IMS stations specifications

Introduction

The IMS stations specifications are based on the Treaty Text and on reports by the Expert Groups of the Ad Hoc Committee in 1995 (e.g. CD/NTB/WP.283, CD/NTB/WP.269 and CD/NTB/WP.224).
These specifications are defined for the four required technologies : seismics (primary and auxiliary), infrasound, hydroacoustics (T-phase and hydrophones) and radionuclide (particulate and noble gas).

I. General requirements

1. Environmental specifications such as temperature range of operation, or down time are standard values. They might be adapted for specific sites where conditions are extreme (the Arctic region or Antarctica for example).
2. Data availability or timely data availability is computed over a period of one year. It is highly dependant on power failure, lightning and communication reliability.
3. To reach the required availability and limit future maintenance costs it is essential that stations be as autonomous and low consuming as possible. This will limit power backing equipment. Solar power should be preferred when possible. Stations should be hardened against lightning.
4. When indoors, systems requiring no or limited ambient room temperature control should be preferred.
5. Field communication equipment is part of the station. It should also comply with the above requirements.
6. Surveys should be conducted to ensure that siting does not alter station operational characteristics.
7. There should be some level of protection against physical damage to the field equipment.
8. New stations should comply with specifications. Existing stations should be upgraded to meet specifications. Planning of upgrading should be adapted to budget.
9. Certification procedures for compliance of station with requirements will have to be defined.

II. Minimum requirements for station specifications

Table 3. Specifications for primary and auxiliary seismic stations

Characteristics	**Minimum Requirements**
Sensor type	seismometer
Station type	3C or array
Position (with respect to ground level)	Borehole or vault
3 C Pass Band [1]	SP: 0.5 - 16 Hz + LP : 0.02 - 1 Hz or BB : 0.02 - 16 Hz
Sensor response	flat to velocity or acceleration over the pass band
Array Pass Band	(SP : 0.5 - 16 Hz LP : 0.02 - 1Hz) [2]
Number of sensors for new arrays[3]	9 SP (1C) + (1 SP (3C) + 1 LP (3C)) [4]
Seismometer noise	≤ 10 dB below minimum-earth noise at the site over the pass band
Calibration	within 5 % in amplitude and 5° in phase over the pass band
Sampling rate [1]	≥ 40 samples/s[5] LP : ≥ 4 samples/s
Resolution	18 dB below the minimum local seismic noise
System Noise	≤ 10 dB below the noise of the seismometer over the pass band
Dynamic range	≥120 dB
Absolute timing accuracy	≤ 10 ms
Relative timing accuracy	≤ 1ms between array elements
Operation temperature (° C)	-10° C to 45 °C [6]
State of health	Status to be transmitted to the IDC : clock, calibration, vault and/or borehole status, telemetry
Delay in transmission to IDC	≤ 5 min
Data frame length	SP : ≤ 10 s ; LP ≤:30s
Buffer at station or at NDC [7]	≥ 7 days
Data availability	≥ 98 %
Timely data availability	≥ 97 %
Mission capable arrays	≥ 80 % of the elements should be operational

1 For existing GTSN stations upgrading will need further consideration.
2 For 1C element of teleseismic arrays, the upper limit is 8 Hz.
3 In case of noisy sites or when increased capability is required number of sensors could be increased.
4 Can be achieved by a single Broad Band instrument.
5 This applies to 3C and regional arrays. For existing teleseismic arrays, 40 samples/s are necessary for 3C but 20 samples/s are suitable for other sensors
6 Temperature range to be adapted for some specific sites
7 Procedure for buffering to ensure minimum loss of data and single point failure should be addressed in the IMS Operation Manual.

Precision on station location	≤ 100 m absolute for stations (WGS84) ≤ 1 m relative for arrays elevation above sea level ≤ 20 m
Seismometer orientation	≤ 3°
Data format	GSE format
Data transmission	primary : continuous auxiliary : segmented

Data from auxiliary stations are essential for the IDC to achieve the required location precision for seismic events. For existing auxiliary stations the minimum requirement for certification as an IMS facility is a 90 % data availability. Existing auxiliary stations will be upgraded over some period of time. When not otherwise specified in the above table upgraded or new auxiliary stations should comply with technical requirements adopted for primary stations in terms of operational characteristics. Overall auxiliary station reliability should match as closely as possible those of the primary stations.

When auxiliary stations have a dual use, priority access to data, status monitoring and command of the station should be given to CTBTO / IDC. This should be firmly established by National Authorities and accounted for in terms of communication field equipment.

Table 4. Specifications for hydroacoustic stations

T-Phase stations

T-phase stations are seismic stations specifically equipped to detect waves from underwater explosions. Data are continuously transmitted to IDC. Therefore their specifications are identical to that of primary stations except for some parameters listed below.

