit the waveform data which it acquired to another computer for signal processing, specialized display, archiving, or reporting, as well as the capability to receive data from another device for viewing on its display screen or printing on a hardcopy device.

3.4 *Types of Communication Supported*—A further delineation of complexity of implementation concerns two-way communication between systems. In a fully integrated hospital information system, for example, a laboratory computer may receive from another computer system an order to perform a test or a request for data; it might be expected to respond to such an event, and this specification defines the mechanisms to implement this capability. On the other hand, a particular instrument may only be able to output the data it acquires, without any facility for interaction with the receiving system.

3.5 *Description of Implementation*—A full description of a given implementation of this specification in a laboratory instrument or software system will require designation of level (Level I, II, or III), type of data handled (waveforms or annotations, or both), direction of exchange (transmitter or receiver), and communications capability (one-way or two-way message interface) as well as the type(s) of networks or storage media, or both, supported for data transmission or reception. Furthermore, coding schemes for Level III implementations must be specified or described. In addition, the limitations of the system (for example, minimum and maximum sampling frequencies for digital waveform data, maximum numbers of channels and montages, allowed transmission data formats, etc.) must be specified.

4. Message General Content Considerations

4.1 *Relation to Specification E 1238 and HL7 Standards*:

4.1.1 This specification is primarily based on Specification E 1238. All requirements of Specification E 1238 must be adhered to by implementations of *this* specification, except where specifically noted herein. Specification E 1238 defines some features (such as data types, information categories, and code tables) which are not mentioned in this specification; if any of these features are applicable, they may be used by a system which implements *this* specification.

4.1.2 Although the message format defined by Specification E 1238 is the recommended standard and portable format for applications which use this specification for transferring electrophysiologic data (including digitized waveforms) between independent computer systems, some systems or institutions which already implement the HL7 message protocol may wish to embed their electrophysiologic data instead within an HL7 message. Since Specification E 1238 OBR (order) and OBX (result) segments are essentially identical to the HL7 OBR and OBX segments, orders for electrophysiologic studies as well as the results (observations) from those studies can be transmitted within an HL7 formatted message instead of a Specification E 1238 formatted message. In this case, the HL7 message types such as ACK (general acknowledgment), ORF (observation result, response to query), ORM (order), ORR (order response), ORU (observation result, unsolicited), QRY (query), etc., as well as the HL7 segment types such as EVN (event type), MSA (message acknowledgment), MSH (message header), NTE (notes and comments), ORC (common order), PID (patient identification), PV1 (patient visit), QRD (query definition), QRF (query filter), etc., defined in the HL7 document are used in place of the Specification E 1238 message format and segment types such as H (message header), P (patient identification), E (error checking), C (comment), Q (query), and L (message terminator) described in this specification.

4.1.3 While Specification E 1238 is concerned only with the transfer of clinical provider and diagnostic service orders and results (observations), HL7 is concerned with all information services within a hospital network including admission/

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discharge/transfer, billing, pharmacy orders, and other functions); the HL7 message structure is correspondingly more complex and general and may involve additional processing overhead (for example, all HL7 messages transmitted over the network must be acknowledged). Although the message and segment formats differ (aside from OBR and OBX segments), many of the data fields and their formats are similar between the two standards. Thus, in institutions which need to use HL7 for networked communications between most institutional computer systems, but want to use the simpler Specification E 1238 format for communications among a limited number of laboratory computer systems, a *gateway* system which translates HL7-formatted order messages to Specification E 1238 format and Specification E 1238 formatted result messages to HL7 format would be relatively easily implemented.

4.1.4 This specification, like Specification E 1238 and HL7, defines both the logical content of a data interchange and the encoding rules for representing that content in a particular message. *Logical content* means the specification of the data elements (fields), their logical representation (for example, a date is recorded as **YYYYMMDD**), their aggregation into segments, and the aggregation of segments into messages. *Encoding rules* means the rules that now specify that messages be represented as ASCII characters, that fields be identified by their position in a segment, and that delimiters separate the data elements within segments. The distinction between logical content and encoding rules is important because the two should be independent. With the exception of the data and segment types, Section 4 deals mostly with encoding rule issues; subsequent sections deal mostly with logical content. Future versions of this specification will make these distinctions more formal to permit the use of alternative encoding rules to represent the specification's logical content.

4.2 *Extensions to Specification E 1238 and HL7 Standard Formats*—This specification defines several minor extensions to these standards, as described as follows. The use of these extensions in data transmissions is optional; a transmitting system which implements this specification may choose to send data in a format which is entirely compatible with Specification E 1238 and HL7 standards, but a receiver system must be able to accept transmissions that use these extensions when appropriate, in order to be considered compatible with this specification.

4.2.1 *Specifying Information Categories in OBR and Q Segments*—This specification extends the order (OBR) segment test/observation identification (ID) field to allow specification of an optional information category code after the test/observation ID (separated by a subcomponent delimiter) when it is desired to restrict the types of result segments which will be returned in response to the order request in a two-way message transmission system; this would also apply to the Specification E 1238 request results (Q) segment test/observation ID field. Although this capability is currently not explicitly stated in the Specification E 1238 and HL7 standards, it is consistent with the usage of information category codes in test/observation IDs in result (OBX) segments.

4.2.2 *Specific Code Table Identifiers in Coded Entries*—This specification extends the Specification E 1238 and HL7 standards coded entry (CE) format to allow specification of an optional specific code table identifier as a second subcomponent of the third or sixth components (following the coding system mnemonic identifier). The Specification E 1238 and HL7 standards explicitly allow a second subcomponent in these components only when the coding system mnemonic indicates local codes (**99zzz**, where each *z* represents an alphanumeric character, or **L**), but it is also useful to be able to delineate specific code tables for other coding systems (for example, to distinguish SNOMED **(6)** diagnostic codes from SNOMED topographic codes).

4.2.3 *Maximum Field Lengths in OBX Segments*—This specification increases the maximum length of several OBX segment fields to accommodate the needs of electrophysiologic data transmissions. The maximum length of the OBX segment test/observation ID field is increased from 80 to 590 characters, to allow for the long text descriptions of tests, portions of tests, and individual test results which may be needed for electrophysiology. The maximum length of the OBX segment units field is also increased from 20 to 590 characters, to allow for longer units of measure in the coded entry (CE) data format. In addition, this specification allows an alternative format for the reference range in the OBX segment that may be used when there is only one bound, not two.

4.2.4 *Message Acknowledgment (MSA) Segment*—This specification defines an additional segment type MSA (message acknowledgment), which may be used in messages sent in reply to another message (in systems that implement two-way communication) to identify the original message, specify whether the original message was successfully processed or whether an error was detected, and (in messages responding to a system characteristics query request) to return the system characteristics or capabilities (the response to the query). This segment closely follows the format of the HL7 MSA segment; however, the last two fields of the HL7 MSA segment are not used in this specification because they are not relevant to Specification E 1238 formatted messages.

4.2.5 *Subject Filter and Qualifiers Field in Q Segments*—This specification uses requestor special field 2 in the request result (Q) segment as a subject filter and qualifiers field. Its data type is changed from ST (string) to CM (composite miscellaneous) so that it may contain more than one component. The field is used to extend the usage of the Q segment to encompass a variety of queries other than requests for results. The first component of this field is similar to the *What Subject Filter* field in the HL7 Query Definition (QRD) segment, while subsequent components further qualify the subject of the query. This field was set aside by Specification E 1238 for arbitrary use by the requesting (querying) system.

4.3 *Message Characteristics and Terminology*—Specification E 1238 and the HL7 encoding rules define a format for message transmission which is compatible with a wide variety of computers, operating systems, and communications media.

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4.3.1 *Characters*—In order to promote interchange of data among systems using the largest possible variety of architectures, operating systems, networks, and storage media, all data in the message should be limited to a restricted set of ASCII characters as defined in ANSI X3.4-1986; specifically, these include ASCII 32 through 126 (space, lower and upper case letters, digits, and special printing characters), 7 (bell), 9 (tab), 10 (linefeed), 11 (vertical tab), and 12 (formfeed), with ASCII 13 (carriage return) reserved for use as a line terminator. However, any unprintable characters (ASCII 0 to 31 or 127) immediately following a carriage return and up to the next printable character (ASCII 32 through 126) will be ignored by the receiver. Thus, for example, either carriage return or carriage return followed by linefeed can be used as an end of line sequence. The restriction to the limited subset of 7-bit ASCII characters is necessary since some existing operating systems and media or networks can only send and receive these characters, while others may make use of the high-order bit of each 8-bit byte or of the non-printable control characters to control message flow or for parity and similar data integrity checks.

4.3.1.1 It is recognized that, in certain contexts, a full 8-bit character set may be necessary or useful. For example, the international community has need of printable characters such as é or ü, which are not within the restricted character set defined in 4.3.1 (such a character may be included in text data by use of the \Dnnn\ escape sequence defined in 4.4.15, where *nnn* is the three-digit decimal code for the desired character, but this method requires six bytes to transmit a single character). ISO 8859 defines one 256 character (8-bit) set that does include all of the needed letters for the European languages, and at this time it would be the recommended character set for implementations of this specification in countries which use European languages and need to conveniently and compactly represent characters other than those defined in ANSI X3.4-1986. Also, certain systems may need to transmit waveform data in a nonstandard format for efficiency reasons, and may use the \Zdddd\ escape sequence for this purpose with 8-bit characters included in the sequence (for example, when transmitting *binary* data). The restriction on character set in 4.3.1 may therefore be ignored (that is, arbitrary 8-bit characters may be transmitted) if the transmitting and receiving systems and the communications media used are known to support the full set of character codes, but the transmitting system then runs a risk of not being able to send its data to an alternate receiving system or by means of alternate communications media or networks. The use of characters other than the restricted set defined in 4.3.1 is thus to be considered non-portable and nonstandard, and should be used primarily for internal communications within a particular system or institution. A receiving system which is compatible with this specification need not be designed to accept characters other than from the restricted set.

4.3.1.2 For many languages (such as Japanese or Chinese), even 8-bit character codes are not sufficient to represent all of the characters that may be needed, especially in text data, such as comments and reports. Two possible ways to transmit characters represented by more than eight bits are (*1*) to use a fixed number (two or more) bytes to transmit each character in the message (including delimiter characters and line terminator characters), or (*2*) to mix single-byte and multi-byte characters in the same message by using special escape sequences to switch from single-byte mode to multi-byte mode and from multi-byte mode to single-byte mode. An example of the former method is the UNICODE character set (**7**) or the ISO 10646 standard. An example of the latter method is the ISO 2022 standard (which has been adopted in Japan as JIS × 0202 in order to mix Kanji and ASCII characters). Either of these methods could be used in implementations of this specification in countries that need to conveniently and compactly represent characters requiring more than eight bits, but until a single such character set achieves the status of a universal world standard, interchange of data using such multi-byte character sets can take place only within particular systems or institutions that agree to communicate in this fashion. When escape sequences are used to switch between different character byte lengths, the multi-byte characters and their surrounding escape sequences should be confined to specific data items (most commonly text fields) in the message; the delimiter characters that separate these data items should be the usual single-byte (preferably 7-bit ASCII) characters.

4.3.1.3 In this specification, *alphabetic* characters refer to lower and upper case letters; *numeric* characters refer to the digits 0 to 9 and the decimal point (.); and *alphanumeric* characters refer to lower and upper case letters, digits, period (.), hyphen (-), slash (/), plus (+), asterisk (*), percent (%), parentheses (()), and underscore (_); the last nine are *alphabet extenders* that may be used in codes or names to increase readability, or for special purposes.

4.3.2 *Segments*—The message consists of a sequential series of segments, each of which conveys one aspect of the message. Each segment is of a particular type. For example, there are header segments, order (OBR) segments, result (OBX) segments, etc. Paragraph 4.5 lists the allowed types of segments in a Specification E 1238 message; see the HL7 document for allowed segment types in an HL7 message. A segment is transmitted as a single line ending in a carriage return character or, when necessary, as multiple lines (the first line beginning the segment, and the subsequent *addenda* lines continuing it, as described in 4.3.7).

4.3.3 *Fields*—A segment consists of one or more fields, separated from each other by field delimiter characters. Each field defines one attribute of the segment. A field may itself contain aggregates of data elements in a hierarchical fashion, each separated from the others by an appropriate delimiter character. Specifically, a field may consist of more than one subfield separated by repeat delimiters; a subfield may consist of one or more components separated by component delimiters; and a component may consist of one or more subcomponents separated by subcomponent delimiters. Each of these data elements has a defined data type (text, numeric, coded entry, etc.), as described in 4.4.

4.3.4 *Delimiters*—Within data elements (fields, subfields, components, and subcomponents), only printable ASCII characters (32 through 126) are permitted, and field, repeat, component, and subcomponent delimiters, and the escape

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character (except when beginning or ending an escape sequence in text data) must be excluded. The sender is responsible for screening all data elements to ensure that they do not contain those delimiters. The recommended delimiters are: field delimiter |(vertical bar); repeat delimiter ~ (tilde); component delimiter ^(caret); subcomponent delimiter **&** (ampersand); and escape character \ (backslash). Although other printable (@, #, $) and special (bell, tab, vertical tab, formfeed, linefeed) characters *may* be used for delimiters (since the five delimiter characters are specified in the message header segment at the start of the transmission), these characters are used in the examples in this specification. The alphanumeric characters defined in 4.3.1.3, spaces (blanks), punctuation marks (!;:`'",.?), braces and brackets ([{}]), and the less than (<), equal (=), and greater than (>) characters should not be used as delimiters because they are likely to appear within data elements.

4.3.5 *Case Sensitivity*—Keywords and code names defined in this specification are *case insensitive* (their meaning is unchanged whether transmitted in upper or lower case). The case of free-format text, including user-defined electrode, channel, and analysis parameter names, is preserved during transmission; a receiver may or may not treat instances of user-defined names with differing case (for example, FP1 and fp1) as the same name.

4.3.6 *Field Lengths*—All fields are variable in length. Fields are terminated by a field delimiter (or by a carriage return if the following line is not an addenda line). This specification defines a maximum length for each field, component, or subcomponent. A transmission *may* include fields, components, or subcomponents which exceed these maximum lengths (due to transmitter software design or error, or due to a transmission error such as a lost delimiter), and all receiving systems which adhere to this specification must accept the extra characters without generating a fatal error. However, a receiver may ignore any characters in a field, component, or subcomponent beyond the maximum length; alternatively, to allow more flexibility and to provide for increases in the maximum lengths that may be incorporated into future versions of this specification, receiving systems *may* be designed to process more characters than the currently specified maxima.

4.3.7 *Maximum Line Length*—Specification E 1238 allows a maximum line length of 220 characters, including the terminating carriage return. Segments longer than 220 characters must be transmitted as multiple lines, using an addenda marker in the first two character positions of lines after the first to indicate logical continuation of a field, component, or subcomponent into the next line. That is, any segment which would exceed the 220 character maximum line length must be split by inserting a carriage return, an **A** character, and a field delimiter (|) in the character stream at appropriate intervals (the break may occur at any point, even in the middle of a field, subfield, component, or subcomponent). This provision is necessary because of the maximum line lengths allowed by some communications networks, media, file systems, and operating systems. This restriction on line length may be ignored (that is, lines longer than 220 characters may be transmitted) if the transmitting and receiving systems and the communications media used are known to support longer lines, but the transmitting system then runs a risk of not being able to send its data to an alternate receiving system or by means of alternate communications media or networks. The use of lines longer than 220 characters within a Specification E 1238 message is thus to be considered non-portable and nonstandard, and should be used primarily for internal communications within a particular system or institution. A receiving system which is compatible with this specification need not be designed to accept lines longer than 220 characters. HL7 does not define maximum line lengths and HL7 messages do not use addenda lines.

4.3.8 *Not Present and Null Values*—All fields, components, and subcomponents are positional. Values which are not present (omitted if they are the last field, or else specified as two adjacent delimiters) are usually interpreted by the receiving system as an instruction to use some default or previously transmitted value for that field, component, or subcomponent. If it is desired to set a field, component, or subcomponent explicitly to a null string, two adjacent double quotes " " (ASCII 34, 34) may be used to override any default or preexisting values for the field, component, or subcomponent. If a receiving system cannot deal with a data item which is not present, it may treat it as present but null.

4.3.9 *Units of Measure*—The standard representations of units of measure are either the SI unit abbreviations defined by ISO 2955-1983 or the U.S. customary unit abbreviations defined by ANSI X3.50-1986, supplemented by additional units used for clinical care given in Specification E 1238, Tables 26 (ANSI) and 25 (ISO). This specification also defines two special units for electrophysiology (*pha* = number of phases and *tur* = number of turns in a waveform) which may be used as if they were part of the ISO units. The two systems of units are identified by coding system mnemonic identifiers **ISO+** and **ANS+**, respectively, in coded entry fields (see 4.4.2). It is necessary to specify which system is used, since some abbreviations have different meanings in each system (for example, ft = femptotesla in **ISO+**, but ft = foot in **ANS+**); the default is **ISO+**. Only single case abbreviations are used since all names are case insensitive in this specification. New units may be created by prefixing a multiplier to a basic unit (for example, uv = micro + volts). Derived units can also be created by raising a basic unit to an exponential power by appending the exponent (with leading 0. if fractional) to the unit (for example, uv2 = μV^2 = microvolts squared, hz-1 = Hz^{-1} = 1/hertz, hz0.5 = $Hz^{1/2}$ = square root of hertz). Derived units can also be created by multiplying or dividing two basic units. This is signified by a period **(.)** or a slash **(/)** between units (for example, mv.s = millivolts times seconds, m/s = metres per second). These options may be combined when necessary; for example, uv2/hz = microvolts squared per hertz (unit of spectral power), uv/hz0.5 = microvolts per square root of hertz (unit of spectral amplitude). Exponentiation has precedence over multiplication or division.

4.4 *Data Types*—The following briefly describes most of the data types which may be used in fields, components, and subcomponents of segments, along with their two character

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mnemonics. Refer to Specification E 1238 or HL7 for detailed information about the use and format of all of these data types.

4.4.1 *Address Data (AD)*—This composite data type is used to represent postal addresses. An AD type field consists of six-components, separated by component delimiters (**^**). The first component is the street address or post office box number. The second component is the apartment number or other internal address. The third component is the city. The fourth component is the state or province. The fifth component is the zip or postal code. The sixth (optional) component is the country name.

4.4.2 *Coded Entry Data (CE)*—This composite data type is used to represent most of the computer-interpretable variable data items within a segment. This specification, along with the Specification E 1238 and HL7 standards, encourages the transmission of diagnostic impressions, anatomic localizations, qualitative test results or findings, and similar items as coded data, and it requires that test/observation identifiers be transmitted as coded data. By providing both an alphanumeric code and the identity of the coding system and code table, the CE data type decouples the definition of the message structure (syntax) from the actual diagnostic/anatomic/observation codes (semantics), and allows flexible choice of a coding system and the use of multiple coding systems for different purposes. Finally, the CE data type permits a transmitting system to send a data item using locally defined codes in addition to or instead of universal (national or international) codes, provided that the locally defined codes are known to the receiving system. A coded entry (CE) field contains up to six optional components, organized as two triplets. Each triplet specifies a code and a coding system, so the complete coded entry field can specify two completely separate codes and coding systems for the same data item. The format is as follows:

<Code 1> ^ <Text or description of Code 1> ^ <Nature of Code 1> ^
< Code 2> ^ <Text or description of Code 2> ^ <Nature of Code 2>

In most cases, only the first three components are used, and often the third component is not present because the default applies. The components of a CE format field are as follows:

4.4.2.1 *Code 1*—This component contains an alphanumeric code that identifies the data item, taken from a generally accepted coding system; in certain cases (specifically, for test/observation IDs), this code may consist of an alphanumeric portion, followed by a subcomponent delimiter (**&**) and an alphabetic information category code. It is possible for this alphanumeric code in a CE format field to be not present, so that the data item being transmitted is defined by a text description only, but this practice is discouraged.

4.4.2.2 *Text for Code 1*—This component contains a text description of the data item identified by Code 1. It may be used to provide an annotated description of the alphanumeric code for Level I or II receiving systems that do not implement code tables and are, therefore, unable to supply a text description from the code alone. Also, it can be used to identify and describe an item that the sender cannot represent with an alphanumeric code from any available coding system, or to provide added specificity or detail to the specified alphanumeric code, but, in this case, manual intervention by the receiving system may be needed to determine the exact nature of the data item. In a Level III implementation of this specification, tables of text descriptions of each code in the available coding systems are part of the receiving system so that an alphanumeric code sent alone can be expanded to a full text description; such tables are not implemented in lower levels.

4.4.2.3 *Nature of Code 1*—This component identifies the coding system used for Code 1. It consists of a coding system mnemonic identifier (alphanumeric) and an optional specific code table identifier (alphanumeric) separated from the coding system identifier by a subcomponent delimiter (**&**). Examples of available coding system mnemonic identifiers and corresponding specific code table identifiers are given in Table 1; refer to Specification E 1238 for a complete list. The default coding system and code table depends on the nature of the CE format field. For diagnostic impressions, the default is **I9C**. For anatomic localizations, the default is **SNM+&TOPO**, except when used in a result segment transmitting an anatomic localization (distribution) as an individual test result, for which the default is **AS4&DIST**. For test/observation IDs, the default is **AS4&TEST**. For individual qualitative test results or findings, the default is **AS4&xxxx**, where the specific code table identifier *xxxx* depends on the individual test, which is determined by the test/observation ID (see Appendix X2). For units of measure, the default is **ISO+**.

4.4.2.4 *Code 2*—This component contains any secondary alphanumeric code used to identify the data item. The format is the same as Code 1.

4.4.2.5 *Text for Code 2*—This component contains a text description of the data item identified by Code 2. The format is the same as Text for Code 1.

4.4.2.6 *Nature of Code 2*—This component identifies the coding system used for Code 2. The format is the same as Nature of Code 1, but the default coding system is **L**.

4.4.3 *Composite ID with Check Digit Data (CK)*—This composite data type is used to represent patient identifiers. A CK type field consists of three subcomponents separated by subcomponent delimiters (**&**). The first (required) subcomponent is an ID number, which should not include special characters such as hyphens. The second (optional) subcomponent is a check digit (a single digit used to verify the validity of the ID number). The third (optional) subcomponent is a code which identifies the algorithm used to calculate the check digit; the default is **M10** (mod 10), but alternatives such as **M11** (mod 11) can be employed. See Specification E 1238 for information on how to calculate a mod 10 check digit. The use of check digits for patient identifiers is encouraged but not required.

4.4.4 *Composite Miscellaneous Data (CM)*—This composite data type applies to entire fields of segments, and consists of data of arbitrary length, with a defined format, using repeat, component, and subcomponent delimiters to separate individual items within the field. It is used in segments that transmit miscellaneous non-narrative type data. For example,

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TABLE 1 Mnemonic Identifiers of Coding Systems

Mnemonic	Description
All Coding Systems	
99zzz or L	Locally defined codes (where each *z* represents an alphanumeric character); a specific mnemonic *zzz* may be used to distinguish between different locally defined coding systems in use at one site, or the letter **L** may be used if there is only one locally defined coding system; also a specific code table identifier may be used which is unique to each laboratory or application in a given site (identified by the sending system ID in the message header).
Diagnostic Impression Coding Systems	
I9C	ICD-9-CM (International classification of diseases, 9th revision, clinical modification) diagnosis codes.
I10	ICD-10 (International classification of diseases, 10th revision) diagnosis codes.
SNM	SNOMED (Systemized Nomenclature of Medicine) diagnosis codes, one of the seven currently defined axes of SNOMED (specific code table identifier **DIAG**).
ICSD	ICSD (International Classification of Sleep Disorders) diagnosis codes.
AS4	Specification E 1467 universal diagnosis codes, defined in Appendix X2 (specific code table identifiers **BAED**, **DVED**, **ECOD**, **EEGD**, **EMGD**, **ERGD**, **LAED**, **MAED**, **MNCD**, **MRPD**, **MSED**, **NMJD**, **PSED**, **SEPD**, **SNCD**, **SSED**, **TSED**, and **VEPD**).
Anatomic (topographic) Localization Coding Systems	
SNM+	SNOMED (Systemized Nomenclature of Medicine) topographic codes, one of the seven currently defined axes of SNOMED, extended with qualifiers; those most applicable to electroneurophysiology are listed in Appendix X1 (specific code table identifier **TOPO**).
AS4	Specification E 1467 universal anatomic distribution (localization) codes, defined in Appendix X2 (specific code table identifier **DIST**).
Test/Observation ID Coding Systems	
AS4	Specification E 1467 universal test/observation ID codes, defined in Specification E 1238 and in Appendix X2 (specific code table identifier **TEST**).
C4	CPT-4 (Physicians' Current Procedural Terminology, 4th edition) test codes.
Individual Test Result Coding/Grading Systems	
AS4	Specification E 1467 universal test result codes, defined in Appendix X2 (specific code table identifiers **ABUN**, **ASYM**, **COLO**, **DIST**, **LOHI**, **MRPH**, **PATT**, **REAC**, **RELA**, **RTHM**, **SHLO**, **SMLG**, **STAG**, **TMPM**, and **WAVE**).
Units of Measure Coding Systems	
ISO+	Extended SI units standard single case abbreviations.
ANS+	Extended U.S. customary units standard single case abbreviations.
Producer Identifier Coding Systems	
MCR	Medicare/HCFA's universal producer numbers (unique codes for each medical facility or laboratory in the United States).
UPIN	Medicare HCFA's universal physician identification numbers (unique codes for each physician or health care provider in the United States).
Drug/Medication Coding Systems	
W1	World Health Organization record number codes (six-digit format); these codes are unique for each single component and multicomponent drug.
W2	World Health Organization record number codes (eight-digit format); these codes add an additional two digits to the **W1** codes to identify the salt of single content drugs.
Medical Device Coding Systems	
UMD	Universal Medical Device Nomenclature System (MDNS) codes; these codes are unique for each type of biomedical device, but do not uniquely identify a particular make or model.

the digitized waveform data). Each component/subcomponent within a CM field has its own data type.

