

Distributed fibre-optic acoustic and vibration sensing systems

Performance parameters and test methods

Part 1: Phase-sensitive OTDR DAS

Reproducible procedures from controlled excitation and data validity to spectral, noise, dynamic and spatial measurements.

DOCUMENT

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Foreword

OS-MSP is the series of reproducible performance test methods for distributed fibre-optic sensing systems developed by OriginSense. This part addresses phase-sensitive optical time-domain reflectometry (phase-sensitive OTDR) distributed acoustic sensing systems that use Rayleigh backscatter and phase detection. Its methodological structure covers controlled excitation, preservation of raw data and fixed configurations, validity screening, metric calculation, uncertainty and reporting.

This draft distinguishes measurement methods from conformity decisions. The test conditions, algorithms and reporting fields in its provisions support comparable results; product grades, procurement acceptance limits and application-specific criteria are specified in separate documents. This draft may be used for technical discussion and methodological validation, provided that its draft version is identified when cited.

Publicly available information concerning the IEC 61757 series, SEAFOM MSP-02, JCGM 100 and the ISO 5725 series was consulted during preparation. These references constitute neither reproduction of those documents' provisions nor a declaration of conformity. Formal comparison requires a clause-by-clause review of the applicable, current full texts under appropriate rights of use.

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1. Scope

This document specifies test-object levels, general test conditions and data-validity rules for phase-sensitive OTDR distributed acoustic sensing systems, together with methods for measuring and reporting frequency response, signal fidelity and total harmonic distortion, background noise, dynamic range, spatial response, spatial uniformity, fading and long-range performance.

It applies to laboratory interrogators, end-to-end chains incorporating reference fibre and actuators, and field systems whose installation conditions are documented as specified here. For phase, differential-phase, strain or strain-rate outputs, the report shall separately identify the measurand and calibration chain. Identical numerical units alone shall not be taken to make results interchangeable.

Quasi-static measurements below the conventional acoustic/vibration bandwidth, recognition accuracy for external environmental events and diagnosis of fibre installation structures are outside the basic measurement scope of this part. Where required, these items shall be covered by separate extended test specifications with their additional conditions stated.

2. Reference documents and their relationship to this draft

This draft is an independently prepared test-method document. IEC 61757:2026 provides the generic framework for fibre-optic sensors; IEC 61757-3-2:2022 addresses distributed acoustic sensing interrogators; SEAFOM MSP-02 V2.0 provides recommendations for DAS performance measurement; JCGM 100:2008 provides the general framework for measurement uncertainty; and the ISO 5725 series provides principles for validating measurement precision. Full bibliographic information is given in Annex D.

A report using the expression “conforms to IEC” or “conforms to SEAFOM” shall undergo a separate conformity assessment against the full text of the applicable document. An OS-MSP measurement result establishes only that the result was obtained using the method specified in this document.

3. Terms, symbols and units

Term	Definition
Temporal sampling rate f_s	Number of valid output samples produced per unit time at the same spatial position, in Hz. It shall be recorded separately from optical pulse repetition frequency and output decimation ratio.
Spatial sampling interval Δx	Nominal distance between adjacent output positions, in m. It is distinct from spatial resolution.
Gauge length L_g	Physical distance, in m, between the two reference positions used in a phase difference, strain conversion or another spatial operator. The actual algorithmic definition shall be recorded.
Spatial response function	Output amplitude or energy as a function of position in response to a local controlled perturbation. It can be used to estimate main-lobe width, side lobes and crosstalk.
Valid measurement position	A position satisfying the requirements for data completeness, finite values, signal quality and predeclared spatial boundaries.
Phase-noise ASD	One-sided amplitude spectral density of the phase time series with the excitation output disabled, in rad/ $\sqrt{\text{Hz}}$.
Input-referred noise	Output noise referred to the input through a calibrated input–output transfer function. The corresponding frequency, position and calibration conditions shall be retained.
Detection limit	Smallest physical input detectable using a predeclared signal-to-noise criterion. Measured values and estimates extrapolated from noise shall be identified separately.
Usable upper limit	Largest input amplitude over a continuous amplitude range satisfying the declared requirements for linearity error, waveform integrity and unambiguous phase recovery.
Coverage	Ratio of valid measurement positions to all candidate positions within the predeclared target spatial interval.