Characteristics	**Minimum Requirements**
Pass-band	0.5 - 20 Hz
Type	Minimum of one vertical component.
Sampling rate	≥ 50 samples per second

Hydrophones

Characteristics	**Minimum Requirements**
Sensor type	Hydrophone with wet end digitiser
Band Pass	1 – 100 Hz
Sensor Response	flat to pressure over the pass band
Number of sensors	1 operational sensor with 2 backup sensors per cable
Sensors location	in the SOFAR channel
Location precision	≤ 500 m
Number of cables	2 at a site when necessary to prevent local blockage
System noise	≤ 10 dB below Urick's deep ocean low noise curve
Calibration	within 1 dB no phase requirements
Sampling rate	≥ 240 samples/s
Timing accuracy	≤ 10 ms
Delay in transmission to IDC	≤ 5 min
State of health	Status to be transmitted to the IDC : hydrophone, clock, calibration, telemetry
Data availability	≥ 98 %
Timely data availability	≥ 97 %
Sensitivity	≤ 60 dB /μPa (one Hz band) ≤ 81 dB /μPa (wide band))
Dynamic range	120 dB
Data transmission	continuous
Data format	GSE format
Data frame length	≤ 10s
Buffer at dry end	≥ 7 days
MTBF for wet end equipment	20 years (to be confirmed)

Table 5. Specifications for Infrasound stations

Characteristics	**Minimum Requirements**
Sensor type	microbarograph
Number of sensors	4 element array[8]
Geometry	triangle with a component at the centre
Spacing	triangle basis : 1 to 3 km[9]
Station location accuracy	≤ 100 m
Relative sensor location	≤ 1 m
Measured parameter	absolute[10] or differential pressure
Pass-band	0.02 - 4 Hz
Sensor response	flat to pressure over the pass band
Sensor noise	≤18 dB below minimum acoustic noise[11]
Calibration	≤ 5 % in absolute amplitude[12]
State of health	status data transmitted to IDC
Sampling rate	≥ 10 samples per second
Resolution	≥ 1 count/1 mPa
Dynamic range	≥108 dB
Timing accuracy	≤ 1 ms
Standard temperature range	-10 °C to 45 °C[13]
Buffer at station or at NDC	≥ 7 days
Data format	GSE format
Data frame length	≤ 30 s
Data transmission	continuous
Data availability	≥ 98%
Timely data availability	≥ 97%
Mission capable array	≥ 3 elements operational
Acoustic filtering	noise reduction pipes (site dependent)
Auxiliary data	meteorological data[14]

8 In case of noisy sites or when increased capability is required number of components could be increased.

9 3 km is the recommended spacing

10 Used for daily state of health.

11 Minimum noise level at 1 Hz : ~ 5mPa.

12 Periodicity : once per year (minimum).

13 Temperature range to be adapted for some specific sites.

14 Once per minute.

Table 6. Specifications for Radionuclide stations

Particulate monitoring

Characteristics	**Minimum requirements**
System	manual or automated
Air flow	500 m^3/h
Collection time [15]	24 h
Decay time[16]	≤ 24 h
Measurement time [17]	≥ 20 h
Time before reporting	≤ 3 days
Reporting frequency	Daily
Filter	Adequate composition for compaction, dissolution and analysis
Particulate collection efficiency	for filter : ≥ 80 % at ∅ = 0.2 µm global [18]: ≥ 60 % at ∅ = 10 µm
Measurement mode	HP Ge High resolution gamma spectrometry
HP Ge relative efficiency	≥ 40 %
HP Ge resolution	< 2.5 keV at 1332 keV
Base line sensitivity [19 20]	10 to 30 $\mu Bq/m^3$ for 140Ba
Calibration range	88 to 1836 keV
Data format for gamma spectra and auxiliary data	RMS (Radionuclide Monitoring System) format [21]
State of health	status data transmitted to IDC
Communication	two-way
Auxiliary data	meteorological data flow rate measurement every 10 minutes
Data availability	≥ 95 %
Down time [22]	≤ 7 consecutive days ≤ 15 days annually

15 Time specifications allow for an uncertainty of 10 %, except for the reporting time parameter.

16 This value can be reduced, down to a minimum of 6 hours, if a suspicious event is detected by other stations or techniques.

17 This value allows for authentication measurements for manual systems.

18 This global value includes the 80% filter efficiency and the collection efficiency of the incoming air circuitry.

19 The upper limit is intended for high background areas.

20 Certification procedures to be defined for baseline sensitivities (a posteriori MDCs) as well as the efficiency. Sample preparation losses should not affect base line sensitivities.

21 This format should make provision for auxiliary data, authentication data and state of health data.

22 Provision should be made for spare parts in particular areas where periodicity of transportation facilities is more than 7 days.

Noble gas monitoring

Characteristics	*Minimum requirements*
Air flow	0.4 m^3/h
Total volume of sample	10 m^3
Collection time	≤ 24 h
Measurement time	≤ 24 h
Time before reporting	≤ 48 h
Reporting frequency	daily
Isotopes measured	^{131m}Xe, ^{133m}Xe, ^{133m}Xe, ^{135m}Xe
Measurement mode [23]	beta-gamma coincidence or high resolution gamma spectrometry
Minimum Detectable Concentration [24]	1 mBq/m^3 for ^{133}Xe
State of health	status data transmitted to IDC
Communication	two-way
Data availability [25]	95 %
Down time [25]	≤ 7 consecutive days ≤ 15 days annually

23 Calibrations need to be defined.
24 MDCs for the other isotopes are not defined here since they critically depend on the detection system used.
25 This is a goal to be reached.