4.4.5 *Composite ID and Name Data (CNA)*—This composite data type is used to represent the ID code and name of a caregiver (for example, physician). A CNA type field consists of three optional components separated by component delimiters (^). The first component is the alphanumeric caregiver ID code, using the coding system specified in the third component. The second component is the caregiver name; it consists of six optional subcomponents separated by subcomponent delimiters **(&)**, as follows: last name; first name; middle name or initial; name suffix (for example, Jr., or III); prefix or title (for example, Dr., Mr., Ms); and degree (for example, MD, PhD, DDS). The third component identifies the coding system used in the first component. Allowed values include **UPIN** (Unique Physician Identification No., HCFA's universal physician codes **(8)**, the default) or **99zzz** or **L** (locally defined codes, where each *z* represents an alphanumeric character). In a CNA format field either a code or a name, or both, may be included.

4.4.6 *Composite Quantity and Units Data (CQ)*—This composite data type is used to represent numeric quantities and their units. A CQ type field consists of two components separated by component delimiters (^). The first component is a numeric quantity. The second (optional) component specifies the units of measurement of the quantity, and consists of six optional subcomponents separated by subcomponent delimiters **(&)**, in a format similar to the CE data type. The first and fourth subcomponents contain standard abbreviations for the units of measure using a standard coding system; the second and fifth subcomponents contain corresponding text descriptions of the units; and the third and sixth subcomponents contain an identification of the coding system used in the first (the default is **ISO+**, but **ANS+** is an alternative) and fourth (the default is **L**, local codes) subcomponents. The coding system mnemonic identifier **ISO+** indicates standard single case abbreviations of SI units (ISO 2955-1983), while **ANS+** indicates standard single case abbreviations of U.S. customary units (ANSI X3.50-1986) not included in the ISO set; derived units may also be used. Many type CQ fields have a default unit defined, which is assumed if the entire second component is omitted.

4.4.7 *Identification String Data (ID)*—This data type is used to represent items for which one choice applies out of a number of defined options. The particular choice is represented by an alphanumeric keyword, and the available choices are usually defined in the relevant sections of this specification. In some cases, a transmitting system may send a keyword *not* included among the available options, if this keyword is known to have some meaning to the receiving system. This allows for *ad hoc* extensions to this specification; note, however, that future versions of this specification may add new keywords that may preempt the nonstandard meanings attached to the same keywords by existing applications.

4.4.8 *Money Data (MO)*—This composite data type is used to represent monetary quantities and the currency of measure. An MO type field consists of two components separated by component delimiters (^). The first component is a numeric quantity that specifies the money amount. The second (optional) component specifies the currency of measure, using the short ISO codes for currency (ISO 4217-1990). If omitted, the default currency is dollars in the United States; other defaults may be assumed by local agreement.

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4.4.9 *Numeric Data (NM)*—This data type is used to represent quantitative items, which may consist of digits (0–9), an optional decimal point (.), and an optional preceding plus (+) or minus (–) sign. Scientific notation (mantissa and exponent) is not allowed.

4.4.10 *Person Name Data (PN)*—This composite data type is used to represent a person's name, such as a patient name. A field of type PN consists of six optional components separated by component delimiters (^). The first component is the last name. The second component is the first name. The third component is the middle name or initial. The fourth component is the name suffix (for example, Jr., or III). The fifth component is a prefix or title (for example, Dr., Mr., Ms). The sixth component is a degree (for example, PhD, DDS, MD).

4.4.11 *Reference Pointer Data (RP)*—This composite data type is used to uniquely identify data which is stored on another system using a pointer to that data. An RP type field consists of three components separated by component delimiters (^), as follows:

<pointer> ^ <application ID> ^ <type of data>

The first component is a unique key or address assigned by the system on which the data is stored, and may be used to identify and access the data. The second component specifies the unique name (up to six characters in length) of the system on which the data is stored (like the sender ID and receiver ID fields in the message header segment); these names must be unique within a given set of systems which communicate using the E1467 message format. The third component is a code identifying the type of data stored and may be one of the following codes, or another code that has meaning to both the sending and receiving systems (the last of these codes is not defined by Specification E 1238, but is a Specification E 1467 extension):

SI = scanned image
SD = scanned document
TX = *machine-readable* text
FT = formatted text
WV = digitized waveform data

4.4.12 *String Data (ST)*—This data type is used to represent items as a simple text string, left justified. String fields are limited in length (typically up to 200 characters), as opposed to TX (text) data, which are virtually unlimited in length.

4.4.13 *Telephone Number Data (TN)*—This data type is used to represent telephone numbers. A field of type TN is a string field with a specific format, as follows:

iii(aaa)ppp-nnnnXeeeeBbbbbCcccc

where **iii** is an optional long distance access code or international country code, **(aaa)** is an optional area code enclosed in parentheses, **ppp** is a telephone prefix code, **-nnnn** is a telephone exchange preceded by a hyphen, **Xeeee** is an optional extension number preceded by the letter **X**, **Bbbbb** is an optional beeper or pager number preceded by the letter **B**, and **Ccccc** represents arbitrary text comments about the applicability of the telephone number, preceded by the letter **C**. The length of each part of the telephone number is variable. An example of a TN field is:

1(312)959-0800X4790B43905Cafter 5pm or on Sundays

4.4.14 *Time Stamp Data (TS)*—This data type is used to represent a date and optional time, as follows:

YYYYMMDDHHMMSS.FF±hhmm

where **YYYY** is the four digit year, **MM** is the month number, **DD** is the day, **HH** is the hour (00 to 23) on a 24-h clock, **MM** is the minute, **SS** is the second, **.FF** is the fractional seconds, and **hhmm** represents the number of hours (and minutes, if needed) by which local time is offset from coordinated universal time. The date portion is required; the time portion may not be present if it is not known or relevant (for example, a birth date alone is sufficient for adult subjects, while birth date and time are needed for newborns). Within the time field, the seconds and fractional seconds are optional, and fractional seconds may be of any length (within the total maximal field length). The local time offset is also optional; it is used only if it is necessary to designate the time zone for the given time value.

4.4.15 *Text Data (TX)*—This data type is used for text strings of up to 64K characters (where 1K = 1024), with leading spaces preserved and trailing blanks trimmed. In TX fields, repeat delimiters (~) represent *hard* carriage returns (that is, they display as a carriage return and linefeed), and two repeat delimiters in a row (~ ~) represent a new paragraph. A receiving system would word-wrap text between repeat delimiters to fit an arbitrarily sized display window, but start text following a repeat delimiter on a new line. The escape character (\ ) may be used within TX format data fields to signal certain special characteristics of portions of the text field. An *escape sequence* consists of the escape character followed by an escape code ID of one character followed by 0 or more data characters followed by another occurrence of the escape character. Allowable escape sequences defined in the Specification E 1238 and HL7 standards include \H\ (start highlighting) and \N\ (end highlighting, revert to normal text), used to delimit a portion of text to be displayed using underlining or reverse video or a similar technique. They also include sequences used to transmit delimiter characters (which otherwise are not allowed within text fields): \F\ for a field delimiter, \S\ for a component delimiter, \T\ for a subcomponent delimiter, \R\ for a repeat delimiter, or \E\ for an escape character. The escape sequence \Dnnn\ where *nnn* is a three-digit decimal number is used to indicate a special character whose ASCII code is *nnn*; this may be used to transmit control characters or special characters (such as è or ö) which are otherwise not allowed in text fields.

4.4.16 The HL7 standard defines an alternative data type to TX known as formatted text (FT), which differs from TX in that repeat delimiters are not allowed for formatting, but instead special formatting commands (analogous to word processor directives) enclosed in escape characters (\) may be included (see the HL7 document for details); this data type may be used in place of TX in HL7-formatted messages but not in messages formatted in accordance with Specification E 1238.

4.5 *Segment Types*—Table 2 lists the Specification E 1238 segment types (plus the MSA segment added by this specification), the defined fields of each segment, and their data type, requirement status, and maximum lengths. Only the fields of

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those Specification E 1238 segments of most interest to neurophysiology are listed in Table 2; refer to Specification E 1238 for a complete list of fields for all segments. The segment types and data fields defined by HL7 are not listed in Table 2; refer to the HL7 document for more information. In Table 2, fields with a requirement status of *R1* are required to be present in all transmissions. Other fields may not be present under certain circumstances. *R2* fields are required to be present whenever the value they represent is known to the sender (but they may not be present if the information is not known), and *R3* fields are required to be present *unless* the information is not known to the sender *or* is already known to the receiver (the last option should be used with great caution). Fields designated as *O* (optional) by Specification E 1238 are filled in by the transmitting system only if the information is available and pertinent; otherwise, values for such fields are not present. However, in order to comply fully with this specification (and regardless of implementation level), a receiving system should be able to accept values for all fields and all segment types defined by this specification and by Specification E 1238 without generating an error condition, although the data from *optional* fields or segment types may be ignored or merely logged without further interpretation. Fields not designated as *R1*, *R2*, *R3*, or *O* may, in principle, be assigned to any of these categories by mutual agreement of the transmitting and receiving systems, according to the needs of the application. If a transmitting system does not know the intended receiver's requirements, it should treat these fields as optional; similarly, the mostgeneral receiving systems should not require the presence of these fields. The following briefly describes Specification E 1238 segment types and their fields; refer to Specification E 1238 for detailed information on each segment and field type.

TABLE 2 Synopsis of Specification E 1238 Segments and Field Names

Mnemonic	Field Name	Type	Required	Length, max
Message Header Segment (H)				
H-1	Segment type ID	ST	R1	3
H-2	Delimiter definition	ST	R1	5
H-3	Message control ID	ST	R1	12
H-4	Security	ST	R2	12
H-5	Sender ID	ST	R1	40
H-6	Sender street address	AD		100
H-7	Message type	CM		7
H-8	Sender telephone number	TN		40
H-9	Characteristics of sender	ST		40
H-10	Receiver ID	ST	R1	40
H-11	Comment or special instructions	ST		80
H-12	Processing ID	ID	R1	20
H-13	Version	ST	R1	5
H-14	Date/time of message	TS	R1	26
Message Acknowledgment Segment (MSA)				
MSA-1	Segment type ID	ST	R1	3
MSA-2	Acknowledgment code	ID	R1	2
MSA-3	Message control ID	ST	R1	12
MSA-4	Text message	CM	R2	200
General Test/Observation Master Segment (OM1)				
(The OM1 segment fields are defined in Specification E 1238)				
Numeric Test/Observation Master Segment (OM2)				
(The OM2 segment fields are defined in Specification E 1238)				

TABLE 2 *Continued*

Mnemonic	Field Name	Type	Required	Length, max
Categorical Test/Observation Master Segment (OM3)				
(The OM3 segment fields are defined in Specification E 1238)				
Test/Observation Master Segment for Observations Requiring Specimens (OM4)				
(The OM4 segment fields are defined in Specification E 1238)				
Test/Observation Master Segment for Observation Batteries (OM5)				
(The OM5 segment fields are defined in Specification E 1238)				
Test/Observation Master Segment for Calculated Observations (OM6)				
(The OM6 segment fields are defined in Specification E 1238)				
Patient Identifying Segment (P)				
P-1	Segment type ID	ST	R1	3
P-2	Patient segment sequence number	NM	R1	4
P-3	Requestor (practice) assigned patient ID	CK	R1	16
P-4	Producer (diagnostic service) assigned patient ID	CK	R3	16
P-5	Alternative patient ID	ST		16
P-6	Patient name	PN	R3	48
P-7	Patient mother's maiden name	ST	R3	24
P-8	Patient birth date/time	TS	R3	26
P-9	Patient sex	ID	R3	1
P-10	Patient race or ethnic origin	ID		40
P-11	Patient street address	AD		200
P-12	[Not used]			0
P-13	Patient telephone number	TN		40
P-14	Patient attending physician ID	CNA		60
P-15	Producer (diagnostic service) special field 1	ST		60
P-16	Producer (diagnostic service) special field 2	ST		60
P-17	Patient height	CQ		10
P-18	Patient weight	CQ		10
P-19	Patient known or suspected diagnoses	CE		200
P-20	Patient medications	ST		200
P-21	Patient diet	ST		200
P-22	Requestor (practice) special field 1	ST	R2	60
P-23	Requestor special field 2 (hand/foot/ eye dominance)	ST	R2	60
P-24	Admission date/time and discharge date/time	TS		53
P-25	Patient admission status	ID		2
P-26	Patient location	ST		25
P-27	Patient diagnostic classification	CE		100
P-28	Patient religion	ID		30
P-29	Patient marital status	ID		2
P-30	Patient isolation status	ID		20
P-31	Patient language	ST		20
P-32	Patient confidentiality status	ID		20
P-33	Date/time patient registered	TS		26
P-34	Patient death date/time	TS		26
Guarantor Segment (GT1)				
(The GT1 segment fields are defined in Specification E 1238)				
Insurance Segment (IN1)				
(The IN1 segment fields are defined in Specification E 1238)				
Order Segment (OBR)				
OBR-1	Segment type ID	ST	R1	3
OBR-2	Order segment sequence number	NM	R1	4
OBR-3	Requestor (practice) accession number	CM	R1	75
OBR-4	Producer (diagnostic service) accession number	CM	R2	75
OBR-5	Test/observation ID	CE	R1	200
OBR-6	[Not used]			0
OBR-7	Requested date/time	TS		26
OBR-8	Test/observation begin date/time	TS	R2	26
OBR-9	Test/observation end date/time	TS		26
OBR-10	Specimen collection volume	CQ		20
OBR-11	Specimen collector ID	CNA		60
OBR-12	Action code	ID	R1	1
OBR-13	Danger code	CM		60
OBR-14	Relevant clinical information	CM		300
OBR-15	Date/time of specimen receipt	TS		26

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TABLE 2 *Continued*

Mnemonic	Field Name	Type	Required	Length, max
OBR-16	Source of specimen	CM		300
OBR-17	Ordering physician	CNA		60
OBR-18	Ordering physician telephone number	TN		40
OBR-19	Requestor (practice) special field 1	ST	R2	60
OBR-20	Requestor (practice) special field 2	ST	R2	60
OBR-21	Producer (diagnostic service) special field 1	ST		60
OBR-22	Producer (diagnostic service) special field 2	ST		60
OBR-23	Date/time observation reported or status changed	TS	R2	26
OBR-24	Producer (diagnostic service) charge	CM		60
OBR-25	Producer (diagnostic service) section ID	ID		10
OBR-26	Order result status code	ID	R2	1
OBR-27	Link to parent result	CM		200
OBR-28	Quantity/timing	CM	R2	200
OBR-29	Send copies to	CNA		150
OBR-30	Link to parent order	CM	R2	150
OBR-31	Transportation mode	ID		20
OBR-32	Reason for study	CE		300
OBR-33	Principal interpreter of study	CNA		60
OBR-34	Assisting interpreter of study	CNA		60
OBR-35	Technician identity	CNA		60
OBR-36	Transcriptionist identity	CNA		60
OBR-37	Date/time scheduled	TS		26
Result (Observation) Segment (OBX)				
OBX-1	Segment type ID	ST	R1	3
OBX-2	Result segment sequence number	NM	R1	10
OBX-3	Value type	ID	R1	2
OBX-4	Test/observation ID	CE	R1	590
OBX-5	Observation subID	ST	R2	20
OBX-6	Observation value (result)	(variable)	R3	64K
OBX-7	Units of measure	CE	R3	590
OBX-8	Reference range	ST	R3	60
OBX-9	Abnormal/change flags	ID	R3	10
OBX-10	Probability	NM		5
OBX-11	Nature of abnormal testing	ID		5
OBX-12	Observation result status	ID	R3	2
OBX-13	Date/time of last change in normals/units	TS	R3	26
OBX-14	User-defined access checks	ST		20
OBX-15	Physiologic observation date/time units	TS		26
OBX-16	Producer ID	CE		200
OBX-17	Responsible observer	CNA		60
Error Checking Segment (E)				
E-1	Segment type ID	ST	R1	3
E-2	Error checking segment sequence number	NM	R1	4
E-3	Error check byte count	NM	R1	10
E-4	Check code	NM	R1	3
Comment Segment (C)				
C-1	Segment type ID	ST	R1	3
C-2	Comment segment sequence number	NM	R1	4
C-3	Comment source	ID	R1	8
C-4	Comment text	TX	R1	64K
Request Results Segment (Q)				
Q-1	Segment type ID	ST	R1	3
Q-2	Request results segment sequence number	NM	R1	6
Q-3	Requestor (practice) assigned patient ID	CK	R2	200
Q-4	Producer (diagnostic service) assigned patient ID	CK	R2	200
Q-5	Test/observation ID	CE	R2	200
Q-6	Nature of request time limits	ID	O	10
Q-7	Beginning request results date/time	TS	O	100
Q-8	Ending request results date/time	TS	O	100
Q-9	Requesting physician	CNA	R2	60
Q-10	Requesting physician telephone number	TN		40
Q-11	Requestor (practice) special field 1	ST		80
Q-12	Requestor special field 2 (subject filter and qualifiers)	CM		80
Scientific Segment (S)				
(The S segment fields are defined in Specification E 1238)				
Message Terminator Segment (L)				
L-1	Segment type ID	ST	R1	3
L-2	Message terminator segment sequence number	NM	R1	1
L-3	[Not used]			0
L-4	Patient count	NM		4
L-5	Line count	NM		10
L-6	Batch number	ST		12

4.5.1 *Message Header Segment (H)*—This required segment is the first segment of any transmission. R1-required fields include the segment type ID (**H**), the delimiter definition (field, component, repeat, escape, and subcomponent delimiters, where the field delimiter character immediately follows the segment type ID; **| ^ ~\&** for standard delimiters), a message control ID (a text string which uniquely identifies the message, such as a sequence number), the sender ID (an ID code and optional name of the sender), the receiver ID (an ID code and optional name of the receiver; may use the string **ANY** if the intended receiver is not known), a processing ID (**P** for production, **T** for training, or **D** for debugging messages), the version ID which applies to the message format being used (in the form **E.x** where *E* indicates a message using the electrophysiologic data format described in this specification and *x* is a number which identifies the particular version of this specification; the version number *E.2* applies to messages described by this document), and the date and time of the message. A security field (password or encryption key) is an R2-required field. Other fields include the sender street address, sender telephone number (for voice communications), a message type (with two components, a type code and an optional trigger event code which the receiver can use for message routing; allowed type codes and trigger event codes are defined by HL7), characteristics of the sender (such as baud rate or parity), and a comment or special instructions (for example, could be used to identify special-purpose transmissions or locally defined variations of the standard message format).

4.5.2 *Message Acknowledgment Segment (MSA)*—This optional segment is used only in a two-way message transmission system to identify a message returned in response to another message. When an MSA segment is used, it is always the second segment of the response message, following the header (H) segment. R1-required fields include the segment type ID (**MSA**), the acknowledgment code, and the message control ID of the original message (to which this message is a response). The allowed acknowledgment codes are given in Table 3. Code **AA** indicates that the original message was accepted and processed successfully. Code **AE** indicates that it was rejected due to a syntax or other error. Code **AR** indicates that it was rejected, either because the message type (if used), processing

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TABLE 3 Acknowledgment Codes

Code	Meaning
AA	Application Accept
AE	Application Error
AR	Application Reject

ID, or version in the message header (H) segment was invalid for the system receiving the message, *or* because of reasons unrelated to the message content (receiver system down, internal error, etc.). The text message field is an R2-required field. It is used when the acknowledgment code was **AE** or **AR** to return an error code and optional text error message (preceded by the string **ERR**), which explains the reason for rejection of the original message (see 9.6). It is also used (with an acknowledgment code of **AA**), in messages which respond to a query for system characteristics or system status, to contain the system characteristics or capabilities in answer to the query (see 9.5.10). In the latter case, this field may contain more than one component. For compatibility with HL7, MSA segment fields 5 and 6 are reserved and will not be used by future versions of this specification.

4.5.3 *Test/Observation Master Segments (OM1–OM6)*—These six optional segments may be transmitted by a diagnostic (laboratory) service to its *clients* to inform them about the observations and observation batteries or functional procedures (tests) performed by the diagnostic service (producer). The transmission of a message containing test/observation master segments may be either unsolicited (for example, when the laboratory adds new observations or changes the format, technique, or interpretation of existing observations or procedures) or may occur in response to a query sent by the *client* system. See Specification E 1238 for a complete description of the OM1–OM6 segments and their formats.

4.5.4 *Patient Identifying Segment (P)*—This segment contains information about an individual patient (subject). R1-required fields include the segment type ID (**P**), a patient segment sequence number (increments from one for each P segment in the message), and a requestor (practice) assigned patient ID. R2-required fields include two requestor (practice) defined special fields. For electroneurophysiologic data transmissions, requestor special field one may be used as desired, but requestor special field two should specify the patient hand, foot, and eye dominance (using keywords **LEFT**, **RIGHT**, **BOTH**, or **UNKNOWN**) as three optional strings separated by repeat delimiters (~). R3-required fields include a producer (diagnostic service) assigned patient ID (may be the same as the requestor assigned patient ID), patient's name, patient's mother's maiden name (when required to distinguish between patients with the same birthdate and last name), patient's birth date/time (time required primarily for neonates), and the patient's sex (**M** for male, **F** for female, or **U** for unknown). Other fields include an alternative patient ID (such as billing number, account number, or social security number), patient's race or ethnic origin (**W** for white, **B** for black, **NA** for Native American, **O** for Oriental, **H** for Hispanic, or **OTH** for other), patient's street address, patient's telephone number, patient's attending physician ID (or multiple IDs separated by repeat delimiters), two producer (diagnostic service) defined special fields, patient's height (default units cm), patient's weight (default units kg), patient's known or suspected diagnoses (as a list separated by repeat delimiters; for example, using ICD-9-CM or SNOMED codes), patient's medications (as a list of generic names separated by repeat delimiters), patient's diet (for example, time food was last ingested), admission date/time and discharge date/time (two subfields separated by a repeat delimiter), patient's admission status (**OP** for outpatient, **PA** for pre-admit, **IP** for inpatient, or **ER** for emergency room), patient's location (such as nursing unit and bed), patient's diagnostic classifications (for example, a list of DRGs in CE format separated by repeat delimiters; coding system name = **DRG**), patient's religion (**P** for protestant, **C** for Catholic, **M** for Church of Latter Day Saints, **J** for Judaism, **H** for Hinduism, or **A** for atheist), patient marital status (**M** for married, **S** for never married, **D** for divorced, **W** for widowed, **A** for separated, **U** for unknown), patient's isolation status (see Specification E 1238 for possible values), patient's language, patient's confidentiality status (see Specification E 1238 for possible values), date/time patient registered (or date/time patient registration data was last changed), and date/time of patient's death (if applicable).