Unless otherwise stated, amplitudes are sinusoidal peak values; actuator voltage is the peak-to-peak voltage V_{pp} measured at its terminals; frequency is in Hz; distance is in m; and noise ASD is in the applicable unit/ $\sqrt{\text{Hz}}$. Values in dB shall identify the reference quantity and justify the use of a factor of 10 or 20 in the logarithm.

4. Test object and configuration declaration

4.1. Test-object levels

Level	Boundary	Reporting wording
I: Interrogator	The test object is defined by its optical interface and acquisition/demodulation output. Reference fibre, actuator and environment belong to the test apparatus.	“Measurement results for the interrogator with the stated reference apparatus.”
II: End-to-end chain	Includes the interrogator, reference fibre, connectors, actuator and specified mechanical coupling.	“Measurement results for the stated end-to-end chain.”
III: Field system	Includes the actual fibre installation, mounting, coupling, protection and field disturbances.	“Field-system results under the stated installation conditions.”

The report shall identify one primary level. Results from different levels shall not be combined into an unqualified “equipment performance” value. Input-referred noise obtained using a local actuator at Level II or III shall retain information about coupling and the spatial transfer function.

4.2. Required configuration information

Before each test, the following shall be fixed and recorded: equipment and optical-path identifiers; fibre type and length; connection and reflection structures; number of polarisation channels; optical pulse width; pulse repetition frequency; fast-time sampling rate and sample count; measurement start and end positions; output temporal sampling rate; spatial sampling interval; gauge length; filter and demodulation algorithm versions; output physical quantity and unit; recording format; and calculation-program version.

Multi-polarisation or multi-channel systems shall also record channel registration and fusion methods. Changes to software parameters or the optical path, actuator remounting or fibre rewinding create a new configuration. Such a configuration shall not be treated as an independent repeat of the previous configuration.

5. Test equipment and arrangement

5.1. Controlled excitation chain

The excitation chain shall include a waveform generator, any necessary driver/amplifier, a fibre strain or vibration actuator, and independent measurement equipment for verifying terminal voltage, frequency and waveform. The generator identifier, terminal impedance, actual load, drive-chain gain, rated limits, connections and uncertainty shall be recorded. Generator setpoints shall not directly replace measured actuator-terminal values.

Where results are expressed as strain or strain rate, the calibration function from actuator input to actual fibre strain, its valid frequency band, calibration uncertainty and mechanical-coupling conditions shall be provided. Where only a voltage-to-output-phase relationship is available, V_{pp} input-referred results shall be reported; these shall not be relabelled directly as strain results.

5.2. Fibre and spatial arrangement

Reference-fibre length, attenuation, connectors and reflection structures shall be traceable. Actuator positions should cover the near end, an intermediate distance and a location close to the declared maximum test distance. Distance points shall be determined in advance in the test plan. The complete spatial response shall be acquired at each test location, distinguishing the high-response interior plateau of the actuator, transition edges and an unexcited reference region.

When the same actuator is moved between distances, consistency of mounting and strain transfer shall be verified. Where multiple actuators are used, their transfer functions shall be calibrated separately. Fibre attenuation, backscatter amplitude and polarisation state shall be recorded as influence quantities.

5.3. Environment and safety

The test shall record temperature, mechanical isolation, power-supply state, periodic mechanical disturbances such as fans or pumps, and operation of nearby equipment. The actuator excitation output shall be verified as disabled at the beginning and end of the test. Excitation shall not exceed the lowest applicable limit of the generator, driver, actuator or fibre. Safety limits shall be reverified after wiring or load changes.

