

## Chapter 1.3

### **IFCN standards for digital recording of clinical EEG**

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#### **Introduction**

To assure good quality digital EEG recording in clinical use, the following standards have been adopted for recording, storing, reviewing and exchanging EEG among clinicians and laboratories. These standards are meant for digital EEG used in clinical patient care. They should not be used to constrain research use of EEG recordings.

Digital recording gained popularity over analog EEG because of several advantages. It takes advantage of modern microprocessor costs and general flexibility. More specifically it allows EEG record review with user selected montages, filters, vertical scaling (gain or sensitivity), and horizontal scaling (e.g. time resolution or compression). It also replaces the need to warehouse or microfilm paper records, enables optional additional digital EEG signal processing, and allows for electronic exchange of EEGs.

#### **Patient information**

The digitally recorded EEG must include basic information about the patient's name and date of birth, the date on which the test was run, relevant patient and laboratory identification numbers, the patient's relevant current medications, conscious state at the time of testing and any other relevant data or comments. The EEG physician's interpretation should be able to be stored along with the EEG recording after the record is reviewed by a physician. Correction of errors or omissions in the patient identifying information should be possible after the recording.

#### **Documentation during recording**

To assess integrity of the amplifiers, A-D conversion and other elements of the system, square wave calibration signals must be recorded at the beginning using a series of 100  $\mu$ V square waves of each recording, 1–2 s long each. This should be checked on the referential montage used for EEG acquisition. Biocalibration or sine wave signals are optional, not necessary.

The recording must contain the technologist's comments, notes and markers about any patient

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movements, artifacts, clinical changes, patient interactions or other relevant events. The technologist must be able to enter free text comments describing events or interaction during the recording. Event markers must be available for finding events as marked by the technologist. These markers and comments should include common EEG events such as eyes closed or eyes open, beginning and end of hyperventilation, details of photic stimulation, and notation of the patient's alert, drowsy, or asleep state.

In addition, there must be provision for automatically recording information such as the time of day, filter settings, gain, montage selections, and other technical settings chosen at the start of the recording. Notation about any changes in acquisition parameter made by the technologist during the recording should be automatically recorded with the data. Photic stimulation events should be marked on the record within 5 ms of each stimulus delivered. These data must be available to the physician during record review.

## Recording

Amplification and channel acquisition must be available for at least 24 channels, and preferably 32 channels, of recording EEG along with artifact channels. For acquisition and for storage of EEG data the minimum digital sampling rate is 200 samples/s. Higher rates are preferable. Sampling rates should be multiples of 50 or 64, e.g. 500 or 512 samples/s. Prior to sampling at 200 samples/s, an anti-aliasing high filter at 70 Hz must be used, with a roll-off of at least 12 dB/octave. Higher filter settings require proportionally higher sampling rates. Whenever possible the low filter should be set to 0.16 Hz or less for recording, although the on-line EEG display during the recording may use a different setting of the low filter. Routine use of higher settings of the low filter for recording are discouraged, as they should be reserved for specific or difficult clinical recordings only. The low filter must be labeled in terms of *hertz* but there may be an additional display as a time constant in *seconds*. A 50–60 Hz notch filter should be available, but not routinely used. Recording should be made on a

referential montage to facilitate subsequent montage reconstruction. Digitization must use a resolution of at least 12 bits and must be able to resolve EEG down to 0.5  $\mu\text{V}$ . Larger digital resolution is optional. Electrode impedances should be kept below 5 k $\Omega$ , and preamplifier input impedances must be more than 100 M $\Omega$ . Interchannel cross talk must be less than 1%, i.e., 40 dB down or better. Common mode rejection ratio must be at least 110 dB for each channel measured at amplifier input. Additional noise in the recording should be less than 1.5  $\mu\text{V}$  microvolts peak to peak and 0.5  $\mu\text{V}$  root-mean-square at any frequency 0.5–100 Hz including 50–60 Hz.

## Recording media

Routine commercial digital magnetic or optical storage devices are adequate for routine long term recording and storage of EEG records. Some uncertainty remains about durability, especially regarding magnetic recording media. Careful handling remains necessary to avoid abrasions of optical surfaces or other disk damage. Various commercially available storage devices may become obsolete making impossible reading, repair or replacement of some recordings and drives in the future. It is the user's responsibility to remain aware of deteriorating legibility or impending technical obsolescence and make suitable arrangement to copy onto newer storage media any clinical EEG records which should be maintained for a longer time.

Note is made of the existence of statutes governing medical records in individual nations and states, as well as existence of local or hospital statutes regarding EEG record storage. These govern the legal duration of storage, and in some instances they may also specify or restrict the type of long term storage allowed.

Storage devices and their software must make easy the task of retrieving the records of individual patients as needed.