4.5.5 *Billing Segments (GT1 and IN1)*—These two optional segments may be used in a message used to electronically order an electrophysiolgic test to transmit billing information needed by the producer (laboratory). The GT1 segment identifies a person (guarantor) and the IN1 segment identifies an insurance company and plan that may be billed for the study. Multiple GT1 or IN1 segments, or both, may be transmitted in a contiguous sequence when multiple guarantors and insurance plans apply. These segments apply to all of the orders that follow until superseded by another set of GT1 and IN1 segments or a new P (patient identifying) segment. See Specification E 1238 for detailed information about the format and usage of these segments.

4.5.6 *Order Segment (OBR)*—In a two-way message transmission system, this segment (optionally followed by OBX segments containing data necessary for proper performance or interpretation of the order) may be sent from the requestor (practice) system to the producer (laboratory) system to electronically order an electrophysiologic study to be performed on the subject. This segment (with additional fields supplied) is later returned to the requestor (now receiver) system followed by the requested results of the study; in this case or in a one-way message transmission system, this segment acts as a result header segment. R1-required fields include the segment type ID **(OBR)**, an order segment sequence number (increments from one for each OBR segment following a given P segment), a test/observation ID (a code or text string, or both, identifying the test or tests performed and optionally the particular categories of results returned; one or more type CE subfields separated by repeat delimiters), an action code indicating the action taken or to be taken with regard to the order (see 9.3.7 for allowed values), and a requestor (practice) accession number consisting of two components (same as the producer accession number in a one-way message transmissionsystem); the first component uniquely identifies the order (increments continuously for each new order made from the

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time of system installation) and the second identifies the requesting application (constant for any given requestor system). R2-required fields include a producer (diagnostic service) accession number with two components, the first of which uniquely identifies the study performed (increments continuously for each new study performed from the time of system installation) and the second of which identifies the producer application (constant for any given laboratory system), the test/observation begin date/time (the starting date and time of the study), two requestor (practice) defined special fields, the date and time observation reported or status changed (date/time of test interpretation and result reporting or date/time the order result status changed), the order result status code (see 9.3.10 for allowed values), quantity/timing information (with ten optional components defining quantity, interval, duration, start date/time, end date/time, priority, condition, text comments, conjunction, and order sequencing; used for ordering repetitive or timed tests; see Specification E 1238 for details), and a link to parent order that is used when a parent order spawns multiple secondary orders; this last field consists of two components, the first of which identifies the parent order by its requestor accession number (two subcomponents) and the second of which identifies the parent order by its producer accession number (two subcomponents). Other fields include the requested date/time (date and time the test was requested or ordered), the test/observation end date/time (date and time the study was completed), danger code (subject-specific hazards to laboratory personnel, with two components: an optional alphanumeric code and a text description), relevant clinical information (has two components: an optional alphanumeric code and a text description), the ordering physician ID and ordering physician telephone number, two producer (diagnostic service) defined special fields, producer (diagnostic service) charge for the study (has three components: a monetary amount, a billing code, and a currency code), the producer (diagnostic service) section ID (see Specification E 1238 for all allowed values; **EN** for electroneurophysiology laboratories), *send copies to* list (list of persons who need copies of the study results; multiple subfields separated by repeat delimiters), transportation mode (**PORT** for portable study, **CART** if patient travels by cart, **WHLC** if patient travels by wheelchair, **WALK** if patient can walk), reason for study (for example, one or more *rule-out* diagnoses separated by repeat delimiters), principal interpreter of study, assisting interpreter of study (for example, resident), technician identity, transcriptionist identity, date/time test scheduled, and other fields which are specimen-related and not applicable to most neurophysiologic tests.

4.5.7 *Result Segment (OBX)*—One or more result segments containing some or all of the data generated during a study are generally transmitted following an order segment (acting as a result header) in a message used to return the results of a study to the ordering system (or to any system used to review the data from the study). One or more result segments containing status or error information in response to a query about an order may also be transmitted following an order segment in a message used to respond to the query. Finally, one or more result segments containing data required for proper performance or interpretation of a study (such as equipment settings, for example, montage and channel definitions) may also be transmitted following an order segment in a message used to electronically order a study. The fields in the result segment are explained in detail in Section 5.

4.5.8 *Error Checking Segment (E)*—This optional segment provides for simple error checking within a message. All fields are R1-required and include the segment type ID **(E)**, error segment sequence number (increments from one for each E segment in a message), error check byte count (byte count for data transmitted since the last error checking segment or the start of the message, except carriage returns), and a check code (exclusive OR of all character codes except carriage returns in the transmission, expressed as a three-digit decimal number).

4.5.9 *Comment Segment (C)*—This optional segment contains only R1-required fields including the segment type ID **(C)**, a comment segment sequence number (increments from one for each C segment in a message), a comment source which is either **P** (practice or requestor) or **L** (laboratory or producer), and comment text related to the immediately preceding patient, order, result, request, or scientific segments. It may be used, for example, to specify additional detail about electrodes, channels, filters, stimulus paradigms, analysis results, etc., which cannot be expressed in the currently defined field structure of result (OBX) segments. It is not to be used for technical comments (often technician generated) related to the behavior of the subject or events during the performance of the electrophysiologic procedure itself (the TCM category result segment is used for these comments). The receiving system usually logs or retains comment segments, along with the preceding segment to which they apply, for inspection.

4.5.10 *Request Results Segment (Q)*—This optional segment is used only in a two-way message transmission system when one system wishes to request information from another system regarding tests and test results, orders, lists of patients or tests, or system characteristics. The results of the query are returned in an acknowledgment message sent by the queried system to the querying system. The format of the acknowledgment message depends on the query (that is, on the particular results to be returned). Some queries can be answered in the MSA (message acknowledgment) segment alone. Others require additional segment types, including P (patient), OBR (order), and OBX (result) segments. Specific query types include the following. A request results (Q) segment may be used when a requestor (data receiving) system wishes to request, from the producer (laboratory or data sending) system, results of tests previously ordered and possibly previously reported. It may also be used to query the producer system about the status of a previously ordered but not yet reported test or individual test result, about the status of active functions related to a test in progress on a system, or about equipment settings (such as current montage and channel definitions). The answer to the query is returned in the order result status field of an OBR segment or in one or more OBX segments. A single request results segment may ask for all or some of the results for a given test or multiple tests, specified as a list. Alternatively, it may request results for all tests performed on a single date, a series or range of dates, and for an individual subject, groups of subjects, or all subjects. In addition, requestors

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segment may be used when one system wishes to request from another system new or current order information; a patient list or patient demographic data, or test/observation master data describing the types of tests that can be performed by the laboratory. In this case, the answer to the query may be a message containing one or more patient (P), order (OBR), or test/observation master (OM1–OM6) segments. Also, a request result segment may be used when one system wishes to request information about the characteristics, operational status, configuration, or capabilities of another system. The answer to such a query is returned in the text message field of a message acknowledgment (MSA) segment in the response message. Finally, a request segment may be used when one system wishes to remotely control a process on another system, or cancel a transmission of result data in progress. R1-required fields in a request results segment include the segment type ID **(Q)** and a request results segment sequence number (increments from one for each Q segment in a message). R2-required fields include requestor (practice) assigned patient IDs (multiple entries separated by repeat delimiters), producer (diagnostic service) assigned patient IDs (multiple entries separated by repeat delimiters), test/observation IDs (multiple entries separated by repeat delimiters), and the requesting physician ID. Optional **(O)** fields include the beginning request results date and time (or several individual dates and times; one or more entries separated by repeat delimiters) and the ending request results date and time (these may be used, for example, when requesting a brief segment of electrophysiologic waveform data to specify the starting and ending time of the requested segment), and a code indicating the nature of the request time limits (**S** for study date or **R** for report date). Other fields include the requesting physician telephone number, and two requestor (practice) defined special fields. Requestor special field 1 can be used as desired. Requestor special field 2 is a multicomponent field that contains a subject filter and optional qualifiers (which together define the type of query).

4.5.11 *Scientific Segment (S)*—This optional segment may be used to exchange results between laboratory sites concerning laboratory performance, quality control, or method development. It is primarily intended for use in clinical chemistry and similar laboratories. Its usage for electrophysiology laboratories is undefined.

4.5.12 *Message Terminator Segment (L)*—This required segment is the last in any message and indicates the logical end of the message. R1-required fields include the segment type ID **(L)** and message terminator segment sequence number (always one since there can be only one terminator segment per message). Other fields are used to check message integrity and include a patient count (number of patient segments transmitted in the message), line count (number of lines, that is, number of carriage returns in the message), and a batch number (assigned by the sender to identify the entire transmission; may be the same as the message control ID in the header segment).

4.6 *Overall Message Logical Structure*:

4.6.1 Table 4 presents the overall logical structure of a Specification E 1238 message in terms of its component segments arranged in a hierarchical fashion; note that the structure of an HL7 message is similar, although additional segment types may be necessary.

TABLE 4 Logical Structure of a Message

Message header	(information about the transmission)
Message acknowledgment	(optional, for two-way communication)
Patient 1	(general information about first patient)
Guarantor/Insurance 1	(optional billing information for the first patient)
Guarantor/Insurance 2	(more optional billing information)
Order 1	(information about the first ordered test)
Result 1	(first result segment for first test)
Result 2	(second result segment)
.	
.	
Result n_1	(last result segment for first test)
Order 2	(information about the second ordered test)
Result 1	(first result segment for second test)
Result 2	(second result segment)
.	
.	
Result n_2	(last result segment for second test)
.	
.	(segments for other orders and results)
Order m	(information about the last ordered test)
Result 1	(first result segment for last test)
Result 2	(second result segment)
.	
.	
Result n_m	(last result segment for last test)
Patient 2	(general information about second patient)
.	
.	(all of the structure repeats)
Message trailer	(indicates the end of the overall message)

4.6.2 In this logical message structure, segments at the highest level (level 0) of the hierarchy define the message boundaries (message header and trailer segments). Message acknowledgment segments (used in response messages in two-way communication systems) follow message header segments and also occupy level 0 of the hierarchy. Segments at the first level contain information about individual patients (patient identifying segments). Segments at the second level contain information needed for billing (guarantor and insurance segments). Segments at the third level contain information about a particular test or study (order segments). Segments at the fourth level contain individual test results or observations (result segments). Test/observation master (OM1–OM6), query (Q), and scientific (S) segments, when used, take the place of patient identifying segments at the first level. A sequence of patient identifying segments, billing segments, order segments, or result segments at one level is terminated by the appearance of a segment type of the same or higher level. Thus, for example, a sequence of result segments (OBX) for one test is terminated by the next order (OBR), billing (GT1 or IN1), patient identifying (P), scientific (S), or request results (Q) segment or by a message terminator (L) segment. An order (OBR) segment or a billing (GT1 or IN1) segment may never appear without a preceding patient identifying (P) segment, and a result (OBX) segment may never appear without a preceding order (OBR) segment. Test/observation master (OM1–OM6) segments, when used, must be transmitted at the start of the message prior to the first patient identifying (P), request results (Q), or scientific (S) segment; they are often the only segments in the message other than the message header

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(H) and trailer (L). The comment (C) and error checking (E) segments may be inserted at any level and do not terminate the current level.

4.7 *Test/Observation Identifiers*:

4.7.1 The test/observation identifiers (same as observation battery or observation identifiers in Specification E 1238/HL7 nomenclature) are coded entry (CE) data items used to identify specific tests (batteries), individual portions of tests, or individual test results (observations) in order segments, request results segments, and result segments. In order (OBR) and request results (Q) segments (but not in result segments), multiple test/observation identifiers may be supplied to order or request multiple tests or subtests; each test/observation identifier is separated from the others by a repeat delimiter (~). Specifications E 1467 and E 1238 (**AS4**) universal alphanumeric codes (coding system **AS4&TEST**) are the default for Code 1 in the CE data field, and are based on CPT-4. Other coding systems may be used (such as CPT-4 codes without modifiers, coding system **C4**, or local codes defined by a particular laboratory or institution, coding system L), but the **AS4** coding system is preferred. Specification E 1238 defines universal test/observation ID codes for clinical chemistry, hematology, microbiology, and similar laboratory results, for spirometry, ultrasound, chest X-ray, endoscopy, physical exam and medical history (including neurologic examination and history), physiologic measurements, cardiac catheterization, coronary angiography, electrocardiography, and other clinical tests or procedures. Appendix X2 of this specification defines the **AS4** universal test/observation ID codes for various classes of electroneurophysiologic studies. It may be noted that *all* medical information available for a given subject may be transmitted in a single message, if desired; thus, one transmission may include intermixed order (OBR), result (OBX), or request result (Q) segments using test/observation IDs defined by Specification E 1238 and using test/observation IDs defined in Appendix X2 of this specification; CPT-4 codes not mentioned in either Specification E 1238 or in Appendix X2 may also be used if necessary. CPT-4 codes may be identified either by the coding system mnemonic identifier **C4** (which specifically indicates CPT-4 codes without modifiers) or **AS4** (which may be used to indicate either modified CPT-4 codes or unmodified CPT-4 codes); thus, **C4** codes are a proper subset of **AS4** codes.

4.7.2 The test/observation ID specified in an order (OBR) segment used to order electrophysiologic studies in a two-way message transmission system is often a generic code (whose scope is determined by local norms and individual laboratory practice) or a set of several individual specific or generic codes separated by repeat delimiters, to indicate an order for multiple individual specific tests or any relevant tests within a class of related studies (often to be chosen at the discretion of the laboratory according to local custom and the individual needs of the subject). When such a *parent* order is received by the laboratory system, it leads to the generation internally of multiple *child* orders; when a response message is returned to the ordering computer system containing the study results, each individual specific study performed would be transmitted as an OBR segment containing a specific test/observation ID for that study, followed by many OBX segments containing the study results including waveform data. For example, one could order generic *EMG studies* by transmitting a message containing an OBR segment with the appropriate test/observation ID (9586X using **AS4** universal codes), and the response message containing the study results could include three separate OBR segments defining a motor nerve conduction study (test/observation ID code 95900 using AS4/CPT-4 universal codes), a sensory nerve conduction study (code 95904), and a one extremity EMG (code 95860), together with the corresponding OBX (result) segments (see Appendix X3 for a complete example). This is analogous to the example given in Specification E 1238 of a *parent* order for *Routines* being expanded into *child* orders for urinalysis, complete blood count, and electrolytes by a particular laboratory computer system.

4.7.3 The alphanumeric code in the first and fourth components of the test/observation ID field is often followed by an alphabetic information category code; a subcomponent delimiter **(&)** is used between the alphanumeric test code and the alphabetic information category code. For example, a diagnostic impression could have the identifier **95816&IMP** using **AS4** universal codes.

4.7.4 The use of an information category code is optional in order segments and in request result segments transmitted in a two-way message system to order a test or obtain the results of a previously performed test; its presence in this context implies that only the result segments with the given information category code are to be returned to the requesting system (in contrast to the usual situation in which an information category code is not present, and result segments with all information category codes are therefore returned). If multiple test/observation identifiers separated by repeat delimiters (~) are used in order (OBR) and request results (Q) segments, the alphanumeric code may not be present before the information category code in the second and subsequent identifiers if the alphanumeric code used in the previous test/observation identifier applies. This may be used to request transmission of result segments with a number of different information category codes. In this context, a subfield which is not present (that is, two repeat delimiters in a row) may be used to request transmission of result segments with no information category code (those which return individual quantitative or qualitative test results). For example, a report, interpretation, diagnostic impression, all quantitative and qualitative individual test results, and recommended follow-up tests (but not the digital waveform or technical data) could be ordered to be transmitted using the following string of test/observation identifier codes: **95816&GDT~&MDT~&IMP~~&REC**.

5. Descriptions of Fields in Result Segments

5.1 Result (OBX) segments have a format defined by Specification E 1238 and HL7. The fields contained in result segments, their data types and maximum lengths, and their usage are defined in 5.2 through 5.18.

5.2 *Segment Type ID*—This R1-required field (data type ST, maximum length three characters) contains the characters **OBX**, signifying a result segment containing observations.

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5.3 *Result Segment Sequence Number*—All result segments following a given order (OBR) segment are numbered sequentially beginning with one. This R1-required field contains the decimal sequence number (data type NM, maximum length ten characters).

5.4 *Value Type*—This R1-required field (data type ID, maximum length two characters) defines the data type or structure of the observation value field (field 6). Many of the valid data types are described in this specification (see 4.4), and others are described in the Specification E 1238 and HL7 standards. Those which are used most often in electrophysiologic study result segments are summarized in Table 5.

5.5 *Test/Observation ID*:

5.5.1 This R1-required field contains a test/observation identifier in coded entry (CE) format. The test/observation ID identifies both the general category of study and a more specific type of study or a specific portion of a study, and it may identify also a particular quantitative or qualitative study result. The test/observation ID field may change in successive result segments transmitted during the course of the recording as different subtests or portions of the study are performed (for example, awake, sleep, hyperventilation, photic stimulation in an EEG, or studies on various different muscles in an EMG). When the result segments are all labeled in this fashion, it becomes possible to search automatically for a desired portion of the recording. The receiving system may even generate an index into the recording as result segments are received, to allow faster random access to the desired portion of the data. The first component is required in all result segments; the other components need not be present.

5.5.2 The first and fourth components of the test/observation ID consist of an alphanumeric code and, in some cases, an information category code separated from the alphanumeric code by a subcomponent delimiter (**&**).

5.5.3 The second and fifth components of the test/observation ID are text strings describing the test, portion of test, or individual quantitative or qualitative study result identified by the first and fourth components. To save space, the second and fifth components may not be present in result segments in which the first and fourth components are exactly the same as in the previous result segment; in this case, the text descriptions can also be assumed to have remained the same since the previous result segment. The second and fifth components of the test/observation ID may also not be present if the receiving system is known to be a Level III system which can reconstruct the text description from the alphanumeric codes given in the first and fourth components, or if the transmitting system itself does not know the text description of the alphanumeric code.

5.5.4 The third and sixth components of the test/observation ID are strings identifying the coding system used in the first and fourth component. When not present, the default for the third component is **AS4&TEST** (**AS4** universal codes, as listed in Appendix X2). The default for the sixth component is **L** (local codes). The maximum total length of the test/observation ID field is 590 characters, which includes 80 characters each for components 1 and 4, 200 characters each for components 2 and 5, and 12 characters each for components 3 and 6.

5.5.5 The information category code that usually follows the alphanumeric code defines the nature and format of the data contained in the result segment's observation value field. Table 6 presents the information category codes and their corresponding value types defined for electrophysiologic study data.

5.5.6 The only time that an information category code is *not* present in a result segment is when transmitting single quantitative or qualitative test results, such as velocities, latencies, amplitudes, peak or waveform morphologies, etc. These results have a value type of NM (numeric) or CE (coded entry). Numeric results are sent along with their units of measure, the normal range defined by the laboratory (if applicable), and abnormal/change flags.

5.5.7 Test/observation IDs in result segments that do not contain an information category code must fully specify the particular final test result of type NM or CE which is

TABLE 5 Value Types in Result Segments

Value type	Meaning
NM	Numeric—single numbers; used for reporting quantitative results of a study such as velocities, amplitudes, and latencies.
ST	String—short text string; used for reporting noncoded nonnumeric results.
CE	Coded entry—coded data, including a code, description, and coding system identification; used for reporting qualitative test results (such as peak morphologies) or grading quantitative test results, and for reporting anatomic localizations, diagnostic impressions, medications, devices, special procedures, and recommended follow-up tests.
TX	Text—arbitrary length text data; used for reporting technical comments, descriptive reports, interpretations, and addenda.
CM	Composite miscellaneous—data with a defined format; used for reporting technical data, waveform digital data, data derived from analysis of waveform data; and test status and error data.
RP	Reference Pointer—specifies the address of actual waveform data on a remote system.

TABLE 6 Information Category Codes and Value Types

Result Segment Contents	Category	Value Type
Electrode definition data	ELC	CM
Montage definition data	MTG	CM
Channel definition data	CHN	CM
Time stamp and epoch/averaging data	TIM	CM
Waveform digital data	WAV	CM/TX/RP
Anatomical distance data	DST	CM
Stimulus or calibration data	STM	CM
Technical comments	TCM	TX
Medications administered	MED	CE
Device or instrument used	DEV	CE
Device or instrument serial number	SER	ST
Special procedures/testing performed	CNP	CE
Data derived from analysis of waveform data	ANA	CM
Auxiliary montage selection	SEL	CM
Quantitative or qualitative single test results	...	NM/CE
Anatomic localization	ANT	CE
Diagnostic impression	IMP	CE
Descriptive report	GDT	TX
Interpretation	MDT	TX
Addenda to report	ADT	TX
Recommended follow-up tests	REC	CE
Error code and error message	ERR	CM
Active function status	STA	CM

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transmitted in that segment. Test/observation IDs in result segments of type TIM, WAV, STM, TCM, MED, and ANA (and often ANT and IMP as well) should identify the particular portion of the study to which the results apply. Test/observation IDs in result segments with information category codes of ELC, MTG, CHN, DST, and SEL should identify only the study as a whole, because these segments contain data which define recording conditions that may apply to several different portions of the study. Similarly, test/observation IDs in result segments with information category codes of CNP, DEV, SER, and REC (and often GDT, MDT, ADT, ANT, and IMP) should identify only the study as a whole, since these segments generally specify data that applies to all parts of the study. Finally, test/observation IDs in result segments with information category codes of ERR and STA should identify only the study as a whole.

5.6 *Observation SubID*—This R2-required field (data type ST, maximum length 20 characters) uniquely identifies each OBX segment following a given OBR segment; it may be absent only if the OBX segment is already uniquely identified by its information category code or test/observation ID. If there are multiple OBX segments (with logically independent data) having the same information category code (regardless of test/observation ID) or having the same test/observation ID with information category codes which are not present, they must be numbered sequentially from one and this number used as the observation subID. More than one OBX segment with the same test/observation ID, information category, and observation subID may occur only when transmitting a single result in two forms, for example, in numeric and coded entry format.

5.7 *Observation Value (Result)*—This R3-required field, which may contain multiple subfields, components, and subcomponents, contains the actual results. The data type of this field is given in the value type field (field 3) of the result (OBX) segment. The format of this field is described in Sections 6 through 9 for each category of result segment. The maximum length of this field is 64K characters.

5.8 *Units of Measure*—This R3-required field (data type CE) describes the units in which the result in the previous field is expressed. It contains a coded entry in the six-component format defined by Specification E 1238 and HL7. The first and fourth components would contain standard abbreviations for the units of measure using a standard coding system, the second and fifth components could contain corresponding longer text descriptions of the units, and the third and sixth components could contain an identification of the coding system used in the first (the default is **ISO+**, but **ANS+** is an alternative) and fourth (the default is **L**, local codes) components. The coding system mnemonic identifier **ISO+** indicates standard single case abbreviations of SI units (ISO 2955-1983), while **ANS+** indicates standard single case abbreviations of U.S. customary units (ANSI X3.50-1986) not included in the ISO set; two special units (pha and tur) defined in this specification for electrophysiology may be used as well. Derived units may also be used as described in 4.3.9. Units of measure are used only in result segments that return a single numeric result such as a velocity, latency, or amplitude. The maximum length of this field is 590 characters, which includes 80 characters each for components 1 and 4, 200 characters each for components 2 and 5, and 12 characters each for components 3 and 6.

5.9 *Reference Range*—This R3-required field (data type ST, maximum length 60 characters) is used only in result segments that return a single numeric test result. It contains the laboratory-specific normal range for the result value. This may be expressed in the form *low-high* (for example, 105.5–125.3). If the lower or upper bounds are negative, they may be preceded by a minus sign (for example, – 12.2––6.5). If the range includes no upper bound, the format >*low* is used (for example, >20.5). If the range includes no lower bound, the format< *high* is used (for example, <14).

5.10 *Abnormal/Change Flags*—This R3-required field (data type ID, maximum length 10) indicates the normalcy status of the results or changes since the last performance of the test. The keyword values (defined by Specification E 1238 and HL7) which are most useful for electrophysiologic study data are given in Table 7.

5.10.1 The < and > flags are used in result segments with information category codes of WAV (digital waveform data) to indicate that one or more digitized data values were outside the range of the analog-to-digital converter (ADC); in this context, this field is required when applicable for all implementation levels. The **N**, **A**, **B**, and **W** codes may be used in result segments with information category code IMP to indicate whether the diagnostic impression for this study is normal, abnormal, better, or worse, or in result segments that report qualitative data such as peak or waveform morphologies using a coded entry format. The **L**, **H**, **N**, **A**, **U**, **D**, **B**, and **W** flags may be used in result segments that report velocities, latencies, amplitudes, or other single numeric values. Multiple codes can be specified, separated by repeat delimiters (for example, **H**~**W**).