6. General test procedure

6.1. Fixing the test plan

Before acquiring data intended for the formal calculation, the test plan shall specify the test-object level, configuration, distance points, spatial selection rules, frequency and amplitude sequences, durations, repeat counts, anchor measurements and output-disabled segments, data-quality gates, calculation-code version and reporting fields. Formal test data shall not be used to select favourable parameters, remove unfavourable positions or change decision thresholds retrospectively.

Development optimisation and formal validation shall use non-overlapping datasets. Invalid steps that require repetition shall retain the original record, invalidity reason and retest identifier.

6.2. Baselines and sequence

Each formal test cycle shall contain excitation-disabled data segments before and after testing. Response anchors at a fixed frequency and amplitude should be inserted between frequency blocks to identify drift. Increasing-amplitude tests should include some reverse-order steps or repeated anchors to identify history dependence and actuator hysteresis. Repeat acquisitions shall include independent operating states after a restart or reconnection, rather than merely subdivisions of one continuous record.

6.3. Data integrity

For each output track, sample counts, monotonic event time, expected time step, dropped-row/overflow counts, fraction of finite values, saturation and clipping shall be checked. Excitation logs and data tracks shall be paired on a common time base, retaining the pairing tolerance and unpaired intervals. Formal analysis shall use only the fully paired common time interval.

6.4. Quality classification

Each time segment and spatial position shall be labelled valid, inconclusive or invalid, with a reason code. Signal-quality screening shall be independent of the final performance value, for example using predeclared fundamental SNR, finite-value fraction and anchor drift. A high performance result shall not itself be a selection criterion. Counts and proportions of invalid positions and fading regions shall be reported rather than silently removed.

This draft sets no system-wide performance pass/fail limit. A test plan may declare application-specific or product-grade limits, but these shall be fixed before the data are sealed and presented separately from measurement results.

7. Measurement methods for performance parameters

7.1. Coordinates, valid distance and spatial selection

Output positions shall have a traceable mapping to raw sample points or optical-path sample points. Distance conversion shall state the sampling clock, group refractive index or calibrated reference distance, zero offset and uncertainty. Raw fast-axis sampling interval, output spatial sampling interval, gauge length and effective spatial response width shall be reported separately.

At each actuator distance, a spatial response curve shall first be measured using a low-amplitude sine excitation below the nonlinear limit. Local performance positions shall be selected from the actuator's high-response interior using predeclared rules; edge positions are used for spatial-response and crosstalk analysis. Low-amplitude points at the edge of the spatial response shall not be treated as "poorer interior measurement positions" when calculating background noise or dynamic range.

7.2. Frequency response

7.2.1. Excitation and acquisition

The basic test uses stepped, steady-state sinusoidal excitation. Fundamental frequencies should span $0.02f_N$ to $0.8f_N$, where $f_N = \frac{f_s}{2}$. The basic profile uses at least 40 logarithmically spaced frequencies and at least 2.5 s of steady-state data per frequency. Additional frequency intervals may be tested but shall be identified separately. At each frequency, excitation amplitude shall maintain the same calibrated input measurand and remain below the known linearity limit for that frequency.

At each predeclared distance, the actual actuator input and valid output over the same time interval shall be recorded. Fundamental output amplitude may be estimated using in-phase/quadrature least-squares fitting or amplitude-corrected FFT; the chosen method shall be fixed in the plan. Missing frequencies, low-SNR points and loss-of-lock points shall retain their status rather than having original results replaced by interpolation.

7.2.2. Results

Frequency response is the ratio of output fundamental amplitude to input fundamental amplitude at each frequency. Reports shall include the unnormalised transfer magnitude, the dB curve normalised to the selected reference frequency, passband peak-to-valley variation, valid frequency range and measurement uncertainty at each point. Phase-response and group-delay measurements shall state clock alignment at both ends, the excitation phase reference and fixed delays introduced by filtering.

7.3. Fidelity and total harmonic distortion

Stable sinusoidal signals shall be acquired at low, medium and high input amplitudes within the usable dynamic range. The basic fidelity test should use a fundamental of $0.1f_N$, with at least 60 s of steady-state recording per amplitude. Additional fundamentals shall be used where frequency dependence is to be evaluated. For each amplitude, the mean, standard deviation, maximum relative deviation and drift of the fundamental response across time windows shall be reported.