## Display

Digital EEG equipment must be able to present

the record on a video display or on paper, preferably with both review methods available. Review on paper or on a display screen should approximate the temporal and spatial resolution traditionally used for paper EEG recordings. Montages available for review should be consistent with those in standard use in the laboratory and with previous IFCN recommendations, preferably allowing additional user flexibility. This should be accomplished with bipolar or referential montage reconstruction (remontaging). Additional digital filtering during review should be available. Digital low filters must be available at least at 0.5, 1.0, 2.0 and 5.0 Hz. Digital high filters must be available at least at 15, 30 and 70 Hz. Playback systems should be able to display montage designations, gain and filter settings where appropriate, technologist comments, and event markers along with the raw or transformed EEG data. A time stamp on each screen or page of EEG data is essential. The screen should alert the reader that the patient is hyperventilating throughout that event.

A standard horizontal screen display scaling

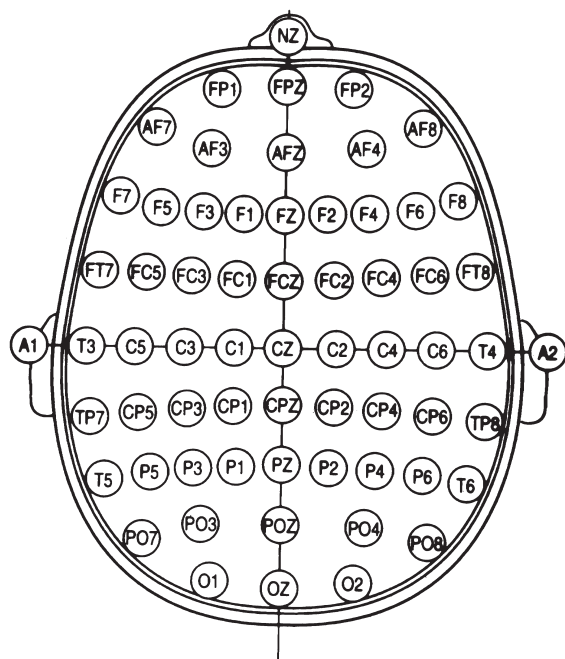


Fig. 1. Electrode nomenclature in Federation of Clinical Neurophysiology's 10-20 system with additional electrode site names. Collectively this extended nomenclature is called the 10% system.

should be available in which 1 s occupies approximately 30 mm with a minimum display resolution of 120 datapoints per second, per channel. Other more compressed and more expanded horizontal scales should also be available, including scaling differing from standard by a factor of 2, e.g. 7.5, 15, 30 or 60 mm/s. For the 60 mm/s display, at least 200 datapoints per second should be presented for each channel. Vertically, appropriate channel spacing between the baseline of each channel depends on the number of channels displayed, and should be adjustable to suit the reviewer's practice. A standard vertical scaling with a minimum spacing of 10 mm per channel should be available. Larger vertical channel separation should be available for use as needed. Occasional overlap of data between channels is acceptable. The standard video screen must have a minimum 4 pixels resolution per vertical millimeter. The horizontal and vertical scales must be indicated on the display. Comparison of capability of different devices, should take into account the maximum number of channels and the maximum number of seconds displayed on a single screen using the standard scaling as defined above.

The display system must allow simultaneous display of multiple separated segments of EEG, allowing side-by-side visual comparison of different segments within one recording as well as different segments from different recordings obtained on different days. For paper printout, at least 300 dots per inch (dpi) resolution is needed.

## Electrode nomenclature

When additional scalp sites are used, attempts should be made to locate them at the points halfway between the traditional 10-20 electrode system sites. Collectively these halfway sites, along with the original 10-20 electrode system sites, are named the 10% system or the extended 10-20 electrode system. In this system, the coronal row AF lies halfway between rows Fp and F; FC between F and C; CP between C and P; PO, halfway between P and O. Lateral rows 1 and 5 lie halfway between Z and 3, and between 3 and 7, respectively; see Fig. 1. This can be extended laterally to rows 9, 11, etc.,

onto the face or neck as needed. In these additional columns, rows 3 and 4 are aligned with rows 3 and 4 of the traditional 10-20 system sites. Other locations are proportionally more medial or lateral. Traditional sites T3-T6 remain as names preferable at those sites; but the names T7, T8, P7 and P8 would be acceptable, alternate names for these same sites under special circumstances. C7, C8, FC7, FC8, CP7 and CP8 might also be substituted for T3, T4, FT7, FT8, TP7 and TP8 respectively under special circumstances.

### **Exchange of clinical EEG**

Each manufacturer must make available to every user a method for sending the electronic EEG record to other users who have a reasonable clinical need to review the record. This method cannot assume that every EEG reader will have available

hardware from each vendor. The vendor should make available a method to put the EEG record into a standard file format generally accepted for use in that medical community and whose use is shared by many vendors, e.g. ASTM format. Also, the vendor must make public the EEG file format and allow other vendors, or third party software vendors, to read and to translate the EEG record into another format readable by another vendor's equipment. Clinical EEG data belongs to the health care providers or to the patients, not to the vendors.

### **Approvals**

A vendor may state that a digital EEG product is 'approved as meeting IFCN Standards for Digital EEG' only if the IFCN has given its approval in writing.