5.11 *Probability*—This field (usually considered optional for all implementation levels) can be used to report the probability of a diagnostic impression (in a result segment with information category code IMP) as a decimal number between zero and one (data type NM, maximum length five characters).

5.12 *Nature of Abnormality Testing*—This field (used only in result segments that return a single numeric result, and usually considered optional for all implementation levels) indicates the kind of normative data employed by the laboratory, using the representations given in Table 8 (data type ID,

TABLE 7 Abnormal/Change Codes in Result Segments

Value	Meaning
L	Below low normal
H	Above high normal
<	Below absolute low
>	Above absolute high
N	Normal
A	Abnormal (applies to non-numeric results)
--	(Not present) No ranges defined or normal ranges do not apply
U	Significant change up since last performance of test
D	Significant change down since last performance of test
B	Better (improvement) since last performance of test
W	Worse (deterioration) since last performance of test

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TABLE 8 Codes for Nature of Abnormality Testing

Code	Meaning
A	An age-based population was tested
S	A sex-based population was tested
R	A race-based population was tested
N	None of the above (generic normal range)

maximum length five characters). As many of the codes as apply may be included, separated by component delimiters. For example, normal values based on age, sex, and race would be coded as **A^S^R**.

5.13 *Observation Result Status*:

5.13.1 This R3-required field (data type ID, maximum length two characters) defines the status of the data being transmitted and determines the action of the receiving system. For this specification, a default value (**F**) is defined which is used when this field is not present. The keyword codes defined by the Specification E 1238 and HL7 standards are given in Table 9.

5.13.2 Codes **P**, **R**, or **U** could be used in result segments with information category codes ANT, IMP, REC, GDT, MDT, or ADT, or in segments that do not have an information category code. Codes **X** and **I** could be used in a result segment (with an observation value field which is not present) to flag explicitly ordered subtests (for example, a sleep portion of an EEG) which could not be performed or which have not yet been performed. Result segments with any of these codes would be specially flagged by a receiving system when displayed or stored. An immediately following comment (C) segment could be transmitted to explain the reason for the **X** or **I** code.

5.13.3 Codes **C** and **D** may be used with any result segment when a change to previous data is intended, and are interpreted as follows by a receiving system (note that this interpretation is more specific than that stated in the Specification E 1238 and HL7 standards). Code **C** indicates that data contained in the observation value (result) field of the segment so flagged are to replace previously transmitted data with the same test/observation ID and information category code and observation subID. If the result field has a value type of CM, then any components or subcomponents which are not present in the result sent with the **C** code indicate that no change should be made in the corresponding components or subcomponents of the previously transmitted data. This differs from the usual processing of a segment with an **F** (or not present) status code, in which, if a parameter is not present in a type CM result field, either an appropriate default value is supplied or the parameter is taken to be the null string. For example, if it were necessary to redefine a few of the parameters (such as sensitivity or filter settings) of one or more channels while leaving most parameters unchanged, a result segment with information category code CHN having the same test/observation ID and observation subID as the last transmitted CHN category result segment could be sent with result status code **C** and an observation value field containing only the channel numbers and parameters to be changed.

TABLE 9 Result Status Codes

NOTE—Priority: XDISRPFUC (temporal order in which codes may replace one another)

Code	Meaning
R	Result entered, not verified (for example, only technician measured peak latency or amplitude, not physician-verified)
P	Preliminary result: a verified early result is available, final result not yet obtained (for example, resident, not staff, diagnosis)
F	Final result (complete and verified)
S	Partial result: some of this result has been entered; but some is still pending
C	Corrected: the result changes or corrects previous results with same test/observation ID, information category, and observation subID
X	Test or procedure could not be performed, order canceled
I	Test or procedure scheduled or in progress, results pending
D	Deleted: the previously transmitted or default result data of the same test/observation ID, information category, and observation subID is deleted (that is, marked *not present*; no new result sent)
U	Unchanged: the previously transmitted preliminary result data of the same test/observation ID, information category, and observation subID may be taken to be the final, verified result (which need not therefore be retransmitted in the result segment)

5.13.4 Code **D** indicates that data previously transmitted in a result segment with the same test/observation ID and information category code and observation subID should be deleted (marked *not present*). For example, if it were necessary to remove one or more previously defined channels from a montage, a result segment with information category code CHN having the same test/observation ID and observation subID as the last transmitted CHN category result segment could be sent with a result status code of **D** and an observation value field containing just one or more channel numbers separated by repeat delimiters (~). When changing or deleting a result previously transmitted in an OBX segment with no information category code (having a value type of NM or CE), the particular result affected is identified by the test/observation ID code and observation subID (if needed). For this purpose, multiple OBX segments with the same test/observation ID and observation subID are replaced or deleted as a unit.

5.14 *Date/Time of Last Change in Normals/Units*—This R3-required field (used only in result segments that return a single numeric result) is not present unless there has been a recent change in the normal values or units pertaining to data in the result segment, in which case the date and time (in the standard date-time format) of the change is encoded (data type TS, maximum length 26 characters). A change in this date and time compared to that recorded in the receiving system's database could trigger a manual review of the results, for example.

5.15 *User-Defined Access Checks*—This field (usually considered optional for all implementation levels) can be used to specify a special-purpose code classifying the data in the result segment for the purpose of controlling access to or later processing of the data. For example, certain result segments containing waveform data could be flagged using this field by one code which indicates that the data satisfy some criteria (determined by the transmitting system) for printing on a hard copy device; other result segments could be flagged using this field by another code which indicates that the data should be excluded from special processing such as averaging or frequency spectral analysis (for example, because of excessive

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artifact). A system receiving the data which was aware of these special codes could then selectively print, not print, process, or ignore the data depending on the contents of this field. The uses of and possible values for this field are left entirely to an agreement between the sending and receiving applications that is beyond the scope of this specification. The use of this field is therefore to be considered non-portable and nonstandard.

5.16 *Physiologic Observation Date/Time*—This field (usually considered optional for all implementation levels) can be used in result segments that do not have an information category code (those used to return a single numeric or coded result) if it is necessary to specify the date/time at which the result was measured. It could be used, for example, to indicate the date/time at which a body temperature measurement was made, when this is relevant to the interpretation of the study. It is not to be used to indicate the date/time that characterizes waveform data or other data directly associated with the waveform data (such as technical comments) since the TIM category result segment is used for this purpose, as described in 6.5.1. It is also not necessary to specify a date/time for result segments containing reports and interpretations derived from analysis of the entire study, since the study beginning and ending times are specified in the OBR segment (fields OBR-8 and OBR-9, respectively).

5.17 *Producer ID*—This field (usually considered optional for all implementation levels) may be used to specify the identity of the laboratory at which the data in the result segment was acquired or generated, using a coded entry (CE) data format. The first and fourth components specify unique codes for the laboratory. The second and fifth components specify text strings identifying the laboratory specified in the first and fourth components. The third and sixth components specify the coding system used in the first (the default is **MCR**, Medicare/HCFA's universal provider numbers (**8**)) and fourth (the default is **L**, indicating local codes) component. If this field is not present, the receiving system may assume that the data in the result segment was generated by the transmitting organization. Thus, this field need only be used when the data originated elsewhere. For example, when an EEG tracing performed elsewhere is interpreted by a laboratory and the original waveform data and annotations are transmitted to another party along with the resulting interpretation and report from that laboratory, the result segments containing waveform data and annotations would contain the ID of the original laboratory performing the study in field OBX-16, while this field would be omitted in segments used to transmit the report and interpretation.

5.18 *Responsible Observer*—This field (usually considered optional for all implementation levels) may be used to specify the individual directly responsible for the data in the result segment. For waveform data and annotations, this is usually the technician or physician who performed the study. For reports, interpretations, and analyzed data, this is usually the physician who interpreted the waveform data and generated the report. Since the information about the principal and assisting interpreter and technician is contained in fields OBR-33, OBR-34, and OBR-35 of the preceding order segment, this field need only be used if different technicians or physicians participated in different portions of the study, and it is necessary to associate the appropriate individual with the appropriate portion of the data. This field uses the composite ID and name (CNA) format described in 4.4.5.

6. Result Segments Needed for Waveform Transmission/Display

6.1 These categories of result segments comprise the minimal subset required to define and transmit waveform data (Level I implementations). They would allow reconstruction, display, and minimal labeling of the waveforms; this is analogous to a recording on strip chart paper with only channel, sensitivity, and filter setting labels. The ELC, MTG, and CHN categories of result segments together define the information required to identify and label the waveform data or analyses made on that data. TIM category result segments define the time of the start of the epoch of waveform data which follows, the sampling interval of the waveform data, the epoch length, the transmitted data format, and waveform averaging information. WAV category result segments contain the actual waveform data.

6.1.1 ELC category result segments define and name the electrodes or transducers attached to the subject and associate them with a physical amplifier input jack or pin number, when applicable. If only standard electrodes are used (for example, the standard 10–20 electrodes), no ELC category result segments need be transmitted; in this case, the receiving system either doesn't need to know the electrode or transducer characteristics, or uses a built-in set of default electrodes. Some studies (for example, polysomnograms) use special electrodes or transducers whose definition is critical for interpretation of the recording but for which no standards exist; for these studies, ELC category result segments should always be sent.

6.1.2 MTG category result segments define a named montage (an array of recording channels), while CHN category result segments define individual recording channels within a montage. These categories of result segment are required for all implementation levels. In a Level I implementation, only a single montage is available, and the MTG category result segment merely specifies the number of channels. In this case, ELC (if used) and then CHN category result segments are transmitted *after* the single MTG category result segment. CHN category result segments refer to electrode or transducer names defined in previously transmitted ELC category result segments (or to default electrode names when ELC category result segments are not used). TIM and WAV category result segments follow the ELC and the CHN category result segments. If electrode definitions change later in the recording, further ELC category result segments can be transmitted, which then apply to any subsequently transmitted waveform data. Similarly, if channel settings change later in the recording, further CHN category result segments can be transmitted at any time to specify the new channel definitions.

6.1.3 In Level II and greater implementations, multiple montages may be available. Montages are identified by a number in the range from one to *N*, where *N* is the maximum number of montages allowed by the transmitting system. Data

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acquisition) and receiving (or display) systems. It is suggested that systems used for EEG be designed with a minimum *N* of ten.

6.1.4 In Level II and greater implementations, each montage has associated with it a set of electrode definitions (specified by ELC category result segments) and channel definitions (specified by CHN category result segments). The maximum number of each of these is also determined by the transmitting and receiving systems; for EEG systems, it is suggested that at least 40 electrodes or transducers and 32 channels be permitted. Whenever a MTG category result segment is received, the receiving system should respond by selecting that montage's electrode and channel definitions to be currently in effect (for interpreting subsequent waveform data transmissions). The number of channels in the montage (given in the MTG category result segment) determines the number of data values expected for each time sample in subsequent WAV category result segments. If the MTG category result segment received specifies a montage number which has not yet been used in the current study (that is, since the last OBR segment), an empty set of electrode and channel definitions is selected, which can be filled in by subsequently transmitted ELC and CHN category result segments. If the MTG category result segment specifies a previously used montage number, the previously defined electrode and channel definitions for that montage are put into effect. Thus, the order of result segment transmission used is generally MTG category followed by ELC category followed by CHN category.

6.1.5 A set of electrodes or transducers may also be defined which are *common*, that is, available to all montages. This is done by transmitting the ELC category result segments defining the common electrodes *prior* to the first transmitted MTG category result segment. As for simple one-montage implementations, receiving systems may have a default set of common electrodes (for example, the standard 10–20 or extended 10–20 system scalp electrodes) which can be modified or added to by any ELC category result segments that precede the first MTG category result segment. *Montage-specific* ELC category (and all CHN category) result segments are transmitted after the MTG category result segment to which they apply.

6.1.6 At least one MTG category result segment must be transmitted prior to any CHN, ANA, or WAV category result segments. Many applications will not require more than one MTG category result segment, since additions to or changes in channel or electrode definitions can be made at any time (by CHN or ELC category result segments) within the currently selected montage. However, the ability to store and later retrieve an entire montage definition may be useful for some systems. A set of defined, named montages may also be used by the receiving (or display) system for purposes in addition to interpreting the waveform data received; for example, some systems allow waveform data to be displayed using a montage other than that used to send the data, by means of a montage reformatting program. Whenever a MTG category result segment is transmitted, it not only selects the montage used for data transmission (either previously defined, or to be defined by subsequent ELC and CHN category result segments), but also usually causes the receiving system to select that same montage for other purposes (for example, display or printing). However, subsequent SEL category result segments (described in 7.10) may be transmitted to specify that different montages should be selected for functions other than data transmission (for example, display or printing).

ELC Category

6.2 This category of result segment defines electrodes (or other physiologic data transducers including SQUID magnetometers and gradiometers) by a name which may be referenced in subsequent ELC, CHN, or STM category result segments (which associate the electrodes or transducers with specific data channels or define them as being used for stimulation). Each electrode or transducer has a number (unique within a given montage, and generally the same as the physical amplifier input jack or pin number) and a unique alphanumeric name (used in subsequent ELC, CHN, or STM category result segments to identify the electrode, as well as in displays). Electrodes may be either *actual* or *derived*. An actual electrode is a physical electrode or a magnetometer or other transducer connected to an amplifier input, with a given location, attributes, and up to five coordinates that further specify its location and orientation. The optional coordinate data can be used for creating mapped displays, for source dipole and other spatial analysis programs, etc. A derived electrode is a fictitious electrode whose signal is calculated as a linear combination (a weighted sum) of the signals at one or more other, previously defined electrodes or transducers. An ELC category result segment may be followed by a comment (C) segment, if needed, to specify additional detail about the electrodes defined. Each ELC category result segment defines one or more electrodes or transducers, and any number of ELC category result segments may be used. The observation value field of this category of result segment contains one or more subfields separated by repeat delimiters (~). Each subfield defines one actual or derived electrode, and consists of multiple components.

6.2.1 *Defining Actual Electrodes/Transducers*—For defining an actual electrode or transducer, a subfield in the ELC category result segment consists of up to eight components separated by component delimiters (^). The format of the ELC category result segment used to define actual electrodes or transducers is summarized in Table 10. The individual components are defined as follows:

6.2.2 *Electrode Number and Name (both required)*—Identifies the electrode or transducer with a number and name. The alphanumeric name follows the number and is separated from it by a subcomponent delimiter (**&**). The maximum length of an electrode name is eight characters, but names longer than four characters should be avoided, if possible, because of space limitations in displays. The name **CAL** should not be used because it is reserved for use in CHN category result segments to indicate a calibration signal input.

6.2.3 *Electrode Location (optional)*—Specifies a general location for the electrode or transducer, which can be further qualified by specifying electrode coordinates if necessary. The electrode location field may not be present, in which case the value given for the previously defined electrode in the same

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TABLE 10 ELC Category Result Segment Format—Defining Actual Electrodes

Components of Result Field	Type	Length, max
Electrode Number and Name		
Electrode number	NM	4
Electrode name	ST	8
Electrode Location		
Location code 1	ST	80
Text for location code 1	ST	200
Nature of location code 1	ID	12
Location code 2	ST	80
Text for location code 2	ST	200
Nature of location code 2	ID	12
Electrode/Transducer Attributes		
Electrode/transducer type	ID	8
Material of element 1	ID	8
Diameter of element 1	NM	20
Polarity/turns of element 1	NM	20
Distance between element 1 and 2	NM	20
Material of element 2	ID	8
Diameter of element 2	NM	20
Polarity/turns of element 2	NM	20
Distance between element 2 and 3	NM	20
Material of element 3	ID	8
Diameter of element 3	NM	20
Polarity/turns of element 3	NM	20
...		
Electrode Coordinate Number 1		
Coordinate	NM	20
Axis or angle identifier	ID	8
Electrode Coordinate Number 2		
...		

ELC category result segment (if any) is used. No specific default applies if the location is not present in the first electrode definition in an ELC category result segment. The electrode location consists of up to six subcomponents separated from each other by subcomponent delimiters (**&**). The subcomponents of the electrode location are similar to the coded entry (CE) data type.

6.2.3.1 *Location Code 1*—An alphanumeric topography code from a generally accepted coding system which identifies the electrode or transducer location. The SNOMED universal topography code (extended by use of qualifiers when necessary) is the default coding system. Other coding systems, beside SNOMED, may be used, if available. Appendix X1 lists the SNOMED codes and qualifiers which are most likely to be useful in defining electrode or transducer locations. This table may be included in Level III implementations of the specification (in data acquisition systems, for example, as a menu from which the technician may select when defining new electrodes or transducers). In Level I and II implementations, the code could be directly entered by means of a keyboard (transmitting systems) or displayed without interpretation (receiving systems), or it may not be present (a less satisfactory alternative), with the electrode location instead specified in text form in the second subcomponent of the location field.

6.2.3.2 *Text for Location Code 1*—A text description of the topographic location identified by the alphanumeric code in the first subcomponent. It may be used to provide an annotated description of the code. Also, it may be used to identify a location that cannot be represented with a code or to provide added specificity to the code. In a Level III implementation of this specification, tables of text descriptions of each topographic code identified in the previous subcomponent are part of the receiving system software so that a standard code sent alone can be expanded to a full text description on displays or reports; such tables are not implemented in lower levels.

6.2.3.3 *Nature of Location Code 1*—Identifies the coding system used for the topographic code in the first subcomponent. Typical values are **SNM+** (SNOMED topographic codes and associated qualifiers as listed in Appendix X1) or **99zzz** or **L** (locally defined codes, where each *z* represents an alphanumeric character). The default is **SNM+**.

6.2.3.4 *Location Code 2*—This subcomponent contains any secondary alphanumeric code used to identify the topographic location.

6.2.3.5 *Text for Location Code 2*—This subcomponent contains a text description of the topographic location identified by location code 2.

6.2.3.6 *Nature of Location Code 2*—This subcomponent identifies the coding system used for location code 2 (the default is **L**, local codes).

6.2.3.7 *Usage of Locations and Coordinates*—When coordinates are *not* specified for electrodes or transducers, the location given may be as specific as desired. When coordinates *are* used, the topographic location need only specify the position of the origin of the coordinate system, since the individual coordinates specify the exact location of the electrodes. For example, the location of the vertex (**T-Y0120**) may be used as an origin for all scalp electrodes.

6.2.3.8 Table 11 shows example locations (using qualified SNOMED topographic codes) appropriate for defining some of the standard 10–20 system electrodes, plus two surface EMG electrodes used to record from the left triceps brachii muscle, two surface EKG electrodes on the chest, and a ground electrode. This level of specificity is not required; for many applications, it is sufficient to identify each 10–20 electrode simply as a scalp location (**T-Y0160**) without further qualifiers.

6.2.4 *Electrode/Transducer Attributes (optional)*—Defines electrode or transducer attributes. Any or all of these attributes may not be present, in which case the values given for the previously defined electrode in the same ELC category result

TABLE 11 Example Electrode Location Definitions

Electrode	Location Identifier
Nz	T-12171-MID&Midline frontonasal suture (nasion)
Fp1	T-Y0111-LFT-ANT&Left anterior frontal region
F7	T-Y0111-LFT-LAT&Left lateral frontal region
F3	T-Y0111-LFT&Left frontal region
Fz	T-Y0111-MID&Midline frontal region
T3	T-Y0150-LFT&Left temporal region
C3	T-Y0120-LFT&Left vertex (central) region
Cz	T-Y0120-MID&Midline vertex (central) region
T5	T-Y0150-LFT-PST&Left posterior temporal region
P3	T-Y0130-LFT&Left parietal region
Pz	T-Y0130-MID&Midline parietal region
O1	T-Y0140-LFT&Left occipital region
Oz	T-Y0140-MID&Midline occipital region
A1	T-XY105-LFT&Left pinna of ear
T1	T-Y0150-LFT-ANT&Left anterior temporal region
Pg1	T-23000-LFT&Left nasopharynx
Sp1	T-10159-LFT&Left sphenoid bone
EMG1	T-13690-LFT-BEL&Left belly triceps brachii muscle
EMG2	T-13690-LFT-INS&Left insertion triceps brachii muscle
EKG1	T-11310-LFT-INF&Left inferior clavicle
EKG2	T-11310-RGT-INF&Right inferior clavicle
GND	T-10133-RGT&Right mastoid process of temporal bone

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segment are used. There are no defaults for the first electrode defined in an ELC category result segment. The attributes consist of multiple subcomponents separated from each other by subcomponent delimiters (**&**). These subcomponents are arranged in groups of four; each group defines the attributes of one of the elements making up the electrode (except that the first subcomponent, the electrode/transducer type, applies to all elements). Most electrodes and transducers have only one element. Multiple contact electrodes (such as concentric needle electrodes) and multiple loop magnetometers (magnetic field gradiometers) have multiple elements. The subcomponents defining electrode or transducer attributes are as follows:

6.2.4.1 *Electrode/Transducer Type*—Specifies the nature of the electrode or transducer. Any of the codes given in Table 12 may be used, or other codes may be used that have meaning to both the sending and receiving system.

TABLE 12 Codes for Types of Electrode or Transducer

Code	Meaning
Electrodes or Special Transducers on or Near Subject	
DA	Self-adhesive disk electrode
dc	Disk electrode held with collodion
DF	Disk electrode held with paraffin
DP	Disk electrode held with paste
DS	Disk electrode held with suction
DT	Disk electrode held with tape
EC	Electrode mounted in cap
EG	Electrode mounted in rectangular grid or array
ES	Electrode mounted in linear strip
MC	Multicontact wire electrode for depth recording
WI	Thin wire electrode
HK	Hooked wire electrode
CL	Clip-on electrode
RI	Ring electrode
NE	Needle electrode, unspecified
NM	Needle electrode, monopolar
NB	Needle electrode, bipolar
NC	Needle electrode, concentric
NS	Needle electrode, EMG single fiber
NA	Needle electrode, macro EMG
MAG	Magnetometer or magnetic field gradiometer (SQUID device)
ACC	Accelerometer (motion detector; for example, piezoelectric crys-tal)
PRS	Pressure transducer (for example, arterial, venous, intracranial, esophageal)
STR	Strain gage (for example, thoracic, abdominal, or penile)
IMP	Impedance measuring device (for example, for impedance pneu-mogram)
IND	Inductance measuring device (for example, for inductive plethys-mogram)
FLO	Flow-pressure transducer (for example, for pneumotachogram)
TMP	Thermometer (temperature sensor; for example, thermistor/thermocouple)
SND	Microphone (sound sensor; for example, laryngeal sound recorder)
HRT	Heart rate monitor (output proportional to average heart rate)
OXY	Oximeter (oxygen tension monitor)
CO2	Carbon dioxide tension monitor
PHM	pH monitor (for example, esophageal)
Signals from Other Devices (for example, used for stimulation)	
FLS	Flash stimulus monitor (for example, strobe light)
VIS	Other visual stimulus monitor (for example, pattern reversal occurrence)
AUD	Auditory stimulus monitor (for example, click or tone occurrence)
ELS	Electric stimulus monitor
SST	Somatosensory tester (signals stimulus such as percussion)
RST	Response tester (signals when subject or technician pushes button)
TIM	Time code or time marker

6.2.4.2 *Material of Element 1*—For physical electrodes, specifies the material of which the first element or contact of the electrode is composed. For magnetometers and gradiometers, this refers to the material of which the first loop (closest to the subject) is composed. The material may be any of the codes in Table 13 or other chemical element symbols or more than one of these codes may be concatenated if the material is an alloy (for example, **AuPt** = gold-platinum combination); also, other codes may be used that have meaning to both the sending and receiving system.

6.2.4.3 *Diameter of Element 1*—Specifies the diameter in centimetres of the first element (contact or loop) of the electrode or transducer (a fraction, for example, 0.4, may be used).

6.2.4.4 *Polarity/Turns of Element 1*—For multicontact physical electrodes, this specifies whether the first contact is connected to the amplifier system in such a way that the signal is added (polarity = + 1) or subtracted (polarity = −1). For example, for the center contact of a concentric needle electrode, polarity = 1 would be specified, but for the outer contact, polarity = −1 would be specified. This is only used when the concentric electrode is defined, for convenience, as a *single* electrode with two elements; it could alternatively be defined as two electrodes with one element each, in which case both electrode names would be specified separately in a CHN category result segment to indicate that one was connected to the first input and one to the second input of the differential amplifier. For multiple-loop gradiometers, this subcomponent specifies the number of turns in the loop. Positive numbers indicate counterclockwise loop polarity, while negative numbers indicate clockwise loop polarity. For example, a second-order gradiometer would have three loops, the first with polarity/turns = 1, the second with polarity/turns = −2, and the third with polarity/turns = 1.