Harmonic amplitudes A_k are fitted using the excitation-synchronous fundamental f_0 . Total harmonic distortion is defined as

$$\text{THD} = \frac{\sqrt{\sum_{k=2}^K A_k^2}}{A_1} \times 100\%.$$

The highest harmonic order K , amplitude-estimation method, window, frequency resolution and noise-subtraction method shall be declared in advance. A harmonic may be included in the corresponding THD result only where $kf_0 < f_N$ and its measurement has sufficient SNR. If the second or third harmonic lies beyond Nyquist, the result shall be labelled “not calculable at the specified harmonic orders”; it shall not be reported as 0%. Harmonics near strong narrowband external interference shall be marked as affected rather than silently removed.

7.4. Background noise with excitation output disabled

7.4.1. Acquisition

The actuator’s electrical excitation output shall be disabled while all other settings remain the same as in the excited test. At least 60 s shall be acquired both before and after testing. Narrowband environmental vibration and power-frequency harmonics shall be recorded. The output time series at every valid spatial position shall be measured, and pre-test/post-test differences reported. Long-distance positions shall be measured separately using the same method.

7.4.2. Spectral calculation

The predeclared deterministic trend shall be removed from the time series, and a one-sided power spectral density estimate with window-power correction used. For segments of length N , sampling rate f_s and window $w[n]$, the following expression may be used:

$$P_{\varphi(f_k)} = c_k \frac{\left| \sum_{n=0}^{N-1} w[n] \varphi[n] \exp(-2\pi i k \frac{n}{N}) \right|^2}{f_s \sum_{n=0}^{N-1} w[n]^2},$$

Here $c_k = 1$ at DC and Nyquist, and $c_k = 2$ at other positive frequencies. Phase ASD is $\sqrt{P_{\varphi}}$, in rad/ $\sqrt{\text{Hz}}$. Welch segment length, overlap, window function, time bandwidth and line-exclusion rules shall be stated. In-band noise shall include both spectral curves and the median and upper-quantile values within predeclared bands. A single “background value” without a stated bandwidth is not comparable.

7.4.3. Input-referred representation

Where an independently calibrated input–output transfer function $H(f, x)$ exists, local input-referred noise may be given as $N_{in(f,x)} = \frac{\sqrt{P_{\varphi(f,x)}}{|H(f,x)|}$. This result shall include actuator calibration, mechanical coupling, position and frequency. Without strain-transfer calibration, rad/√Hz or calibrated V/√Hz shall be retained. A local PZT voltage-to-strain conversion alone does not remove mechanical-coupling and spatial-filtering effects and shall not be labelled intrinsic interrogator strain self-noise.

7.5. Dynamic range and amplitude linearity

7.5.1. Excitation sequence

Dynamic range shall be measured separately by frequency and spatial position. Basic frequencies should include approximately $0.01f_N$, $0.05f_N$, $0.20f_N$ and $0.80f_N$; application-specific absolute frequencies may be added. Each frequency shall have at least three low-amplitude points above the detection limit and below saturation to fit the low-amplitude gain. Amplitude spacing shall become denser near the expected upper limit. Identical anchor excitations shall be placed before and after each frequency block, and pre-test/post-test excitation-disabled noise segments retained.

7.5.2. Lower limit

The measured detection limit $A_{L,meas}$ is the smallest input physically tested whose coherent SNR reaches the predeclared threshold. The basic method uses a fundamental coherent SNR of at least 10 dB. An estimated detection limit $A_{L,est}$ may be extrapolated from excitation-disabled noise and low-amplitude gain. It shall be labelled “estimated”, with its uncertainty and applicable frequency band reported. The two limits shall not be combined into an unexplained single value.

7.5.3. Upper limit and linearity

A fit through the origin using at least three valid low-amplitude points shall establish the fixed low-amplitude gain G_0 . Gain error relative to G_0 shall be calculated for every measured amplitude. The strict-linearity upper limit is the largest measured input over a continuous interval starting at low amplitude for which absolute gain error is at most 1 dB; the engineering-linearity upper limit uses 3 dB. Once the first failure occurs, a higher amplitude that meets the error criterion again does not restore the continuous upper limit.

Response monotonicity, waveform collapse, phase cycle slips, missing cycles and discontinuities shall be examined. The first amplitude at which response drops below 70% of the preceding amplitude step, or gain error relative to the low-amplitude gain falls below –6 dB, shall be investigated as a candidate failure boundary. The basic method takes the usable upper limit A_U as the lower of the engineering-linearity and unambiguous-response upper limits. At frequencies where all specified harmonics are measurable, a low-distortion upper limit at 5% THD shall also be reported separately. The strict linear interval shall be accompanied by R^2 , maximum gain error and evidence concerning input/output zero offsets.

Estimated dynamic range and measured covered range are defined separately:

$$DR_{est} = 20 \log_{10} \left(\frac{A_U}{A_{L,est}} \right), \quad DR_{covered} = 20 \log_{10} \left(\frac{A_U}{A_{L,meas}} \right).$$

Both shall identify frequency, position, input unit and the mechanism determining the upper limit. Results near Nyquist, such as the 800 Hz result, shall not be interpreted using low-frequency THD or an assumed common unambiguous upper limit. Where input is calibrated only in Vpp, the report shall use “voltage-input-referred dynamic range”. Conversion to strain dynamic range requires the complete strain-calibration chain.

7.6. Spatial response, resolution and crosstalk

A local controlled excitation that is sufficiently short, or has known length, shall be used at the predeclared fundamental and linear amplitude to acquire the complete spatial response over the actuator and at least two gauge lengths on each side. Excitation-frequency amplitude shall be calculated using the same time window and estimation method at every position. Reports shall include the raw spatial curve, peak position, main-lobe full width at half maximum, left and right transition widths, peak side lobes, response width above the predeclared detection threshold and edge extension.

Where the actuator’s excited length and mechanical-coupling width are not negligible, the measured curve is the convolution of the actuator response and system spatial response. It shall be reported as “measured end-to-end spatial response width”, rather than directly equated with intrinsic system spatial resolution. Resolving capability may be verified using a calibrated short actuator, an independent spatial transfer model, or two independent excitation points with known separation. A reported “resolvable two-point separation” shall have a predeclared valley-depth or other separation criterion.

Crosstalk shall be expressed as same-frequency coherent amplitude outside the main-response region relative to the reference amplitude in that region, with a dB-versus-distance curve. Main-lobe width, side lobes, crosstalk and noise shall be reported together. Noise reduction obtained by increased spatial smoothing shall be accompanied by the corresponding change in spatial response.

7.7. Spatial uniformity

Spatial uniformity comprises two measurement levels that do not substitute for one another.

1. **Local uniformity:** At least three interior positions shall be preselected within the high-response plateau of one actuator. Maximum differences, coefficients of variation and measurement uncertainties shall be calculated for low-amplitude gain, frequency response, THD and phase ASD. Spatial-response edges, side lobes and unexcited regions shall be excluded from plateau statistics and reported separately as spatial response.
2. **Longitudinal uniformity:** The same reproducible excitation chain, or separately calibrated equivalent actuators, shall be used at predeclared near, intermediate and far distances to compare response and noise at the reference input. Distance, fibre attenuation, backscatter quality and coupling differences shall also be reported. Where excitation equivalence cannot be established, only end-to-end results at the measured positions may be reported; differences shall not be attributed to the interrogator.

P10, P50, P90, extrema, valid coverage and the proportion of positions with deep fading or loss of lock should be reported along the declared valid length. Position selection and aggregation weights shall be fixed before testing. Where only a few actuators are installed, the report shall identify the results as representing those measured distance points, rather than proof of continuous full-length uniformity.