6.2.4.5 *Distance Between Element 1 and 2*—For multicontact physical electrodes, this specifies the distance in centimetres (or fractions thereof) between the first and second electrode contacts. For multiple-loop magnetic gradiometers, this specifies the distance between the planes of the first and second loops in centimetres (the loops are all assumed to have the same orientation in space).

6.2.4.6 *Material of Element 2*—Specifies the material of which the second element (contact or loop) of the electrode or transducer is composed. The same codes are used as for element 1.

TABLE 13 Codes for Material for Physical Electrodes

Code	Meaning
Ag	Silver
AgCl	Silver chloride
Au	Gold
Cu	Copper
Nb	Niobium
Pt	Platinum
Sn	Tin
SS	Stainless steel

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6.2.4.7 *Diameter of Element 2*—Specifies the diameter in centimetres of the second element (contact or loop) of the electrode or transducer.

6.2.4.8 *Polarity/Turns of Element 2*—Specifies the polarity and turns of the second element (contact or loop) of the electrode or transducer. The usage is the same as for element 1.

6.2.4.9 *Distance Between Element 2 and 3*—This specifies the distance in centimetres (or fractions thereof) between the second and third elements (contacts or loops) of the electrode or transducer.

6.2.4.10 *Material of Element 3*—Specifies the material of which the third element (contact or loop) of the electrode or transducer is composed. The same codes are used as for element 1.

6.2.4.11 *Diameter of Element 3*—Specifies the diameter in centimetres of the third element (contact or loop) of the electrode or transducer.

6.2.4.12 *Polarity/Turns of Element 3*—Specifies the polarity and turns of the third element (contact or loop) of the electrode or transducer. The usage is the same as for element 1.

6.2.4.13 *Additional Electrode/Transducer Attributes*—Subsequent subcomponents may be used in electrodes or transducers with more than three elements (contacts or loops) to specify, for each element in sequence, the distance between the previous and current element, the material of the element, the diameter of the element, and the polarity/turns of the element. Note that if a multiple-loop gradiometer is not composed of loops which all have the same orientation or otherwise cannot be defined properly by the conventions defined in 6.2.4.2 through 6.2.4.12, an alternative method is to define each loop as a separate transducer (*electrode*) with its own name, location, attributes, and coordinates, and then define a *derived* electrode which represents the appropriate linear combination (weighted sum) of the signals from each of the separate loops.

6.2.5 *Electrode Coordinate Number 1 (optional)*—Specifies a coordinate which identifies the location or orientation of the electrode or transducer relative to some origin and coordinate system. Coordinates are most useful for scalp, subdural, and cortical depth electrodes, and possibly other cephalic electrodes or transducers—locations where arrays of many electrodes are generally used. Coordinates may be used for other electrode or transducer locations also (for example, to identify different positions along a peripheral nerve or in a muscle). For multi-contact electrodes, the coordinates refer to the first contact (closest to the origin of the coordinate system). For magnetometers or gradiometers, the coordinates refer to the center point of the first loop (closest to the origin of the coordinate system). No default or previous values are used for coordinates which are not present.

6.2.5.1 A linear coordinate is defined along a particular axis, which has a direction in space and an origin (zero coordinate). An angular coordinate is defined with respect to a particular coordinate system (set of rectangular axes). When coordinates are supplied, the general electrode location given previously by means of a location code specifies the *origin* of the coordinate system, while the axis directions in space are specified with the coordinates. In general, three coordinates are necessary to specify a unique position, but for many purposes only two are needed (that is, if the electrode is assumed to be on the skin surface). In addition, for some transducers (for example, magnetometers and gradiometers) and for multi-contact linear electrodes, two additional angular coordinates may be used to specify an orientation of the electrode or transducer in space (for gradiometers with multiple loops, all loops are assumed to have the same orientation). Each coordinate consists of a number specifying a distance in centimetres or an angle in degrees, and a corresponding axis or angle identifier, separated by a subcomponent delimiter (**&**). The allowed axis or angle identifiers are given in Table 14.

6.2.5.2 The coordinate system recommended for all cephalic electrodes or transducers is either rectangular (x = distance left [−] or right [+], y = distance posterior [−] or anterior [+], z = distance inferior [−] or superior [+]), or spherical (r = distance from origin radially outward, th = *longitude* or angle measured with respect to z axis, ph = *latitude* or angle of projection in x-y plane measured with respect to x axis). The orientation angles $th2$ and $ph2$ are used for transducers whose orientation must be specified ($th2$ = angle measured with respect to z direction, $ph2$ = angle of projection in x-y plane measured with respect to x direction). When the receiving system includes spatial mapping software, these coordinates can be used to produce a map, generally with x plotted horizontally and y vertically, or with y plotted horizontally and z vertically.

6.2.5.3 For two-dimensional rectangular coordinates (x and y only) used for scalp electrode arrays, the recommended origin is the vertex (general location **T-Y0120** using SNOMED codes). For three-dimensional rectangular coordinates and for spherical coordinates (which may be used for scalp, subdural, cortical depth, or other cephalic electrode arrays), the recommended origin is the center of the head (general location **T-Y0100** using SNOMED codes; for example, defined as the

TABLE 14 Coordinate Axis or Angle Identifier Codes

Identifier	Meaning
IS	Axis running inferior to superior
SI	Axis running superior to inferior
LR	Axis running left to right
RL	Axis running right to left
ML	Axis running medial to lateral
LM	Axis running lateral to medial
PA	Axis running posterior to anterior
AP	Axis running anterior to posterior
PD	Axis running from proximal to distal
DP	Axis running from distal to proximal
DS	Axis running from depth to surface
SD	Axis running from surface to depth
X	X axis (LR for cephalic locations; x = r sin[th] cos[ph])
Y	Y axis (PA for cephalic locations; y = r sin[th] sin[ph])
Z	Z axis (IS for cephalic locations; z = r cos[th])
R	R axis (radial distance from origin; r = SQRT [$x^2 + y^2 + z^2$])
TH	Angle theta wrt z axis (th = Arccos z/r, range from 0 to 180)
PH	Angle phi wrt x axis (ph = Arctan y/x, range from 0 to 360)
TH2	Orientation angle theta2 with respect to z direction
PH2	Orientation angle phi2 with respect to x direction

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center of a sphere with radius and center coordinates chosen in such a way that it passes most nearly through the scalp electrodes). In this context, the spherical (angular) coordinate system allows electrode positions on the scalp surface to be specified using only two coordinates (*ph* and *th*) which are independent of head size, and it also lends itself more readily to dipole localization and other sophisticated processing of waveform data. Either rectangular (*x, y, z*) or cylindrical (*r, ph, z*) coordinate systems (with appropriate choice of origin) may be used for electrodes or transducers on the limbs or trunk, with the *z* axis often being equivalent to **IS** (trunk) or **PD** (limb).

6.2.6 *Additional Electrode Coordinates (optional)*—Subsequent components may be used to specify additional coordinates for the electrode or transducer. The format of each component is the same as for coordinate number one.

6.2.7 *Standard Electrode Names*—A system may have predefined defaults for the *common* electrode set (available to all montages), which may be supplemented or modified by ELC category result segments transmitted prior to the first MTG category result segment in Level II and higher implementations.

6.2.7.1 For EMG and NCS studies, where as few as two electrodes may routinely be used, the standard or default electrodes for the common electrode set might be, for example, the names G1 and G2 (referring to two electrodes used for surface recording, or to the two contacts on a bipolar or concentric needle electrode). Systems with multiple recording channels could define default electrode names G1, G2, G3, G4, etc.

6.2.7.2 The electrode names and approximate spherical coordinates associated with the extended 10–20 system of electrode nomenclature are listed in Table 15. These electrodes and coordinates (or, alternatively, the standard 10–20 system electrodes which are a subset of those listed in Table 15) might be the standard or default electrodes for the common electrode set for EEG, PSG, MSLT, and EP studies.

6.2.8 *Defining Derived Electrodes*—For defining a derived electrode, the subfield of the ELC category result segment consists of multiple components (up to a predefined limit, preferably 35 or more) separated by component delimiters (^). The format of the ELC category result segment that defines a derived electrode is given in Table 16. The individual components are defined as follows:

6.2.9 *Electrode Number and Name (required)*—Same as the first component used for defining an actual electrode.

6.2.10 *Electrode Location (optional)*—Same as the second component used for defining an actual electrode, but usually not present for derived electrodes.

6.2.11 *Derived Electrode/Transducer Type (required)*—Consists of the single keyword **DERIV** to indicate a derived electrode which is a linear combination of other electrodes.

6.2.12 *Electrode 1 Multiplier and Name (required)*—Identifies the first electrode to be included in the linear combination and the multiplier (weight) to be applied. The alphanumeric name follows the multiplier and is separated from it by a subcomponent delimiter **(&)**.

TABLE 15 Standard Electrodes and Spherical Coordinates

Electrode Names	Electrode Meanings	Theta, deg	Phi, deg
Midline Electrodes			
Nz	Nasion	112.5	90
Fpz	Frontopolar	90	90
AFz	Anterior frontal	67.5	90
Fz	Frontal	45	90
FCz	Frontocentral	22.5	90
Cz	Central	0	0
CPz	Centroparietal	22.5	270
Pz	Parietal	45	270
POz	Parieto-occipital	67.5	270
Oz	Occipital	90	270
Iz	Inion	112.5	270
10 % Parasagittal Electrodes			
Fp1, Fp2	Frontopolar	90	108, 72
F1, F2	Frontal	52.9	112, 68
FC1, FC2	Frontocentral	33.4	132.7, 47.3
C1, C2	Central	22.5	180, 0
CP1, CP2	Centroparietal	33.4	227.3, 312.7
P1, P2	Parietal	52.9	248, 292
O1, O2	Occipital	90	252, 288
20 % Parasagittal Electrodes			
AF3, AF4	Anterior frontal	76.8	118, 62
F3, F4	Frontal	64	129.1, 50.9
FC3, FC4	Frontocentral	51.7	151.3, 28.7
C3, C4	Central	45	180, 0
CP3, CP4	Centroparietal	51.7	208.7, 331.3
P3, P4	Parietal	64	230.9, 309.1
PO3, PO4	Parieto-occipital	76.8	242, 298
30 % Parasagittal Electrodes			
F5, F6	Frontal	76.9	136.9, 43.1
FC5, FC6	Frontocentral	71	157.9, 22.1
C5, C6	Central	62.5	180, 0
CP5, CP6	Centroparietal	71	202.1, 337.9
P5, P6	Parietal	76.9	223.1, 316.9
40 % Parasagittal Electrodes			
AF7, AF8	Anterior frontal	90	126, 54
F7, F8	Frontal	90	144, 36
FT7, FT8	Frontotemporal	90	162, 18
T3, T4	Temporal (alias T7, T8)	90	180, 0
TP7, TP8	Temporoparietal	90	198, 342
T5, T6	Post temporal (alias P7, P8)	90	216, 324
PO7, PO8	Parieto-occipital	90	234, 306
50 % Parasagittal Electrodes			
F9, F10	Frontal	103.7	149.4, 30.6
FT9, FT10	Frontotemporal	108.7	164.3, 15.7
T9, T10	Temporal	112.5	180, 0
TP9, TP10	Temporoparietal	108.7	195.7, 344.3
P9, P10	Parietal	103.7	210.6, 329.4
Other Electrodes			
A1, A2	Ears	120	180, 0
T1, T2	Anterior temporal	106	162, 18
Pg1, Pg2	Pharyngeal		
Sp1, Sp2	Sphenoidal		

6.2.13 *Additional Multipliers and Names*—Subsequent components identify the multipliers and names for additional electrodes to be included in the linear combination, using the same format. An example subfield defining a derived electrode is the following:

35&A12^^DERIV^0.5&A1^0.5&A2

This defines electrode A12 (electrode number 35) as the linear combination calculated as 0.5 times A1 plus 0.5 times A2 (that is, the average of A1 and A2).

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TABLE 16 ELC Category Result Segment Format—Defining Derived Electrodes

Components of Result Field	Type	Length, max
Electrode Number and Name	Same format as for defining actual electrode	
Electrode Location	Same format as for defining actual electrode	
Derived Electrode/Transducer Type	ID	8
Electrode 1 Multiplier and Name		
Multiplier	NM	20
Name	ST	8
Electrode 2 Multiplier and Name		
...		

MTG Category

6.3 This category of result segment selects or defines a named montage and specifies the number of channels in the montage. The observation value field of a MTG category result segment contains two components separated by component delimiters (^). The format of the MTG category result segment is summarized in Table 17. The individual components are defined as follows:

6.3.1 *Montage Number and Name*—Identifies the montage with a unique number and an optional name (used, for example, in displays). The name, if specified, follows the number and is separated from it by a subcomponent delimiter **(&)**. It may contain alphanumeric and special characters (except delimiters).

6.3.2 *Maximum Number of Channels*—Specifies the number of channels in the montage (that is, the maximum number of data values transmitted at each time sample in subsequent WAV category result segments). It may not be present if the MTG category result segment specifies a previously used montage number, in which case the number of channels previously associated with that montage number is used.

CHN Category

6.4 This category of result segment defines a recording channel which is associated with one of the values in each time sample in subsequent WAV category result segments. Each channel has a number (which generally defines its position in a multichannel display) and an optional name (also used in displays). It usually has two associated electrodes (because of the use of differential amplifiers with two inputs), although when a multiple-element electrode or transducer is connected to the channel (for example, a special transducer such as a SQUID magnetometer or gradiometer with multiple coils, or an electrode with two or more contacts such as a concentric needle type), only one electrode name need be specified since the polarity and other attributes of each element (contact or coil) can be defined in the ELC category result segment. A channel also has an associated sensitivity, calibration parameters (sensitivity correction factor and baseline), time skew, sampling (digitization) frequency, minimum and maximum values, and any number of filter settings (up to the maximum allowed by the sending and receiving systems; this maximum should be at least three). Each CHN category result segment defines one or more channels, and any number of CHN category result segments may be used. A CHN category result segment may be followed by a comment (C) segment, if needed, to specify additional detail about the channels and their characteristics (for example, amplifiers and filters used, including detailed analog or digital filter characteristics). The observation value field of this category of result segment contains one or more subfields separated by repeat delimiters (~). Each subfield defines one channel, and consists of multiple components separated by component delimiters (^). The format of the CHN category result segment is summarized in Table 18. The individual components are defined as follows:

6.4.1 *Channel Number and Name*—Identifies the channel by number and name. The number is required, and must be in the range from one to *N* where *N* is the number of channels defined in the last MTG category result segment. The name is an optional text string containing alphanumeric characters; it is used in waveform data displays. If this name is not present, the channel label displayed is **<elec1>–<elec2>**, where <elec1> and <elec2> are the names of the two electrodes connected to this channel (if only one electrode or transducer is connected, the channel label displayed is the same as the electrode name). The maximum length of the channel name is 17 characters, but

TABLE 17 MTG Category Result Segment Format

Components of Result Field	Type	Length, max
Montage Number and Name		
Number	NM	4
Name	ST	40
Maximum Number of Channels	NM	4

TABLE 18 CHN Category Result Segment Format

Components of Result Field	Type	Length, max
Channel Number and Name		
Number	NM	4
Name	ST	17
Electrode 1 and 2 Names		
Electrode 1 name	ST	8
Electrode 2 name	ST	8
Channel Sensitivity and Units		
Sensitivity	NM	20
Units code 1	ST	80
Text for units code 1	ST	200
Nature of units code 1	ID	12
Units code 2	ST	80
Text for units code 2	ST	200
Nature of units code 2	ID	12
Channel Calibration Parameters		
Sensitivity correction factor	NM	20
Baseline	NM	20
Time skew	NM	20
Channel Sampling Frequency	NM	20
Minimum and Maximum Data Values		
Minimum	NM	20
Maximum	NM	20
Filter 1		
Filter type	ID	8
Filter implementation	ID	8
Filter low-frequency limit	NM	20
Filter low-frequency rolloff or second limit	NM	20
Filter high-frequency limit	NM	20
Filter high-frequency rolloff or second limit	NM	20
Filter characteristics	ID	8
Filter order or number of coefficients	NM	20
Filter minimum stopband attenuation	NM	20
Filter maximum passband attenuation	NM	20
Filter 2		
...		

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names longer than 9 characters should be avoided, if possible, because of limited space in displays.

6.4.2 *Electrode 1 and 2 Names*—Identifies the electrodes or transducers connected to the channel. The two names refer to electrodes defined in the montage (or electrodes common to all montages), and are separated by a subcomponent delimiter **(&)**. The first name is required, but the second may not be present if the channel is connected to a special transducer or multi-element electrode or does not represent a differentially amplified signal with two inputs. Using **CAL** for the first (and only) electrode name indicates that the channel is connected to a calibration signal source (which may be further defined by a later STM category result segment).

6.4.3 *Channel Sensitivity and Units*—Defines the channel sensitivity and the units in which it is measured. This component consists of up to seven subcomponents, separated from each other by subcomponent delimiters **(&)**. The first subcomponent specifies the sensitivity, while the remaining six subcomponents are used to specify the units of the sensitivity, using a format similar to the components of the coded entry (CE) data type. If the entire channel sensitivity and units component is not present, the value given for the previously defined channel in the same CHN category result segment is used; for the first defined channel in the segment, the default is 1 μV (microvolt). The subcomponents of the channel sensitivity and units are as follows:

6.4.3.1 *Sensitivity*—Defines the nominal voltage (or other quantity for transducers other than voltage sensitive) corresponding to a value of one unit in the waveform data, that is, the effective resolution of the least significant bit of the ADC, and the polarity of the channel. The sensitivity incorporates both the amplifier gain and the actual ADC resolution. It does not, however, relate to the vertical scaling of a waveform display (that is, it is a measure of voltage, not voltage per unit distance). A positive sensitivity indicates that a positive number in the waveform data represents a potential at the first electrode which is more positive than that at the second electrode. A negative sensitivity indicates that a positive number in the waveform data corresponds to a potential at the first electrode which is more negative than that at the second electrode. The convention for many neurophysiologic studies is that positive potentials at the first electrode produce upward deflections; however, for EEG records the opposite is true.

6.4.3.2 *Units Code 1*—An alphanumeric units designation (for example, uv = microvolt, mv = millivolt, v = volt, or ft = femptotesla) from a designated system of units, such as ISO standard SI unit abbreviations (the default), or ANSI standard U.S. customary unit abbreviations.

6.4.3.3 *Text for Units Code 1*—An optional text description of the units identified by the first subcomponent. It may be used to provide an expanded description of the units abbreviation, or it may be used to identify units that cannot be represented with standard abbreviations.

6.4.3.4 *Nature of Units Code 1*—An identifier for the system of units used in the first subcomponent. Typical values are **ISO+** (SI units standard abbreviations, the default), **ANS+** (U.S. customary units standard abbreviations), or **99zzz** or **L** (locally defined units, where each *z* represents an alphanumeric character).

6.4.3.5 *Units Code 2*—An optional secondary alphanumeric units designation from an alternate system of units.

6.4.3.6 *Text for Units Code 2*—An optional text description of the secondary units designation in units code 2.

6.4.3.7 *Nature of Units Code 2*—An identifier for the alternate system of units used for units code 2 (the default is **L**, locally defined units).

6.4.4 *Channel Calibration Parameters*—This component consists of three optional subcomponents, separated from each other by subcomponent delimiters **(&)**, which define corrections to channel sensitivity, baseline, and channel time skew which may be derived from a calibration procedure. If any of these subcomponents is not present, the corresponding value given for the previously defined channel in the same CHN category result segment is used; for the first defined channel in the segment, the defaults are used as listed in 6.4.4.1 through 6.4.4.3. The three subcomponents are as follows:

6.4.4.1 *Sensitivity Correction Factor*—Defines a correction factor for channel sensitivity which may be derived from the last calibration procedure performed. The actual channel sensitivity is the nominal channel sensitivity given in the previous component multiplied by the unitless correction factor. The default is one.

6.4.4.2 *Baseline*—Defines the actual channel baseline (the data value which corresponds to a nominal input signal of zero). The actual baseline may differ from the ideal because of a dc offset in the amplifier connected to the ADC. The actual baseline values for all channels (which need not be integers) may be determined at the time of calibration as the average digitized values obtained when a zero input signal is connected to each channel. The default is zero.

6.4.4.3 *Time Skew*—Defines the time difference between the nominal sampling (digitization) time (which would be the same for all channels) and the actual sampling time of the channel, in seconds (or fractions thereof). This value will differ from zero when all channels in the montage are not sampled simultaneously, as occurs in systems which sample successive channels at regular time intervals. This value may be determined from a calibration procedure in which an identical time-varying signal is applied to all channels and interchannel time differences are estimated, or more commonly it may be taken from the manufacturer's specifications for the digitizing system used. For example, for a system which samples successive channels at regular time intervals t, the time skew of channel number n would be $(n\text{-}1)t$. The actual time of sampling (digitization) of sample number m of channel number n in such a system would be $R + (m-1)/f + (n-1)t$, where R is the reference time at the start of the epoch specified in a TIM category result segment and f is the channel sampling frequency ($t < 1/f$). The default is zero.

6.4.5 *Channel Sampling Frequency*—Defines the sampling frequency in hertz of the channel (the reciprocal of the time in seconds between successive samples). This value may be zero to indicate that the channel is not sampled at regular intervals but rather is sampled sporadically; in this case, digitized values for the channel appear in waveform data transmission only at

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those times when the channel is sampled, and are not present at all other times. If the channel sampling frequency is not present, the sampling frequency is assumed to be equal to the reciprocal of the sampling interval specified for all channels in a subsequent TIM category result segment which defines the start of an epoch of waveform data for the montage that includes this channel (note that this assumption differs from that applicable to other components of the CHN category result segment, for which values which are not present are taken to be the same as the corresponding value given for the previously defined channel). Thus, in applications in which all channels in a given montage are sampled at the same frequency, individual channel sampling frequencies need not be specified; instead, the sampling interval (reciprocal of the sampling frequency) for all channels is specified in later TIM category result segments. In applications in which channels in a given montage are sampled at different frequencies, usually the sampling intervals of individual channels are integral multiples of the sampling interval specified in later TIM category result segments which define the epochs of waveform data, as described in 6.7 (waveform data acquired at differing sampling frequencies). If this is not the case, the *transmitting* system must convert the digitized data for each channel to effective values for a single sampling interval applicable to all channels for transmission; this practice should be used cautiously to avoid significant data distortion.

6.4.6 *Minimum and Maximum Data Values*—Defines the minimum and maximum data values which can occur in this channel in subsequent WAV category result segments, that is, the range of the ADC (a function of the number of bits in the ADC), and also specifies whether or not nonintegral data values may occur in this channel in subsequent WAV category result segments. If the minimum and maximum values are both integers (or not present), only integral data values may be used in this channel. If either the minimum or the maximum value contains a decimal point, then nonintegral as well as integral data values may be used in this channel (which may require greater overhead in converting the channel values from decimal ASCII to an internal binary representation in the receiving system). Values outside of the specified range are flagged in subsequent WAV category result segments as overflow or underflow. For an n-bit signed ADC, the nominal baseline $B = 0$, and the minimum (L) and maximum (H) values may be calculated as follows:

$$L = -2^{n-1} \tag{1}$$

$$H = 2^{n-1} - 1 \tag{2}$$

For an unsigned n-bit ADC, the minimum value $L = 0$, and the nominal baseline value (B) and maximum value (H) may be calculated from the formulas,

$$B = 2^{n-1} \tag{3}$$

$$H = 2^{n} - 1 \tag{4}$$

6.4.6.1 The actual signal amplitude A (generally, the potential at electrode number one minus that at electrode number two) may be calculated from the data value D (range L to H) in the WAV category result segment using the actual baseline value B and the nominal sensitivity S and actual sensitivity correction factor C by the formula,

$$A = SC(D - B) \tag{5}$$

6.4.6.2 The minimum and maximum values are separated by component delimiters **(&)**. If either of the values is not present, the corresponding value given for the previously defined channel in the same CHN category result segment is used; for the first defined channel in the segment, the default values are the integers – 1024 (minimum) and 1023 (maximum).

6.4.7 *Filter 1*—Defines the characteristics of the primary filter for the channel. The filter is specified in terms of its type (high pass, low pass, band pass, or band stop), implementation (analog or digital), low- and high-frequency limits, order, and other characteristics. This specification is based on the amplitude versus frequency response of the filter and does not describe directly the phase response. If it is necessary to specify more detail concerning the filtering process, a comment (C) segment following the CHN category result segment may be used (for example, one could specify the actual filter coefficients or algorithm for a digital filter).