7.8. Fading, repeatability and long-range performance

Spatial-temporal data of sufficient duration shall be recorded both with excitation disabled and with fixed low-amplitude excitation. Output amplitude, phase validity, coherent SNR, and loss-of-lock/cycle-slip events shall be analysed. Fading thresholds shall use predeclared quality indicators, rather than thresholds chosen retrospectively to improve average performance. Reports shall include fading-duration distributions, spatial coverage, performance recovery time and effects of polarisation-state changes. Multi-polarisation fusion strategies shall have a fixed version.

Background-noise, frequency-response and dynamic-range tests shall be repeated at least at the near end and the declared farthest distance. A system claiming continuous real-time output or recording shall undergo a separate engineering-operation test reporting duration, actual input/output row rates, dropped rows/overflows, buffer occupancy, processing latency, storage rate and temperature. Throughput testing shall not substitute for signal-performance testing.

8. Statistics, validity and measurement uncertainty

8.1. Repeated measurements

Reports shall distinguish time-window repeats within one record, independent repeats after reapplying excitation, repeats after actuator remounting, and repeats across dates or equipment. Correlated windows shall not be counted as independent samples. Every metric shall report at least the valid repeat count, a central statistic and dispersion. For skewed distributions or long-tailed fading, medians and quantile intervals should be reported rather than only arithmetic means.

Adjacent spatial positions are correlated through gauge length and filtering. Spatial statistics used for coverage, quantiles and confidence intervals shall state the correlation length; spatial-block rather than pixel-by-pixel resampling shall be used where needed. Two algorithms should be compared using the same physical excitation and common valid spatial-temporal interval wherever possible, reporting changes in spatial response for both the original and candidate algorithm.

8.2. Uncertainty budget

A measurement model shall be established for each reported unit. At minimum it shall consider generator output and terminal measurement, actuator voltage-to-strain calibration, actuator mechanical coupling, fibre positioning, temporal sampling clock, phase scale factor, spectral-estimation variance, environmental drift, polarisation fading, spatial filtering and data-exclusion rules. Shared calibration errors in multi-distance comparisons are correlated components and shall not be combined repeatedly as if independent.

Reports shall identify Type A repeatability components and Type B calibration/model components, combined standard uncertainty and, where required, expanded uncertainty and coverage factor. Nonlinear ratios, threshold positions and calculations near the noise floor should be cross-checked using numerical propagation or resampling. Reported significant figures shall not imply precision beyond that supported by the uncertainty budget.

8.3. Invalid or inconclusive states

The affected test unit shall be marked invalid or inconclusive for missing data segments or unpaired clocks; unverifiable excitation-terminal state; output saturation; actuator limit exceedance; insufficient fundamental SNR; anchor drift exceeding the pre-test threshold; calibration outside its valid band; cycle slips rendering the waveform unusable; or spatial positions within a pre-excluded actuator edge. Reason codes, affected spatial-temporal intervals and indexes of unscreened original results shall be retained.

9. Presentation of results and test report

9.1. Minimum report content

Content group	Required fields
Object and status	Test-object level; equipment/optical-path/software identifiers; test date; laboratory or field setting; report version; method-draft version.
Configuration	Fibre and excitation chain; distances and positions; temporal and fast-axis sampling rates; pulse width; spatial sampling interval; gauge length; filter and algorithm configuration.
Traceability	Generator and measurement-equipment calibration information; strain or terminal-voltage calibration; raw Session/dataset identifiers; execution logs and code revision.
Data quality	Predeclared quality gates; valid position count and coverage; dropped rows/overflows; loss of lock; drift anchors; invalidity reasons for each item.
Performance results	Results by distance and frequency; frequency-response curves; THD; noise ASD; dynamic-range limits; spatial-response and uniformity statistics.
Uncertainty	Measurement model, principal components, combined value, coverage factor and statement of applicable conditions for each important result.
Conclusion	Measured items and conditions; estimates, measurements, unmeasurable items and items failing data-quality gates listed separately.