6.4.7.1 The frequency response of a filter is characterized by passbands (ranges of frequencies in which the signal is not significantly attenuated) and stopbands (ranges of frequencies in which the signal is significantly attenuated). The description of the filter assumes a maximal gain of one in the passbands and specifies attenuations on a logarithmic scale with respect to this level as 0 dB. High- and low-frequency limits for an analog filter are specified at the 3-dB attenuation points (when the amplitude of a sine wave is attenuated to 70.7 % of its unattenuated value), and high- and low-frequency rolloffs are specified in decibels per octave (10 dB representing a factor of ten change in amplitude, and one octave representing a factor of two change in frequency). A digital filter, which can have a more irregular frequency response curve with *ripple*, is characterized by a maximum attenuation in the passbands (representing the amount of *ripple* in the passbands) and by a minimum attenuation in the stopbands (that is, the attenuation in the stopbands is assumed to be always greater than or equal to this value). Between a passband and a stopband, there is a transition region, in which the attenuation changes continuously from the minimum stopband value to the maximum passband value or vice versa. The slope of the frequency response curve in each transition region is defined by giving the beginning and ending frequency of the transition band (that is, the frequencies adjacent to the passband and adjacent to the stopband).

6.4.7.2 Filter characteristics for a channel are assumed to relate to the sampling interval specified in the TIM category result segment that defines the epoch of digitized waveform data for that channel; as noted in 6.4.5, this sampling interval may differ from that implied by the actual channel sampling frequency as defined by the CHN category result segment. Therefore, if decimation filtering following higher frequency sampling or an operation such as ensemble averaging was

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performed, then the filter characteristics are reported as effective parameters after transformation from the original sampling frequency to the relevant sampling interval for the data as transmitted.

6.4.7.3 The filter 1 parameters consist of up to ten subcomponents, separated by subcomponent delimiters **(&)**. If *all* of the filter 1 parameters are not present, all of the values given or assumed for the primary filter in the previously defined channel in the same CHN category result segment are used; if *all* are not present for the first channel in the segment, no primary filter is defined. If *individual* subcomponents are not present, however, then default values are used as described in 6.4.7.4 through 6.4.7.13. The ten subcomponents are as follows:

6.4.7.4 *Filter Type (optional)*—Defines the filter type. The codes given in Table 19 are used; the default is **BP**.

6.4.7.5 *Filter Implementation (optional)*—Defines the implementation of the filter. The codes given in Table 20 are used; the default is **ANA**.

6.4.7.6 *Filter Low-Frequency Limit (optional)*—For analog filters other than type **LP** (**HLF**), this defines the low-frequency limit of the filter in hertz (at 3-dB attenuation). For digital filters of type **HP** (**LLF**) or **BP**, this defines the frequency in hertz at which the transition from stopband to passband begins (the frequency at which the amplitude is attenuated by an amount given by the minimum stopband attenuation specified by subcomponent nine). For digital filters of type **BS** (notch), this defines the frequency in hertz at which the transition from passband to stopband begins (the frequency at which the amplitude is attenuated by an amount given by the maximum passband attenuation specified by subcomponent ten). This subcomponent is not present for filters of type **LP** (**HLF**). The default is zero.

6.4.7.7 *Filter Low-Frequency Rolloff or Second Limit (optional)*—For analog filters other than type **LP** (**HLF**), this defines the low-frequency rolloff, that is, the slope of the logarithmic amplitude versus frequency curve at the low-frequency limit of the filter, in decibels per octave. For digital filters of type **HP** (**LLF**) or **BP**, this defines the frequency in hertz at which the transition from stopband to passband ends (the frequency at which the amplitude is attenuated by an amount given by the maximum passband attenuation specified by subcomponent ten). For digital filters of type **BS** (notch), this defines the frequency in hertz at which the transition from passband to stopband ends (the frequency at which the amplitude is attenuated by an amount given by the minimum stopband attenuation specified by subcomponent nine). This subcomponent is not present for filters of type **LP** (**HLF**). The default rolloff for analog filters is calculated from the filter order. The default for digital filters is the value of the previous subcomponent (that is, a very sharp transition is assumed).

TABLE 19 Filter Type Codes

Code	Meaning
HP (or LLF)	High pass—removes frequencies below low-frequency limit
LP (or HLF)	Low pass—removes frequencies above high-frequency limit
BP	Band pass—removes frequencies outside low and high limits
BS	Band stop—removes frequencies between low and high limits

TABLE 20 Filter Implementation Codes

Code	Meaning
ANA	Analog filter
FIR	Digital filter, finite impulse response type
IIR	Digital filter, infinite impulse response type
LAT	Digital filter, lattice type
LAD	Digital filter, ladder type

6.4.7.8 *Filter High-Frequency Limit (optional)*—For analog filters other than type **HP** (**LLF**), this defines the high-frequency limit of the filter in hertz (at 3-dB attenuation). For digital filters of type **LP** (**HLF**) or **BP**, this defines the frequency in hertz at which the transition from passband to stopband begins (the frequency at which the amplitude is attenuated by an amount given by the maximum passband attenuation specified by subcomponent ten). For digital filters of type **BS** (notch), this defines the frequency in hertz at which the transition from stopband to passband begins (the frequency at which the amplitude is attenuated by an amount given by the minimum stopband attenuation specified by subcomponent nine). This subcomponent is not present for filters of type **HP** (**LLF**). The default is infinity (no high-frequency limit).

6.4.7.9 *Filter High-Frequency Rolloff or Second Limit (optional)*—For analog filters other than type **HP** (**LLF**), this defines the high-frequency rolloff, that is, the slope of the logarithmic amplitude versus frequency curve at the high-frequency limit of the filter, in decibels per octave. For digital filters of type **LP** (**HLF**) or **BP**, this defines the frequency in hertz at which the transition from passband to stopband ends (the frequency at which the amplitude is attenuated by an amount given by the minimum stopband attenuation specified by subcomponent nine). For digital filters of type **BS** (notch), this defines the frequency in hertz at which the transition from stopband to passband ends (the frequency at which the amplitude is attenuated by an amount given by the maximum passband attenuation specified by subcomponent ten). This subcomponent is not present for filters of type **HP** (**LLF**). The default rolloff for analog filters is calculated from the filter order. The default for digital filters is the value of the previous subcomponent (that is, a very sharp transition is assumed).

6.4.7.10 *Filter Characteristics (optional)*—Defines the filter characteristics. The codes given in Table 21 may be used, or another code may be used which has meaning to both the sending and receiving systems; there is no specific default.

6.4.7.11 *Filter Order or Number of Coefficients (optional)*—For analog filters, this defines the order of the filter. For digital filters, this defines the total number of coefficients used in the filter. The default is one.

6.4.7.12 *Filter Minimum Stopband Attenuation (optional)*—For a digital filter, this defines the minimum attenuation in the stopband, a measure of *ripple* in the stopband. The attenuation within the entire stopband is greater than or equal to this amount. This subcomponent is not used for analog filters. The default is 10 dB.

6.4.7.13 *Filter Maximum Passband Attenuation (optional)*—For a digital filter, this defines the maximum attenuation in the passband, a measure of *ripple* in the passband. The attenuation within the entire passband is less

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TABLE 21 Filter Characteristics Codes

Code	Meaning
BAR	Bartlett filter
BES	Bessel filter
BLA	Blackman filter
BUT	Butterworth filter
CH1	Chebyshev 1 filter
CH2	Chebyshev 2 filter
COM	Comb filter
COS	Cosine taper filter
ELL	Elliptic filter
HAM	Hamming filter
HAN	Hanning filter
INT	Integrating filter
KAI	Kaiser filter
LER	Lerner filter
MOV	Moving average filter
ORM	Ormsby filter
TUK	Tukey taper filter

than or equal to this amount. This subcomponent is not used for analog filters (for which a 3-dB attenuation is always used to define the frequency limits of the passband). The default is 3 dB.

6.4.8 *Additional Filters*—Subsequent components may specify additional filters for the channel; the format of each is the same as for Filter 1. If *all* of the parameters defining an additional filter are not present, the values given for the corresponding filter in the previously defined channel in the same CHN category result segment are used; if *all* are not present for the first channel in the segment, no additional filter is defined. If *individual* subcomponents are not present, then defaults are used as given in 6.4.7.1 through 6.4.7.13.

6.4.8.1 An example subfield defining channel 15 as Fp1-F3 with sensitivity 0.5 µV (microvolts), sensitivity correction factor 1.1, baseline value 1, time skew 0.00031 s, sampling frequency 200 Hz, minimum and maximum data values – 2048 and + 2047, primary bandpass analog filter at 1 Hz (low) and 70 Hz (high) with 6-dB/octave rolloff, and an analog 60-Hz notch filter (filters from 51 to 67 Hz) with 12-dB/octave rolloff is as follows:

15^Fp1&F3^.5&uv^1.1&1&.00031^200^–2048&2047^ BP&&1&6&70&6^BS&&51&12&67&12

TIM Category

6.5 This category of result segment defines a time which characterizes the start of the epoch of waveform data which follows (WAV category result segments), or the start of an epoch in which analysis or feature detection has been performed, the results of which will be transmitted in the next ANA category result segment. It also determines the time which characterizes immediately following STM category result segments (defining the start or end of stimulation), TCM category result segments (technical comments), or MED category result segments (medications administered). It also defines the sampling interval (the time between successive transmitted digitized values for each channel in subsequent WAV category result segments), the transmission data format used, and optional parameters defining the epoch and averaging method for EP or other types of averaged data.

6.5.1 A TIM category result segment must be transmitted prior to any WAV, STM, or ANA category result segments. TCM and MED category result segments may precede the first TIM category result segment, if the comments were recorded or medications administered prior to the actual beginning of data acquisition. The receiving system should maintain a time variable which is initially loaded by the first TIM category result segment and is rewritten by each subsequent TIM category result segment. Each WAV category result segment causes the time variable to be incremented by an amount equal to the sampling interval multiplied by the number of time samples contained in the segment. STM, ANA, TCM, MED, and other categories of result segment do not affect the time variable.

6.5.2 With this arrangement, many applications will not require more than one TIM category result segment, since the time variable is automatically updated as waveform data segments are received. However, if there is a gap in the time sequence of waveform data (for example, a pause in the recording), this should be indicated by the transmission of a new TIM category result segment prior to subsequent waveform data. A change in sampling interval or data format or beginning a new epoch for averaging or sleep stage scoring purposes would also require a new TIM category result segment. It may also be advantageous to transmit a new TIM category result segment preceding a new portion of a recording (for example, when the subject state changes from awake to asleep, or when beginning hyperventilation). Normally, the time variable increases during a transmission, but a TIM category result segment may set it back to a previous time in special circumstances. For example, if it is necessary to transmit both the *raw* unaveraged data for an EP study and the final average, a TIM category result segment could be transmitted to define the start time of the data acquisition, followed by the WAV category result segment(s) containing all of the *raw* data, followed by another TIM category result segment to reset the time back to the initial start time and define an averaged epoch of data, followed by the WAV category result segment(s) containing just the final averaged data. Similarly, if it were necessary to transmit the results of analysis of waveform data at some time *after* the waveform data were transmitted, a TIM category result segment would be transmitted first to define the starting time and (optionally) the duration of the epoch to which the analysis applied, followed immediately by the ANA category result segment containing the results of the analysis.

6.5.3 The time which is defined by a TIM category result segment is an absolute time of day, rather than time relative to the start of the recording, and as such is transmitted as a date and a time (to facilitate prolonged recordings which continue through more than one day). The only exception is the special situation of downloading equipment settings by transmitting result (OBX) segments following the order (OBR) segment that is used to order the study. If time-dependent settings are downloaded, TIM category result segments may be transmitted, but the times that they specify are relative to the start of the procedure. For example, a stimulator program may be downloaded by transmitting a series of STM category result segments to define stimulus types, rates, durations, etc.; TIM category result segments immediately preceding each STM

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category result segment may be included to specify the times, relative to the start of execution of the stimulator program, at which each STM category result segment takes effect. An example of this usage is a photic stimulation program for EEG studies, which specifies 1 Hz light flashes for 10 s at time 00:00:00, then 5 Hz light flashes for 10 s at time 00:00:15, then 8 Hz light flashes for 10 s at time 00:00:30, etc. (providing 5 s gaps between the end of each stimulus group and the beginning of the next).

6.5.4 The observation value field of a TIM category result segment contains up to nine components separated by component delimiters (^); its format is summarized in Table 22. The individual components are defined as follows:

6.5.5 *Time at Start of Epoch*—This component contains a date and time in the standard format described in 4.4.14 (with the time usually specified in seconds and fractions thereof, with a resolution equal to the sampling interval); Table 23 gives some examples. This component is required, except when the TIM category result segment is used only to download the sampling interval, epoch duration, transmitted data format, and averaging information as described in 9.4.4.7. When it is necessary to specify a time relative to the start of a procedure (as was described in 6.5.3) instead of an absolute time, the date portion of the time should be transmitted as 8 zero digits; for example, relative time 00:01:10 becomes 00000000000110.

6.5.6 *Sampling Interval*—This component specifies the time (in seconds) which elapses between samples in the digitized waveform data stream for any single channel (assumed to be the same for all channels in the current montage). For example, a typical value for EEG is 0.005.

6.5.7 *Duration of Epoch*—This component specifies the duration of the epoch of digitized waveform data which will follow, in seconds. The number of samples for each channel is the epoch duration divided by the sampling interval. This component is required when the waveform data represents an averaged set (an average of multiple fixed-length epochs), as for an EP recording. It also may be required when certain types of ANA (analyzed data) category result segments are used (for example, for frequency spectral analysis) or for sleep stage scoring, in order to specify the duration of the epoch on which the analysis or scoring was performed. It is otherwise optional, for example for unaveraged EEG, EMG, or NCS data, since the transmitting system may not know the length of the following epoch until after it is transmitted.

TABLE 22 TIM Category Result Segment Format

Components of Result Field	Type	Length, max
Time at Start of Epoch	TS	26
Sampling Interval	NM	20
Duration of Epoch	NM	20
Transmitted Data Format	ID	8
Time from Reference Mark to Start of Epoch	NM	20
Averaging Method	ID	8
Identification of Epochs Selected for Averaging (Epoch *m* of *n*)		
Integer *m*	NM	20
Integer *n*	NM	20
Number of Epochs Averaged	NM	20
Number of Epochs Rejected	NM	20

TABLE 23 Example Time Specifications

Date/Time	Interpretation
19900325153219.135	135 ms past 3:32:19 PM, March 25, 1990
19900802073512-05	7:35:12 AM EST (5 h behind Coordinated Universal Time), August 2, 1990
19901015134502.925	925 ms past 1:45:02 PM, October 15, 1990

6.5.8 *Transmitted Data Format*—This component indicates the format of the transmitted data in all subsequent WAV category result segments (until the next TIM category result segment). Any of the codes given in Table 24 may be used; instead of **LOC**, a locally defined code may be used to indicate a specific locally defined nonstandard data format which is known to both the sending and receiving systems. The default and preferred value is **DEC**. Only the **DEC**, **DNC**, and **dcB** formats are standard (and portable). Although a particular transmitter or receiver system need only implement the data format(s) required for the type of waveform data it is designed to handle, the **DEC** and **DNC** data formats will be the most commonly used, and will be implemented by most receiver systems. The most general receiving systems will implement all of these standard formats. However, the **HEX**, **BIN**, and **LOC** formats are to be used only for nonstandard (and non-portable) data transmission, as described in 6.6.3.

6.5.9 *Time from Reference Mark to Start of Epoch*—This value is required when defining an epoch of averaged waveform data; it is not present when defining an epoch of unaveraged data. It specifies the time in seconds from the reference point for averaging to the start of the epoch. The reference point is the time at which the stimulus is delivered for EP or NCS averaging, or the time of the external trigger for triggered averaging (for example, averaging of movementrelated potentials triggered by a signal derived from the onset of a compound muscle action potential recorded by an EMG lead), or the time marked by a cursor in manual averaging of EEG, polysomnogram, or EMG transients (such as spikes), or the time marked by an automatic transient detection routine in automatic averaging of EEG, polysomnogram, or EMG transients. A positive number indicates that the averaging epoch begins some time *after* the reference time. A negative number indicates that the averaging epoch begins some time *before* the reference time (back averaging). In the latter case, the epoch may extend beyond the reference time if necessary (back and

TABLE 24 Transmitted Data Format Codes

Code	Meaning
DEC	Decimal standard channel-multiplexed format with optional channel numbers in second subcomponent
DNC	Decimal standard channel-multiplexed format with no channel numbers, transmitted in ascending channel number order
dcB	Decimal channel block (unmultiplexed) format, transmitted in ascending channel number order
HEX	Hexadecimal standard channel-multiplexed format (using \X\ escape sequence), transmitted in ascending channel number order
BIN	Binary standard channel-multiplexed format (using \Z\ escape sequence), transmitted in ascending channel number order
LOC	Locally defined (nonstandard) format (using \X\ or \Z\)

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forward averaging). Zero indicates that the averaging epoch begins at the reference time.

6.5.10 *Averaging Method*—This optional component is used when defining an epoch of averaged data; it specifies the type of averaging performed on the waveform data in the epoch. Any of the codes given in Table 25 may be used, or other codes may be used that have meaning to both the sending and receiving system; the default is **ALL**. Averaging method **ALT** may be used, for example, for averaging evoked potential data resulting from alternating polarity auditory stimuli when it is desired to enhance the polarity-dependent waveforms (such as cochlear microphonics); it may also be used to obtain a *noise* epoch that can be compared with the *signal* epoch resulting from averaging all epochs in the standard fashion. Averaging method **CNT**, for example, may be used with $n = 2$ to generate two averages simultaneously, with the first, third, etc., epochs forming one average, and the second, fourth, etc., forming the other. Averaging method **STM** is appropriate when multiple stimulus types are employed for evoked potential averaging (for example, an *oddball* stimulus paradigm in which unusual stimuli are intermixed randomly among a larger number of usual stimuli and an average is obtained of responses to unusual stimuli).

6.5.11 *Identification of Epochs Selected for Averaging*—This optional component is used only when defining an epoch of averaged data; it consists of two integer subcomponents (m and n) separated by a subcomponent delimiter **(&)** which identify the particular epochs included in the average for averaging methods **CNT**, **STM**, and **SEL**. For averaging method **CNT**, the epochs selected for averaging are those numbered m, $m + n$, $m + 2n$, etc. (for example, **2 & 5** indicates the second, seventh, twelfth, etc., epochs). For averaging method **STM**, the epochs selected for averaging are those evoked by stimulus type m out of a possible n stimulus types. The characteristics of each stimulus type are defined in a subsequent STM category result segment. For averaging method **SEL**, epochs selected for averaging are those satisfying criteria number m out of a set of n criteria. The actual criteria may be specified in an immediately following comment (C) segment if necessary.

6.5.12 *Number of Epochs Averaged*—This optional value, used for averaged data, specifies the number of epochs actually included in the average. The default is one.

6.5.13 *Number of Epochs Rejected*—This optional value, used for averaged data, specifies the number of epochs of *raw* data which were acquired but not included in the average because of artifact or for other reasons. The default is zero.

TABLE 25 Averaging Method Codes

Code	Meaning
ALL	All epochs of data are included in the average
ALT	All epochs of data are included in the average, but successive epochs are alternately added to and subtracted from the average
SEL	Epochs of data are included in the average only if they satisfy one of a number of different predefined selection criteria
CNT	Epochs of data are counted and every *n*th epoch is included in the average where *n* is an integer number
STM	Epochs of data to be included in the average are selected according to stimulus type

WAV Category

6.6 This category of result segment is used to transmit the actual waveform data (the digitized values from an ADC or other digital data source). An epoch of waveform data for all channels and at multiple successive times may be transmitted in a single WAV category result segment (extended when necessary by use of addenda lines if the length exceeds the 220 character limit set by Specification E 1238, and provided that the length of the observation value field does not exceed the maximum defined field length for OBX segments, 64K), or in multiple successive WAV category result segments, possibly with interspersed result segments of other types (for example, containing annotations or comments). The waveform data may be transmitted in either channel-multiplexed format (that is, the values for all channels for the first time sample are transmitted, then the values for the next time sample, and so on until the requisite number of time samples have been transmitted), or in channel block (unmultiplexed) format (that is, the values for the first channel for multiple time samples are transmitted, then the values for the second channel for the same times, and so on until all channels have been transmitted). The data may be transmitted either using standard decimal encoding or in a nonstandard encoding format, as described in 6.6.3. A WAV category result segment may also be used to transmit only a pointer to the waveform data, rather than the data itself, as described in 6.6.3. If one or more digitized values anywhere in the WAV category result segment were out of range of the ADC, then the entire result segment is flagged by inserting a < symbol (meaning values below the ADC range) or a > symbol (meaning values above the range) or both (separated by a component delimiter) into the abnormal flags field.

6.6.1 *Channel-Multiplexed Decimal Waveform Data Formats*—The observation value field of a standard WAV category result segment (with value type CM) that is used when the preceding TIM category result segment defining the epoch of waveform data specifies a data format of **DEC** or **DNC** contains one or more subfields separated by repeat delimiters (~). Each subfield contains data for multiple channels in the current montage at a single sample time. The subfield consists of multiple components separated by component delimiters (^), where each component contains the waveform data for a single channel. The format of the standard channel-multiplexed WAV category result segment is summarized in Table 26.

TABLE 26 WAV Category Result Segment Format for Channel-Multiplexed Data

Components of Result Field	Type	Length, max
First Channel Data		
Digitized value	ST	20
Channel number	NM	4
Second Channel Data		
Digitized value	ST	20
Channel number	NM	4
...		

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6.6.1.1 Each component consists of two subcomponents separated by subcomponent delimiters (**&**). The first subcomponent is the digitized value for a single channel at a single time; this may be either a signed decimal number (which may be nonintegral if a nonintegral minimum or maximum data value was specified in the CHN category result segment which defined this channel) or the special symbols < (meaning input to ADC was below its range) or > (meaning input to ADC was above its range). The second subcomponent is the channel number to which the digitized value applies. For a channel defined in the CHN category result segment with a nonzero sampling frequency, if the digitized value (first subcomponent) is not present, it is assumed not to have changed since the last time sample; this may be used to save space when digitized values for a particular channel remain constant over a number of time points (for example, a slowly varying signal such as from an oximeter). However, for a channel defined with a zero sampling frequency (implying sporadic rather than periodic sampling), if the digitized value is not present, then the channel is assumed not to have been resampled since the last time point. If the channel number (second subcomponent) is not present, then a channel number one greater than that of the previous component is assumed; for the first component, a channel number of one is assumed. If more than one digitized value for a particular channel is transmitted for a single time point, then the receiver system should use the last transmitted value for that channel. If a value for a channel number outside the range from one to *N* (where *N* is the number of channels specified in the last transmitted MTG category result segment) is transmitted, this value should be ignored by the receiver.

6.6.1.2 It is expected that most implementations will define channels within a montage in such a way that the digitized values for each time sample can be transmitted in ascending channel number order beginning with channel one. In this case, the second subcomponent (channel number) of each component in the WAV category result segment may not be present, since the first channel number defaults to one and each successive channel number defaults to one greater than the last. However, there may be some instances in which it is advantageous to transmit the channel values in a different order from that in which the channels are defined (or displayed), or the digitized values for a particular time point may be sufficiently sparse (due to the absence of values for a number of channels) that less characters are required to transmit a new channel number with each transmitted value than would be required to transmit the requisite number of *place-holding* component delimiters separating the values which are not present; in these instances the second subcomponent may be used to define the channel number as needed. For example, the following two result fields in a WAV category result segment are equivalent.

(*1*) **^^^219^^^^^^^^516^^^^^^^^^^^^^^^332^-414^28^12^^^^^^^^^^-1854**

(*2*) **219&4^516&12^332&25^-414^28^12^-1854&36**

6.6.1.3 The second subcomponent (channel number) is not permitted in WAV category result segments which follow a TIM category result segment that specifies a data format of **DNC**; in this situation, digitized values must be transmitted in ascending channel number order. To optimize performance, some receiver systems may use a different program to decode waveform data when **DNC** data format is used than for the default **DEC** format.

6.6.1.4 Successive subfields in a WAV category result segment used for channel-multiplexed data transmission, if present, contain data for successive time samples, the time between corresponding channels in each (the sampling interval) having been specified in the last transmitted TIM category result segment.

6.6.2 *Channel Block Decimal Waveform Data Format*—The observation value field of a standard WAV category result segment (with value type CM) that is used when the preceding TIM category result segment defining the epoch of waveform data specifies a data format of **dcB** contains one or more subfields separated by repeat delimiters (~). Each subfield contains data for a single channel in the current montage at multiple sample times. The subfield consists of multiple components separated by component delimiters (^), where each component contains the waveform data for a single time sample. The format of the standard channel block (unmultiplexed) WAV category result segment is summarized in Table 27.

6.6.2.1 Each component contains the digitized value for a single channel at a single time; this may be either a signed decimal number or the special symbols < or > as described in 6.6.1.1. Successive components contain successive time samples, the time between each (the sampling interval) having been specified in the last transmitted TIM category result segment. For a channel defined in the CHN category result segment with a nonzero sampling frequency, if the digitized value is not present, it is assumed not to have changed since the last time sample. However, for a channel defined with a zero sampling frequency (implying sporadic rather than periodic sampling), if the digitized value is not present, then the channel is assumed not to have been resampled since the last time point.

6.6.2.2 Successive subfields in a WAV category result segment used for channel block (unmultiplexed) data transmission would contain data for successive channels in ascending channel number order. The first subfield determines the number of time samples being transmitted in the WAV category result segment; each subfield after the first normally contains the same number of components (same number of time samples) as the first. If fewer samples are transmitted in a subsequent subfield, the last transmitted value for that channel is assumed to be unchanged for the remaining time points (the last value is duplicated to pad the series to the correct length); if more samples are transmitted in a subsequent subfield, the excess are ignored. If a particular channel number in the range from one to *N* (where *N* is the number of channels specified in the last

TABLE 27 WAV Category Result Segment Format for Channel Block Data

Components of Result Field	Type	Length, max
First Time Sample Digitized Value	ST	20
Second Time Sample Digitized Value	ST	20
...		

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transmitted MTG category result segment) has not been defined by a previous CHN category result segment within the current montage, either a series of zero values (one for each time sample) would be transmitted in the subfield corresponding to that channel or the subfield as a whole would not be present; in either case, the channel when displayed should produce a flat line.

6.6.3 *Nonstandard Formats for Waveform Data*—The entire observation value field in the WAV category result segment may alternatively contain a data format other than signed decimal, or the observation value field may contain a pointer to the waveform data on another system, rather than the data itself. The use of data encoding other than signed decimal or of a pointer value in the observation value field is to be considered non-portable and nonstandard. Any such use would require the knowledge of the specific scheme by both the sending and receiving applications, and should be used primarily for internal communications between networked computers within a particular installation. In particular, a receiving system need not be designed to accept data other than in the standard decimal formats described in 6.6.1 and 6.6.2, in order to be considered compatible with this specification. The primary purpose of this mechanism is to encourage evolutionary incorporation of this specification into existing designs, where internal formats are already established, or into time-critical applications in which the overhead of format conversion, or of transmitting waveform data at all within the message format defined by this specification, is unacceptable with current technology. To indicate that the WAV category result segment contains data encoded in a nonstandard format, a value type of TX rather than CM is used, and the waveform data in the observation value field is preceded and followed by *escape characters* (\), forming a Specification E 1238/HL7 escape sequence, as described in 6.6.3.1 and 6.6.3.2. To indicate that the WAV category result segment contains a pointer to the waveform data rather than the data itself, a value type of RP rather than CM is used, as described in 6.6.3.3.

6.6.3.1 *Hexadecimal Data Format*—Digital waveform data in hexadecimal format is identified by the escape sequence \Xdddd\, where the X is followed by one or more *pairs* of hexadecimal digits (0, 1, ... , 9, A, ... , F). Consecutive pairs of the hexadecimal digits represent 8-bit binary values which together define the data values for one or more channels at one or more sample times. A common scheme is to send signed (two's complement) 16-bit digitized values as four consecutive hexadecimal digits (high-order to low-order), using the same transmission order as in the standard channel-multiplexed decimal format (in ascending channel number order); this hexadecimal format is specified by using the data format **HEX** in the preceding TIM category result segment. Other hexadecimal formats (with different numbers of hexadecimal digits for each value, different order of transmitted values, etc.) may also be used if necessary; such a scheme is specified by using data format code **LOC** (locally defined) or a locally defined data format code. The interpretation of the data stream in this case is left entirely to an agreement between the sending and receiving applications that is beyond the scope of this specification.

6.6.3.2 *Binary and Other Data Encoding Formats*—Digital waveform data may be encoded by other means using the escape sequence \Zdddd\, where the Z is followed by one or more letters, digits, or special characters (including, if necessary, non-printing characters or delimiters); if an escape character (\) must be included in the escape sequence, it must be transmitted as two consecutive escape characters: **\Z3$(Pa ^ \\2*Gb**. Since carriage returns may appear in an escape sequence, such a sequence may not be split by use of an addenda line; the length of the WAV category result segment must be limited to 220 characters or less, or the transmitting and receiving systems must both allow longer lines than the standard 220 character maximum. This mechanism could be used, for example, to encode sample values using a higher radix than 16, such as radix-32, radix-64, radix-128, or (if 8-bit characters are allowed by the communications medium or network), radix-256 (*binary*). This has the theoretical advantage of producing a smaller message length than decimal or hexadecimal encoding. However, the use of this mechanism requires agreement between sender and receiver on such issues as the character set used for encoding, the number of characters used to represent one value, the binary representations employed, etc., and is considered beyond the scope of this specification. Such nonstandard formats are specified by using data format code **LOC** (locally defined) or a locally defined data format code in the preceding TIM category result segment. However, one common scheme for *binary* transmission (with networks or media which support 8-bit characters) is specified by using the data format **BIN**. In this scheme, signed (two's complement) 16-bit digitized values are transmitted as two consecutive 8-bit characters (high-order, then low-order), using the same transmission order as in the standard channel-multiplexed decimal format (in ascending channel number order).

6.6.3.3 *Reference Pointer Data Format*—Rather than including the actual epoch of digital waveform data within the observation value field, a pointer to the data epoch on another system may be given in the format described in 4.4.11, **<pointer> ^ <application ID> ^ <type of data>**, where *type of data* is **WV** (meaning waveform data). The *application ID* (up to six characters) names the system on which the data is stored. The *pointer* is a unique key or address assigned by that system that may be used to access the data (for example, a device name, file name, and byte address within the file). Using this *pointer*, the receiving system may obtain actual waveform data from the system named by *application ID* using network protocols or other mechanisms other than the message scheme defined by Specification E 1238 or HL7. The preceding TIM category result segment specifies the format of the data stored on the other system, often using a locally defined data format code. The use of this mechanism requires agreement between sender and receiver on such issues as the meaning of *pointer*, the means by which the data may be obtained from the other

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system, and the formats of the data stored on the other system, and is considered beyond the scope of this specification.

Waveform Data Acquired at Differing Sampling Frequencies

6.7 This specification may be used to transmit waveform data recorded from various channels with differing sampling frequencies in one of two ways, described as follows.

6.7.1 *Highest Sampling Frequency Method*—Data may be encoded as if all channels were sampled at a single rate (specified in the TIM category result segment) which is in fact the highest sampling frequency in the set. However, a data value for channels sampled at a lower frequency (which must be an integral submultiple of the highest sampling frequency) would only be transmitted periodically at the appropriate sample times (that is, in every *n*th time sample in the WAV category result segment); values for all other time samples for that channel would not be present. Instead of values being not present, the digitized value at the previous sample time may instead be repeated for each subsequent time point in unsampled channels, until new data are available. When the **DNC** data format is used and data for unsampled channels at a given time point are not present, an efficiency can be realized if the lower frequency channel(s) are the highest numbered channel(s) in the channel list. In the time samples (subfields) for which an actual digitized value is not present, both the value(s) and component delimiter(s) for the lower frequency channel(s) may not be present if no other data follows them in that subfield. An alternative equivalent method of transmitting the data which is applicable only when the **DEC** data format is employed (best used when the number of channels sampled at a given time was small compared to the total number of channels in the montage) is to include only digitized values for those channels which were sampled, each followed by their channel number (separated by a subcomponent delimiter).

6.7.1.1 This mechanism is especially appropriate for data sets in which the majority of channels are sampled at the same highest frequency, with one or a small number of channels sampled at a lower frequency (which must be an integral submultiple of the highest sampling frequency). Table 28 shows an example of the digitized values and the times at which they were sampled for three channels, with channel 1 sampled at 100 Hz, channel 2 at 50 Hz, and channel 3 at 25 Hz.

6.7.1.2 In this example, the waveform data for the three channels would be transmitted using the **DEC** (or **DNC**) data format as follows, where the sampling interval specified in a preceding TIM category result segment is 0.01 s:

134^26^-18~142~153^20~150~139^15^
-15~121~114^9~109~98^4^-12

Similarly, the waveform data could be transmitted with the same sampling interval using the **dcB** data format as follows:

134^142^153^150^139^121^114^109^98
~26^^20^^15^^9^^4~-18^^^^-15^^^^-12

6.7.2 *Multiple Montage Method*—In situations in which the sampling frequency of some channels is not an integral submultiple of the sampling frequency of the other channels, epochs of data for each set of channels with differing sampling frequencies could be sent in separate WAV category result segments, each preceded by a MTG category result segment (to select the set of electrode and channel definitions appropriate for the subsequent WAV category result segment) and a TIM category result segment (to select the sampling interval appropriate for the subsequent WAV category result segment and to identify the time corresponding to the beginning of the epoch). The electrode and channel definitions for each montage (each set of channels sampled at a different rate) would have to be defined at the start of the recording by sending sets of MTG followed by ELC and CHN category result segments for each such montage (in Level II and higher implementations).

6.7.2.1 According to this scheme, a particular transmission may contain first a MTG category result segment, TIM category result segment, and all of the WAV category result segments for the entire recording corresponding to one sampling frequency, followed by a new MTG category result segment, TIM category result segment, and all of the WAV category result segments for another sampling frequency, etc. Alternatively, the transmission could be segmented into epochs of time, with a duration appropriate to the application (for example, the length of time that could be displayed on one screen of a display device or printed on one page of a printer). All of the data required for one epoch would be transmitted as a block, consisting of the MTG category result segment, the TIM category result segment, and one or more WAV category result segments for one sampling frequency, then new MTG, TIM, and WAV category result segments for the next sampling frequency, etc. The sequence would repeat for each epoch until all epochs were transmitted, maintaining the stream-oriented structure of the transmission.

6.7.2.2 Table 29 illustrates this method of transmitting waveform data; in this example of a 16-channel recording system, channels 1, 2, 3, and 8 are sampled at 100 Hz; channels 4 and 5 are sampled at 60 Hz; channels 6, 7, and 11 are sampled at 40 Hz; channels 9, 10, and 14 are sampled at 10 Hz; and channels 12, 13, 15, and 16 are unused.

TABLE 28 Example Waveform Data for Channels Sampled at Different Rates

Channel 1		Channel 2		Channel 3	
Time	Data	Time	Data	Time	Data
0.00	134	0.00	26	0.00	−18
0.01	142	0.02	20	0.04	− 15
0.02	153	0.04	15	0.08	− 12
0.03	150	0.06	9		
0.04	139	0.08	4		
0.05	121				
0.06	114				
0.07	109				
0.08	98				

7. Result Segments Used for Annotation of the Waveform Data

7.1 These categories of result segments provide additional relevant information for interpretation of the electrophysiologic study. They do not specify the structure of the transmitted data, and so are not required in order to transmit waveforms for display, but they provide additional information which may be required to interpret the waveform data and are relevant

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TABLE 29 Example Segment Sequence Required to Transmit Waveform Data

Segment	Function
ELC-0	Define all electrodes common to all montages
MTG-1	Start definition of montage 1 (16 channels maximum)
ELC-1	Define all electrodes unique to montage 1
CHN-1	Define channels 1, 2, 3, and 8 in montage 1 (100 Hz rate)
MTG-2	Start definition of montage 2 (16 channels maximum)
ELC-2	Define all electrodes unique to montage 2
CHN-2	Define channels 4 and 5 in montage 2 (60 Hz rate)
MTG-3	Start definition of montage 3 (16 channels maximum)
ELC-3	Define all electrodes unique to montage 3
CHN-3	Define channels 6, 7, and 11 in montage 3 (40 Hz rate)
MTG-4	Start definition of montage 4 (16 channels maximum)
ELC-4	Define all electrodes unique to montage 4
CHN-4	Define channels 9, 10, and 14 in montage 4 (10 Hz rate)
MTG-1	Select montage 1 again
TIM-1,1	Set starting time of epoch 1, 1st sampling interval (0.01 s)
WAV-1,1	Waveform data for epoch 1, montage 1 (channels 1, 2, 3, 8)
MTG-2	Select montage 2 again
TIM-1,2	Set starting time of epoch 1, 2nd sampling interval (0.016667 s)
WAV-1,2	Waveform data for epoch 1, montage 2 (channels 4, 5)
MTG-3	Select montage 3 again
TIM-1,3	Set starting time of epoch 1, 3rd sampling interval (0.025 s)
WAV-1,3	Waveform data for epoch 1, montage 3 (channels 6, 7, 11)
MTG-4	Select montage 4 again
TIM-1,4	Set starting time of epoch 1, 4th sampling interval (0.1 s)
WAV-1,4	Waveform data for epoch 1, montage 4 (channels 9, 10, 14)
MTG-1	Select montage 1 again
TIM-2,1	Set starting time of epoch 2, 1st sampling interval (0.01 s)
WAV-2,1	Waveform data for epoch 2, montage 1 (channels 1, 2, 3, 8)
MTG-2	Select montage 2 again
TIM-2,2	Set starting time of epoch 2, 2nd sampling interval (0.016667 s)
WAV-2,2	Waveform data for epoch 2, montage 2 (channels 4, 5)
MTG-3	Select montage 3 again
TIM-2,3	Set starting time of epoch 2, 3rd sampling interval (0.025 s)
WAV-2,3	Waveform data for epoch 2, montage 3 (channels 6, 7, 11)
MTG-4	Select montage 4 again
TIM-2,4	Set starting time of epoch 2, 4th sampling interval (0.1 s)
WAV-2,4	Waveform data for epoch 2, montage 4 (channels 9, 10, 14)
(repeat for all epochs recorded)	

conclusions. These categories of result segments are not used in Level I implementations but are used in Levels II and greater.

DST Category

7.2 This category of result segment defines supplemental subject data related to the electrophysiologic procedure, consisting of distance measurements (generally made by a technician) needed for interpretation of the waveform data. Each DST category result segment can define one or more distances, and any number of DST category result segments may be used. The distances could be used for constructing potential maps, in source (dipole) localization programs, in calculating propagation velocities, etc. The observation value field of this category of result segment contains one or more subfields separated by repeat delimiters (~). Each subfield defines one distance measurement and consists of three components separated by component delimiters (^). The format of the DST category result segment is summarized
in Table 30. The individual components are defined as follows:

7.2.1 *First Location Identifier*—Identifies the position of the first of the two locations between which the distance was measured. This location identifier has the same format as that used in the ELC category result segment for electrode locations. It consists of up to six subcomponents, separated by subcomponent delimiters (**&**). The first and fourth subcomponents are alphanumeric location codes, the second and fifth subcomponents are textual representations of the location, and the third and sixth subcomponents specify the coding system used in the first subcomponent (default **SNM+**, qualified SNOMED location codes) and fourth subcomponent (default **L**, local codes).

TABLE 30 DST Category Result Segment Format

Components of Result Field	Type	Length, max
First Location Identifier		
Code 1	ST	80
Text for code 1	ST	200
Nature of code 1	ID	12
Code 2	ST	80
Text for code 2	ST	200
Nature of code 2	ID	12
Second Location Identifier		
Code 1	ST	80
Text for code 1	ST	200
Nature of code 1	ID	12
Code 2	ST	80
Text for code 2	ST	200
Nature of code 2	ID	12
Distance Value	NM	20

7.2.2 *Second Location Identifier*—Identifies the position of the second of the two locations between which the distance was measured, using the same format as the first location.

7.2.3 *Distance Value*—The measured distance in centimetres between the two locations on the subject's body.

7.2.4 Some examples of distance identifiers are given in Table 31.

7.2.5 It is suggested that, for routine EEG, polysomnogram, and EP recordings, the inion to nasion and left to right preauricular area distances be recorded by the technician and included in DST category result segments, since these numbers are routinely measured in placing electrodes according to the 10-20 system and are useful in calculating head radius (approximately, the geometric mean of the inion to nasion distance and the left to right preauricular area distance divided by 1.25

TABLE 31 Examples of Distance Identifiers

Identifier	Meaning
T-1014^T-12171	External occipital protuberance (inion) to frontonasal suture (nasion) distance
T-Y0171-LFT^T-Y0171-RGT	Left preauricular area to right preauricular area distance
T-Y0120^T-10560	Vertex (central) region to fifth cervical vertebra distance
T-10560^T-10770	Fifth cervical vertebra to third lumbar vertebra distance
T-11310-SUP^T-Y8300	Superior clavicle[A] to elbow distance
T-11310-LFT-SUP^T-Y8300-LFT	Left superior clavicle[A] to left elbow distance
T-11310-LFT-SUP^T-11310-RGT-SUP	Left superior clavicle[A] to right superior clavicle[A] distance
T-11310-LFT-SUP^T-Y8600-LFT	Left superior clavicle[A] to left wrist distance
T-X9180-RGT-LC6^T-X9180-RGT-LC9	Right distal arm/thigh portion median nerve to right distal forearm/leg portion median nerve distance
T-Y9100-LFT-ANT^T-Y9100-LFT-PST	Left anterior thigh to left posterior thigh distance
T-13882-BEL^-13882-INS	Belly abductor pollicis brevis muscle to insertion abductor pollicis brevis muscle distance

[A] *Superior clavicle* is used to refer to Erb's point.

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π), which is needed to convert electrode angular (spherical) coordinates to rectangular coordinates and interelectrode distances.

STM Category

7.3 This category of result segment defines the stimulus parameters for an EP or NCS recording. It can also be used, if desired, to define stimulus parameters for photic stimulation or other regular stimuli or trains of periodic stimuli delivered during an EEG or similar recording. Furthermore, it can be used to indicate the type and amplitude of a calibration signal used during instrument calibration procedures. In addition, the occurrence of a STM category result segment at a particular time point in the transmitted waveform data segments can be used to indicate that the stimulus or calibration signal occurred, began, or ended at that time. The time can be set, if necessary, by an immediately preceding TIM category result segment. A STM category result segment may be followed immediately by a comment (C) segment, if needed, to specify additional detail about the stimuli or stimulus paradigms used. When necessary, a single STM category result segment can define more than one simultaneously applied stimulus, or more than one STM category result segment can be used in immediate succession (for example, when continuous masking noise is applied to one ear and stimulus clicks to the other simultaneously, or when a stimulus paradigm employs more than one set of stimulus characteristics in a train of periodic or quasiperiodic stimuli). Multiple stimuli can be defined in a single STM category result segment either by specifying multiple stimulus characteristics (each in a separate subcomponent) within a single train of stimuli which are all of the same general type and all delivered to the same location, or by specifying multiple separate stimuli or trains of stimuli using separate subfields in the segment, or both. An individual stimulus type in such a segment may be referred to in TIM category result segments that define averaging by stimulus type by using a number specifying its ordinal position in the STM category result segment. The order used is: first subcomponent in first subfield, second subcomponent in first subfield, ... , last subcomponent in first subfield, first subcomponent in second subfield, second subcomponent in second subfield, ... , last subcomponent in last subfield. The observation value field of a STM category result segment contains one or more subfields separated by repeat delimiters (~). Each subfield defines one stimulus or train of related (but not necessarily identical, for example in a mixed stimulus paradigm) stimuli and consists of up to twelve components separated by component delimiters (^). The format of the STM category result segment is summarized in Table 32. The individual components are defined as follows:

7.3.1 *Stimulus Status*—This optional component may be used when a stimulus or train of periodic stimuli lasts for an extended period of time during which digital waveform data is accumulated. The stimulus status may be either **BEGIN** or **END**. The transmission of a STM category result segment with a **BEGIN** status at a particular time point in the transmitted waveform data segments indicates that the stimulus or train of stimuli began at that time. Similarly, the transmission of a STM category result segment with an **END** status at a particular time point in the transmitted waveform data segments indicates that the stimulus or train of stimuli ended at that time. It is not necessary to define the beginning and end of a train of stimuli by this method. In some applications, it may be more convenient to transmit a separate STM category result segment for each stimulus in the train. In the latter case, or for brief, nonrepetitive stimuli, the stimulus status component is not present; in this case, transmission of each STM category result segment at a particular time point in the transmitted waveform data segments indicates that a single stimulus occurred at that time. It is not always necessary to indicate the time at which stimulation ended by means of a STM category result segment with status **END**; for example, the ending time of stimuli used in an EP recording is often irrelevant, since only averaged waveform data is usually transmitted, rather than continuous waveform data as in an EEG recording. Since it is possible to use multiple simultaneous stimuli, each of which may begin and end independently, all of the relevant components that

TABLE 32 STM Category Result Segment Format

Components of Result Field	Type	Length, max
Stimulus Status	ID	8
Stimulus Type and Electrode Names		
Stimulus type	ID	8
Cathodal electrode name	ST	8
Anodal electrode name	ST	8
Stimulus Location Identifier		
Code 1	ST	80
Text for code 1	ST	200
Nature of code 1	ID	12
Code 2	ST	80
Text for code 2	ST	200
Nature of code 2	ID	12
Stimulus Rate		
Most common stimulus rate	NM	20
...		
Least common stimulus rate	NM	20
Stimulus Duration		
Most common stimulus duration	NM	20
...		
Least common stimulus duration	NM	20
Stimulus Intensity		
Most common stimulus intensity	NM	20
...		
Least common stimulus intensity	NM	20
Stimulus Intensity Units		
Units code 1	ST	80
Text for units code 1	ST	200
Nature of units code 1	ID	12
Units code 2	ST	80
Text for units code 2	ST	200
Nature of units code 2	ID	12
Stimulus Frequency or Color		
Most common stimulus frequency or color	NM/ST	20
...		
Least common stimulus frequency or color	NM/ST	20
Visual Stimulus Contrast		
Most common visual stimulus contrast	NM	20
...		
Least common visual stimulus contrast	NM	20
Visual Stimulus Pattern Type		
Most common visual stimulus pattern type	ID	8
...		
Least common visual stimulus pattern type	ID	8
Visual Stimulus Pattern Element Size or Spatial Period		
Most common pattern element size/spatial period	NM	20
...		
Least common pattern element size/spatial period	NM	20
Size of Visual Field Stimulated	NM	20

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characterize the stimulus should be repeated in the STM category result segment with an **END** status just as they were originally transmitted in the STM category result segment with a **BEGIN** status, so that the particular stimulus which ended can be uniquely determined.

7.3.2 *Stimulus Type and Electrode Names*—This required component specifies the type of stimulus and (for type **ELC**) the names of the electrodes stimulated. It consists of three subcomponents separated by subcomponent delimiters **(&)**, as follows:

7.3.2.1 *Stimulus Type*—A code specifying the type of stimulus. The codes given in Table 33 or Table 34, or other codes having meaning to both the sending and receiving system, may be used. The difference between the **ECD** (or **ECP**) and **ELC** stimulus types is in the manner of specifying the stimulus electrode location. With **ECD** or **ECP**, a single location may be specified in the following component; with **ELC**, one may (in conjunction with an ELC category result segment) specify an electrode name, location, type, material, size, other attributes, and coordinates for both the cathode and anode.

7.3.2.2 *Cathodal Electrode Name*—This subcomponent is used when the first subcomponent is **ELC**. It specifies the name of the cathodal electrode through which the electric stimulus is delivered.

7.3.2.3 *Anodal Electrode Name*—This subcomponent is used when the first subcomponent is **ELC**. It specifies the name of the anodal electrode through which the electric stimulus is delivered. Both cathodal and anodal electrodes must have been previously defined in ELC category result segments, either in the current montage or in the group of electrodes common to all montages.

7.3.3 *Stimulus Location Identifier*—This optional component is used to specify the general location to which the stimulus was delivered. It is not needed for calibration signals (which are delivered to channels that use the electrode name **CAL**) or when a stimulus type of **ELC** is used (since the ELC category result segments specify electrode locations).

7.3.3.1 The stimulus location identifier has the same format as that used in the ELC category result segment for electrode locations. It consists of up to six optional subcomponents, separated by subcomponent delimiters **(&)**.