9.2. Figures and tables

Frequency-response plots shall show both absolute and normalised response. Noise shall be shown as ASD curves with units, rather than a single minimum value. Dynamic-range plots shall show input-output amplitude curves, continuous linear intervals, detection limits and the first failure point. Spatial measurements shall show complete response curves and the interior plateau, edge and reference regions used. Comparisons across distances shall also show excitation-input equivalence and environmental conditions.

All figures and tables shall identify axis units, frequency/position ranges, processing version, valid sample counts and legends. Captions shall disclose smoothing, cropping, interpolation or background subtraction. Unprocessed curves shall be reproducible from archived data.

9.3. Traceable data package

Each test shall have a unique test ID and include the plan, instrument readback logs, raw/derived-data indexes, data-integrity results, analysis configuration, code version, numerical results and final report. The package shall carry unambiguous timestamps and content-integrity information. Report corrections shall retain the previous version and reason for correction, and shall not overwrite original data.

10. Method-conformity statement

A report using this document may state “measured for the applicable items in accordance with OS-MSP-DAS-01 Technical Draft v0.1.0”. Only items actually completed and satisfying data-quality requirements may be listed as measured. Where other methods are used for some items, a deviation list shall identify the differences and their effect on comparability.

This draft establishes neither product grades nor universal pass/fail thresholds. Measurements produced under this document do not automatically establish conformity with IEC, SEAFOM or any third-party framework. Product conformity certification requires separate decision rules and implementation by a body with the appropriate qualifications or agreed responsibilities.

Annex A: Example basic test plan (informative)

This annex illustrates test organisation at a temporal sampling rate of 2 kHz. The example parameters support test planning and do not restrict the use of other sampling rates, fibre lengths or actuators.

Item	Example settings	Concurrent constraints
Excitation disabled	At least 60 s before and after formal testing.	All demodulation/filter settings unchanged from the excited test.
Frequency response	20–800 Hz; 40 stepped-sine frequencies; at least 2.5 s per frequency.	Terminal input constant and within the low-amplitude linear region.
Fidelity	100 Hz; low, medium and high amplitudes; at least 60 s per amplitude.	Verify that the second to fifth harmonics are below the 1 kHz Nyquist frequency.
Dynamic range	10, 50, 200 and 800 Hz; amplitude sweeps at each frequency as planned.	The second harmonic of 800 Hz exceeds Nyquist; do not report THD on the same harmonic-order basis.
Spatial response	Fixed low-amplitude single frequency; complete sampling over the actuator and both sides.	Retain edges, side lobes and an unexcited reference region.
Spatial uniformity	At least three preselected interior plateau positions per actuator; separate tests at near, intermediate and far distances.	Control or calibrate excitation equivalence for distance comparisons.

Illustrative default analysis gates for development may use coherent SNR of at least 10 dB, strict and engineering gain errors of at most 1 dB and 3 dB, respectively, and anchor drift no greater than 1.5 dB across a dynamic-range frequency block. These values are example conventions in the current methodological draft, subject to revision after cross-equipment and interlaboratory validation. They shall not be treated as product pass/fail criteria.

Annex B: Record structure and recalculation inputs (draft normative provisions)

A test intended to support recalculation shall provide at least the following structured records. Implementations may map field names, but shall not alter their meaning or units.

Record	Required content
system_manifest	Test-object level; equipment/optical-path/fibre/actuator identifiers; calibration and environmental boundaries.
test_plan	Fixed test matrix; spatial selection rules; excitation and safety limits; repeat counts; validity gates.
instrument_log	Setpoints at each step; terminal readback or independent measurements; output-enable state; common-time-base timestamps.
track_index	Raw/derived-track identifiers; units; temporal and spatial coordinates; missing regions; content-integrity information.
quality_mask	Status, reason code and screening-program version for each valid or invalid spatial-temporal region.
analysis_manifest	Calculation method; window function; FFT/fitting parameters; code revision; input-file hashes.
results	Numerical tables; curves; statistical distributions; uncertainty; estimated/measured flags; report references.