The first and fourth subcomponents are alphanumeric location codes, the second and fifth subcomponents are textual representations of the locations indicated by the first and fourth subcomponents, and the third and sixth subcomponents specify the coding system used in the first subcomponent (default **SNM+**, qualified SNOMED location codes) and the fourth subcomponent (default **L**, local codes). A SNOMED location code may contain additional qualifiers including **LFT**, **RGT**, or **BIL** designations when the stimulus is delivered exclusively to the left or right eye, ear, or body or bilaterally; if neither **LFT** or **RGT** designations appear (or if the location code is not present), the stimulus is assumed to be bilateral. Example SNOMED codes for stimulus location identifiers used for VEPs, AEPs, median nerve SEPs, tibial nerve SEPs, and ulnar nerve palmar orthodromic sensory NCS are given in Table 35.

7.3.4 *Stimulus Rate*—This optional component specifies the repetition rate of a repeated or periodic stimulus or calibration signal in hertz. For stimuli such as visual pattern reversals, light or pattern appearance/disappearance, or sinusoidally modulated pattern or light stimuli, the rate is best defined as the number of complete cycles (white to black to white) completed per second. For a square wave calibration signal, the rate is the number of on and off cycles per second. If the stimuli are generated pseudo-randomly rather than periodically, the stimulus rate refers to their average frequency of occurrence.

TABLE 33 Stimulus Type Codes for Somatosensory or NCS Stimuli

Code	Meaning
ECD	Electric stimulus at given location, cathode distal to anode
ECP	Electric stimulus at given location, cathode proximal to anode
ELC	Electric stimulus through specified electrode(s)
MAG	Magnetic stimulus at specified location
SST	Somatosensory tester stimulus (percussion hammer)

TABLE 34 Stimulus Type Codes for VEP/AEP Stimuli and Calibration Signals

Code	Meaning
Visual Stimuli	
FLS	Diffuse light flash stimulus
LAD	Diffuse light appearance or disappearance stimulus
LSM	Sinusoidally modulated diffuse light stimulus
PRV[A]	Pattern reversal stimulus, full field
PRVLH[A]	Pattern reversal stimulus, left half field
PRVRH[A]	Pattern reversal stimulus, right half field
PRVTH[A]	Pattern reversal stimulus, top half field
PRVBH[A]	Pattern reversal stimulus, bottom half field
PRVLT[A]	Pattern reversal stimulus, left top quadrant
PRVLB[A]	Pattern reversal stimulus, left bottom quadrant
PRVRT[A]	Pattern reversal stimulus, right top quadrant
PRVRB[A]	Pattern reversal stimulus, right bottom quadrant
Auditory Stimuli	
CLKRA	Click auditory stimulus, rarefaction polarity
CLKCO	Click auditory stimulus, condensation polarity
CLKAL	Click auditory stimulus, alternating polarity
FCLRA	Filtered click stimulus, rarefaction polarity
FCLCO	Filtered click stimulus, condensation polarity
FCLAL	Filtered click stimulus, alternating polarity
TONRA	Tone auditory stimulus, rarefaction polarity
TONCO	Tone auditory stimulus, condensation polarity
TONAL	Tone auditory stimulus, alternating polarity
GSWRA	Gated sine wave (tone pip), rarefaction polarity
GSWCO	Gated sine wave (tone pip), condensation polarity
GSWAL	Gated sine wave (tone pip), alternating polarity
LOGRA	Logon auditory stimulus, rarefaction polarity
LOGCO	Logon auditory stimulus, condensation polarity
LOGAL	Logon auditory stimulus, alternating polarity
MSK	Continuous masking noise
Calibration Signals	
CAL	Square wave calibration pulse
SIN	Sine wave calibration signal

[A] May substitute **PFL** for **PRV** to indicate pattern flash stimulus, or **PAD** for **PRV** to indicate pattern appearance or disappearance stimulus, or **PSM** for **PRV** to indicate sinusoidally modulated pattern contrast stimulus.

TABLE 35 Examples of SNOMED Stimulus Location Codes

Code	Meaning
T-XX000-LFT	Left eye
T-XY000-RGT	Right ear
T-X9180-LFT-LC9	Left distal forearm/leg portion median nerve
T-X9450-BIL-LC9	Bilateral distal forearm/leg portion tibial nerve
T-X9174-LFT	Left ulnar nerve, palmar branch

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7.3.4.1 For mixed stimulus type paradigms employing a common stimulus type and one or more less common (*oddball*) stimuli types, this component may consist of two or more subcomponents separated by subcomponent delimiters **(&)**. The first subcomponent specifies the repetition rate or average frequency of occurrence of the most common stimulus, the second subcomponent specifies the repetition rate or average frequency of occurrence of the next most common stimulus type, etc.

7.3.5 *Stimulus Duration*—This optional component specifies the duration of the stimulus or calibration signal in seconds, when applicable. For extended stimuli such as pattern reversal visual stimuli, the stimulus duration is one half the cycle period (the reciprocal of the stimulus rate), since each state of a pattern element (black or white) lasts for one half of a cycle. For square wave calibration pulses, the duration is also one half the cycle period (the length of an *on* or *off* period). For brief, repeated stimuli (such as light flashes, auditory clicks, electric stimuli), the duration of a single stimulus in the train is used, when known. For example, an electric stimulus duration might be 0.001. (The start and stop times of the entire train of stimuli may be specified as already described by the use of STM category result segments with status codes of **BEGIN** and **END**, respectively.)

7.3.5.1 For mixed stimulus type paradigms employing a common stimulus type and one or more less common (*oddball*) stimuli types, this component may consist of two or more subcomponents separated by subcomponent delimiters **(&)**. The first subcomponent specifies the duration of the most common stimulus, the second subcomponent specifies the duration of the next most common stimulus type, etc.

7.3.6 *Stimulus Intensity*—This optional component specifies the intensity (average luminance, sound intensity, voltage, or current) of the stimuli or amplitude of the calibration signals in appropriate units (which may be specified in the following component).

7.3.6.1 For mixed stimulus type paradigms employing a common stimulus type and one or more less common (*oddball*) stimuli types, this component may consist of two or more subcomponents separated by subcomponent delimiters **(&)**. The first subcomponent specifies the intensity of the most common stimulus, the second subcomponent specifies the intensity of the next most common stimulus type, etc.

7.3.7 *Stimulus Intensity Units*—This optional component specifies the units in which the stimulus intensity is measured. It consists of six subcomponents with a format similar to the components of the coded entry (CE) data type, as follows:

7.3.7.1 *Units Code 1*—An alphanumeric units designation from a generally accepted system of units, such as ISO standard SI unit abbreviations (the default), or ANSI standard U.S. customary unit abbreviations. Examples of ISO standard units include cd/m2 (candela per m ^{2}) or cd/cm2 (candela per cm^2, also known as stilb) for visual stimuli, or cd.s/m2 (candela seconds per m^2) for brief (flash) visual stimuli; db, db(sl), db(hl), db(nhl), db(spl), or db(pespl) for auditory stimuli (the parentheses around the reference level designation are part of the units; the reference level designations are as follows: sl = sensory level, hl = hearing level, nhl = normal hearing level; spl = absolute reference sound pressure level of 20 micropascal at 1000 Hz; pespl = peak equivalent sound pressure level); v (volts) or ma (milliamperes) for electric stimuli; or uv (microvolts) or mv (millivolts) for calibration signals.

7.3.7.2 *Text for Units Code 1*—An optional text description of the units identified by the first subcomponent. It may be used to provide an expanded description of the units abbreviation, or it may be used to identify units that cannot be represented with standard abbreviations.

7.3.7.3 *Nature of Units Code 1*—An identifier for the system of units used in the first subcomponent. Typical values are **ISO+** (SI units standard abbreviations, the default), **ANS+** (U.S. customary units standard abbreviations), or **99zzz** or **L** (locally defined units, where each z represents an alphanumeric character).

7.3.7.4 *Units Code 2*—An optional secondary alphanumeric units designation from an alternate system of units.

7.3.7.5 *Text for Units Code 2*—An optional text description of the secondary units designation in Units Code 2.

7.3.7.6 *Nature of Units Code 2*—An identifier for the alternate system of units used for Units Code 2 (the default is **L**, locally defined units).

7.3.8 *Stimulus Frequency or Color*—For electric stimuli, this component specifies the frequency of the electric current in hertz (zero if dc current used). For auditory tone stimuli, this component specifies the frequency of the tone in hertz. For sine wave calibration signals, this component specifies the frequency of the signal in hertz. For visual stimuli, this component specifies the color of the stimulus. To specify color, a single code from Table 36 may be used (or other codes which have meaning to both the transmitting and the receiving system). Alternatively, the mixture of the primary colors RED, GREEN, and BLUE used may be specified as a comma-separated string of the form **REDrrr**,**GRNggg**, **BLUbbb**, where *rrr* (0-999) is the relative amount of red light, *ggg* is the relative amount of green light, and *bbb* is the relative amount of blue light in the stimulus. The default is **WHT** (equivalent to **RED100**, **GRN100**, **BLU100**).

7.3.8.1 For mixed stimulus type paradigms employing a common stimulus type and one or more less common (*oddball*) stimuli types, this component may consist of two or more subcomponents separated by subcomponent delimiters **(&)**. The first subcomponent specifies the frequency or color of the most common stimulus, the second subcomponent specifies the frequency or color of the next most common stimulus type, etc.

7.3.9 *Visual Stimulus Contrast*—For visual pattern stimulus types, this optional component specifies the contrast of the

TABLE 36 Visual Stimulus Color Codes

Code	Meaning
WHT	White
RED	Red
ORG	Orange
YEL	Yellow
GRN	Green
BLU	Blue
IND	Indigo
VIO	Violet
MAG	Magenta
CYA	Cyan

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pattern, defined as $(L_{max} - L_{min})/(L_{max} + L_{min})$, where L_{max} is the luminance of the brightest elements of the pattern and L_{min} is the luminance of the darkest elements.

7.3.9.1 For mixed stimulus type paradigms employing a common stimulus type and one or more less common (*oddball*) stimuli types, this component may consist of two or more subcomponents separated by subcomponent delimiters **(&)**. The first subcomponent specifies the contrast of the most common stimulus, the second subcomponent specifies the contrast of the next most common stimulus type, etc.

7.3.10 *Visual Stimulus Pattern Type*—For visual pattern stimuli, this optional component specifies the type of pattern employed. Any of the codes in Table 37 may be used, or other codes which have meaning to both the transmitting and the receiving system; **CPX** indicates any pattern which cannot be described by one of the other codes; the default is **CHK**.

7.3.10.1 For mixed stimulus type paradigms employing a common stimulus type and one or more less common (*oddball*) stimuli types, this component may consist of two or more subcomponents separated by subcomponent delimiters **(&)**. The first subcomponent specifies the pattern type of the most common stimulus, the second subcomponent specifies the pattern type of the next most common stimulus type, etc.

7.3.11 *Visual Stimulus Pattern Element Size or Spatial Period*—For visual pattern stimuli, this optional component specifies the size of the pattern elements (angle subtended by each at the actual viewing distance, in degrees) or their spatial period (total angle subtended by the pattern at the actual viewing distance in degrees divided by the number of cycles, bars, or elements across the pattern).

7.3.11.1 For mixed stimulus type paradigms employing a common stimulus type and one or more less common (*oddball*) stimuli types, this component may consist of two or more subcomponents separated by subcomponent delimiters **(&)**. The first subcomponent specifies the pattern size or spatial period of the most common stimulus, the second subcomponent specifies the pattern size or spatial period of the next most common stimulus type, etc.

7.3.12 *Size of Visual Field Stimulated*—For visual pattern stimulus types, this optional component specifies the size of the visual field stimulated in degrees, that is, the angle subtended by the entire pattern at the actual viewing distance.

TCM Category

7.4 This category of result segment is used to transmit a technical comment (often recorded by a technician) related to the subject's observed behavior or technical aspects of the recording. When it precedes the first TIM category result segment, the TCM category result segment is assumed to pertain to observations made or history obtained prior to the start of the recording. Otherwise, the TCM category result segment is assumed to pertain to and be associated with the digital waveform data at the time determined by the last transmitted TIM category result segment, or the time as updated by subsequent WAV category result segments containing waveform data. These comments would best be displayed by the receiving system overlaid with the waveforms. (This differs from comments in C segments, which are not displayed with the waveform data but are separately logged.)

7.4.1 The text of the technical comment is contained in the observation value field of the TCM category result segment. Any length of text (up to 64K characters) may be included. Repeat delimiters (~) are used as line terminators. If multiple paragraphs are included in the comment, they should be separated from each other by two repeat delimiters (~~). Certain comments which are used frequently during EEG and polysomnogram recordings may be transmitted (in English-speaking countries) as in Table 38 (these formats are suggested,

TABLE 37 Visual Pattern Stimulus Type Codes

Code	Meaning
CHK	Checkerboard pattern
HBG	Horizontally oriented bar grating pattern
VBG	Vertically oriented bar grating pattern
HSG	Horizontally oriented sine wave grating pattern
VSG	Vertically oriented sine wave grating pattern
WMG	Windmill grating pattern
DBD	Dart board pattern
CPX	Complex pattern

TABLE 38 Example Technical Comments in TCM Category Result Segment

Abbreby means oftion	Meaning
Eyes open	Eyes opened by subject
Eyes closed	Eyes closed by subject
Eyes held open	Eyes held opened
Eyes held closed	Eyes held closed
Supine	Subject lying supine
Prone	Subject lying prone
Lat recumbent	Subject lying in lateral recumbent position
Moves	Subject moves
Swallows	Subject swallows
Snores	Subject snores
Talks	Subject talks
Talks in sleep	Subject talks in sleep
Coughs	Subject coughs
Stands	Subject stands up
Walks	Subject walks
Noise	Noise in recording area
Tap	Technician taps subject (to keep awake)
Tech awakens	Technician awakens subject deliberately
Call	Call subject (to awaken or keep awake)
Awake	Subject awake and alert
Drowsy	Subject drowsy
Asleep	Subject asleep
Comatose	Subject comatose (unresponsive and unarousable)
Begin biocal	Begin biocalibration section (all channels same input)
End biocal	End biocalibration section
Begin HV	Beginning of hyperventilation
End HV	End of hyperventilation
Begin photic	Beginning of photic stimulation
End photic	End of photic stimulation
Begin med	Begin continuous administration of a medication (a MED category result segment would define further)
End med	End continuous administration of a medication
Begin spell	Onset of a clinical *spell* or seizure (other comments describe the nature of the recorded *spell*)
End spell	End of a clinical *spell* or seizure
Begin ...	Beginning of a special procedure (the nature of which is specified after *begin*, for example, reading, walking, etc.)
End ...	End of a special recording procedure
"text"	*Text* represents words said to subject by technician
(text)	*Text* represents words said by subject

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not required by this specification).

7.4.2 On some data acquisition systems, these standard comments (except the last two) may be generated automatically by simply pressing an appropriate key or button during the recording; the other *free format* comments would have to be typed on a keyboard. The advantage of having a single key generate comments such as eyes open, eyes closed, awake, drowsy, asleep, comatose, begin HV, begin photic, begin medication, begin spell, and begin <other special recording condition> is that the same key can also trigger a change in the test/observation ID (see Appendix X2) in subsequent result segments to reflect the new recording condition.

MED Category

7.5 This category of result segment defines a medication administered during or before the electrophysiologic study. When it precedes the first TIM category result segment, the MED category result segment is assumed to pertain to a medication given prior to the start of the recording. Otherwise, the MED category result segment is assumed to pertain to a medication given at the time determined by the last transmitted TIM category result segment, or the time as updated by subsequent WAV category result segments containing waveform data. This medication data could then be displayed by the receiving system as a comment overlaid with the waveforms, similar to TCM category result segments.

7.5.1 The observation value field of this category of result segment contains a coded entry in the six-component format defined by the Specification E 1238 and HL7 standards. The format of the MED category result segment is summarized in Table 39.

7.5.2 The first and fourth components could contain alphanumeric codes for a medication administered during or before an electrophysiologic recording. The second and fifth components would contain text defining the medication name, amount, and route of administration. The third and sixth components would contain an identification of the coding system used in the first and fourth components; the default for the first component is **W2**, the eight-digit World Health Organization record number drug codes (**9**), while the default for the fourth component is **L**, local codes (several alternative coding systems for medications are defined in Specification E 1238, which may be used if desired). If more than one medication is administered at the same time, each medication is transmitted in a separate MED category result segment.

DEV Category

7.6 This category of result segment defines the instrument (device) used to perform the electrophysiologic study. The observation value field of this category of result segment contains a coded entry in the six-component format defined by the Specification E 1238 and HL7 standards. The format of the DEV category result segment is summarized in Table 40. The first and fourth component could contain alphanumeric codes defining the instrument. The second and fifth components would contain text defining the instrument's manufacturer, model number, and software version (if applicable). The third and sixth components could contain an identification of the coding system used in the first and fourth components (the default for the third component is **UMD**, the Universal Medical Device Nomenclature System (**10**), which uniquely identifies a type of medical device but not its make or model, and the default for the sixth component is **L**, local codes; **99zzz** may also be used to identify locally defined codes, where each *z* represents an alphanumeric character). If it is necessary to specify the serial number of the instrument as well, this information should be transmitted in a SER category result segment immediately following the DEV category result segment, as described in 7.7. If more than one device was used for the study, each device is transmitted in a separate DEV category result segment.

SER Category

7.7 This category of result segment defines the serial number of the instrument (device) used to perform the electrophysiologic study (specified in an immediately preceding DEV category result segment). The observation value field of this category of result segment contains a text string (value type ST) that defines the instrument's serial number. If more than one device is used for the study, so that more than one DEV category result segment is transmitted, each DEV category result segment is followed by a corresponding SER category result segment when it is necessary to specify the device serial numbers.

CNP Category

7.8 This category of result segment defines a special procedure or test performed during the electrophysiologic study. In effect, CNP category result segments can be used to summarize the testing that was performed. The observation value field of this category of result segment contains a coded entry in the six-component format defined by the Specification E 1238 and

TABLE 39 MED Category Result Segment Format

Components of Result Field	Type	Length, max
Code 1	ST	80
Text for Code 1	ST	200
Nature of Code 1		
Coding system 1 mnemonic identifier	ID	5
Specific code table 1 identifier	ID	7
Code 2	ST	80
Text for Code 2	ST	200
Nature of Code 2		
Coding system 2 mnemonic identifier	ID	5
Specific code table 2 identifier	ID	7

TABLE 40 DEV Category Result Segment Format

Components of Result Field	Type	Length, max
Code 1	ST	80
Text for Code 1	ST	200
Nature of Code 1		
Coding system 1 mnemonic identifier	ID	5
Specific code table 1 identifier	ID	7
Code 2	ST	80
Text for Code 2	ST	200
Nature of Code 2		
Coding system 2 mnemonic identifier	ID	5
Specific code table 2 identifier	ID	7

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HL7 standards. The format of the CNP category result segment is summarized in Table 41.

7.8.1 The first and fourth components would contain alphanumeric codes identifying the electrophysiologic studies performed, the second and fifth components would contain the corresponding text descriptions of the studies, and the third and sixth components could contain an identification of the coding system used in the first (the default is **AS4&TEST**, the test/observation ID codes defined in Appendix X2) and fourth (the default is **L**, local codes) components. The intention of CNP category result segments is to indicate that certain subtests or activation procedures were performed that may not have been explicitly ordered. If more than one special procedure or test was performed during the study, each such procedure or test is transmitted in a separate CNP category result segment.

ANA Category

7.9 This category of result segment is used to transmit the results of analysis or processing of an epoch of waveform data. It is a multipurpose category, which can be thought of as a quantitative annotation attached to an epoch of waveform data or to a single feature of the data. It may be derived manually or by automated processing using a computer algorithm. Receiver system software may display the ANA results overlaid or side by side with the epoch or feature in the data channel to which they apply. A variety of analyses can be performed on waveform data; the ANA category result segment is flexible enough to accommodate many of these.

7.9.1 One use of the ANA category result segment is to mark or identify a feature in the waveform data. For example, for EPs, the feature identified is usually one of the recognized EP peaks. The ANA category result segment may be generated as a result of an automatic transient or peak detection program, or as a result of manually selecting a transient or peak. The marked feature is characterized by the channel number in which it was identified, by the algorithm used for its identification and the class or type of feature identified, and by various optional parameters characterizing the feature, such as one or more latencies relative to the start of the epoch, or one or more amplitudes or frequencies associated with the feature. The same feature is sometimes detected in more than one channel, simultaneously or with a small interchannel time difference, and this may result in the transmission of multiple ANA category result segments on some systems. For peaks in waveform data, the ANA category result segment data may include latencies and amplitudes in multiple channels, while the latencies and amplitudes reported in result segments with no information category code and with a value type of NM (the *final* values which would appear in the report) would generally be based on just one channel. A second possible use of the ANA category result segment is to transmit results of frequency spectral analysis of an epoch of waveform data. The spectrum data is characterized by the channel number from which it was derived, by the algorithm used for the calculation, and by various parameters which characterize the spectrum. The spectral parameters could be organized into named frequency ranges (for example, delta, theta, etc.) or into smaller frequency bins, and could include data such as power or amplitude and phase angles for each bin, or a peak frequency or mean frequency within a given frequency range.

7.9.2 An ANA category result segment applies to the data epoch defined by the last transmitted TIM category result segment. Usually, an ANA category result segment is transmitted just before or after its associated waveform data, but it may occur at any point in the epoch; if needed, the time of a waveform to which it applies is given as a parameter. Alternatively, an ANA category result segment can be transmitted later, if immediately preceded by a TIM category result segment which defines the starting time and duration of the epoch to which the analysis applies. If needed, an ANA category result segment may be followed by a comment (C) segment to specify additional detail about the analysis.

7.9.3 The observation value field of the ANA category result segment contains multiple subfields separated by repeat delimiters (~). Each subfield defines the results of analysis of one channel and consists of a number of components separated by component delimiters (^). The format of the ANA category result segment is summarized in Table 42. The individual components are defined as follows:

7.9.4 *Analysis Identification*—Identifies the analysis performed by specifying the channel on which it was performed and optionally the analysis algorithm and type of analysis. The channel number is required, but the analysis algorithm and type may not be present, in which case the values given for the previous channels in the *same* ANA category result segment (or defaults, in the case of the first channel in an ANA category result segment) are used. These three subcomponents are separated from each other by subcomponent delimiters (**&**).

TABLE 41 CNP Category Result Segment Format

Components of Result Field	Type	Length, max
Code 1	ST	80
Text for Code 1	ST	200
Nature of Code 1		
Coding system 1 mnemonic identifier	ID	5
Specific code table 1 identifier	ID	7
Code 2	ST	80
Text for Code 2	ST	200
Nature of Code 2		
Coding system 2 mnemonic identifier	ID	5
Specific code table 2 identifier	ID	7

TABLE 42 ANA Category Result Segment Format

Components of Result Field	Type	Length, max
Analysis Identification		
Channel number	NM	4
Algorithm name	ID	8
Type of analysis or feature	ID	8
Analysis Parameter 1		
Parameter value	ST	200
Parameter name	ST	8
Units code 1	ST	80
Text for units code 1	ST	200
Nature of units code 1	ID	12
Units code 2	ST	80
Text for units code 2	ST	200
Nature of units code 2	ID	12
Analysis Parameter 2		
...		

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7.9.4.1 *Channel Number*—Identifies the channel to which the analysis applies (for example, the channel in which a feature was detected). A zero value indicates that the analysis applies simultaneously (within one sampling interval) to all channels.

7.9.4.2 *Algorithm Name*—Identifies the method or algorithm used for the analysis (for example, the method used for feature detection). One of the standard algorithm names may be used, or a nonstandard name may be used if it has meaning to both the sending and receiving system. If not present, **MAN** (manual analysis or annotation) is assumed. The standard algorithm names are given in Table 43.

7.9.4.3 *Type of Analysis or Feature*—For algorithms that can perform more than one type of analysis or can detect more than one feature, this subcomponent specifies the type of analysis performed or identifies the feature detected. One of the codes listed in Table 44 may be used, or a name other than those may be used if it has meaning to both sending and receiving systems. No default is used if the type is not present.

TABLE 43 Standard Analysis Algorithm Names

Code	Meaning
MAN	Manual annotation or feature marking, for example, with cursor
AUTO	Automated (computer) feature detection algorithm
PEAK	Simple automated peak detection algorithm
EKG	Automated EKG feature identification algorithm
CAL	Automated calibration mark detection/analysis algorithm
FFT	Spectral analysis based on Fast Fourier Transform

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