The archive structure shall enable another analyst to recalculate the principal results without accessing the original operator's workstation. Hardware component models constituting trade secrets may use stable internal codes, while calibration relationships and test boundaries shall remain traceable.

Annex C: Two-level spatial-uniformity statistics (informative)

Let preselected positions within an actuator's interior plateau be $x_1, \dots, x_m$, with low-amplitude gains $G_1, \dots, G_m$ at the same input. Local uniformity may be reported as the dB difference for $\frac{G_{\max}}{G_{\min}}$, coefficient of variation, and the distribution over three or more spatial positions. These statistics describe output uniformity within the same locally excited segment.

Let preselected actuator distances be $d_1, \dots, d_q$. Longitudinal-uniformity comparisons shall first normalise by the calibrated actual input at each distance, then examine $G(d_i, f)$, phase ASD, usable upper limit and valid coverage versus distance. Where coupling differences are unknown, end-to-end observations at each distance shall be reported; their differences should not be interpreted directly as changes in interrogator sensitivity.

Comparisons of spatial-smoothing settings shall present noise ASD, main-response width, side lobes, edge extension and coverage together. Selecting only the spatial-filter setting with the lowest noise does not demonstrate better overall measurement performance.

Annex D: References and methodological relationships (informative)

1. IEC 61757:2026, *Fibre optic sensors — Generic specification*. Generic fibre-optic sensor framework; IEC Webstore: <https://webstore.iec.ch/en/publication/90208>.
2. IEC 61757-3-2:2022, *Fibre optic sensors — Part 3-2: Acoustic sensing and vibration measurement — Distributed sensing*. Performance measurement for phase-sensitive OTDR DAS; IEC Webstore: <https://webstore.iec.ch/en/publication/29202>.
3. SEAFOM MSP-02 V2.0, *Measuring Sensor Performance — DAS Parameter Definitions and Tests*. Reference for DAS test methods; SEAFOM: https://seafom.com/mdocs-posts/seafom_msp_02-august-2018-pdf/.
4. SEAFOM, *pySEAFOM*. Open-source calculation workflows and examples; <https://github.com/SEAFOM-Fiber-Optic-Monitoring-Group/pySEAFOM>.
5. JCGM 100:2008, *Evaluation of measurement data — Guide to the expression of uncertainty in measurement*. BIPM: <https://www.bipm.org/en/doi/10.59161/jcgm100-2008e>.
6. ISO 5725-1:2023 and ISO 5725-2:2025, *Accuracy (trueness and precision) of measurement methods and results*. References for precision and interlaboratory validation; ISO official catalogue.

Alongside these frameworks, OS-MSP explicitly distinguishes four commonly confused topics: output phase ASD versus local input-referred strain noise; spatial sampling interval, gauge length and experimentally verified resolving capability; local uniformity within one excited plateau versus uniformity across distances; and estimated dynamic range versus the range actually covered by an amplitude sweep. This relationship describes the technical positioning of this draft and is not an endorsement by an external standards organisation.

Annex E: Validation work towards formal standardisation (informative)

Further methodological validation shall include at least the following:

1. Use phase-sensitive OTDR DAS systems from different manufacturers, single/dual-polarisation optical paths and different demodulation algorithms to examine transferability of metric definitions and data interfaces.
2. Validate the effects of actuator installation and calibration errors on frequency response, noise, dynamic range and spatial response at short, intermediate and long distances, under different attenuation and reflection conditions.
3. Organise interlaboratory comparisons to estimate within-laboratory repeatability and between-laboratory reproducibility, then refine acquisition duration, frequency points, validity gates and uncertainty requirements accordingly.
4. Manage method specifications, product-grade/acceptance specifications and application-specific tests as separate parts, preventing numerical thresholds from one apparatus or scenario from becoming universal requirements.
5. After obtaining rights to use the applicable full standards, prepare clause-by-clause comparison tables and review terminology, equipment requirements, test scope and report formats. Formal texts shall proceed through the relevant standards organisation's review procedures.