INTERNATIONAL RECOMMENDATION

OIML R 130

Edition 2001 (E)

Octave-band and one-third-octave-band filters

Filtres à bande d'octave et de tiers d'octave

OIML R 130 Edition 2001 (E)

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY

Contents

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Foreword

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Octave-band and one-third-octave-band filters

1 Scope

1.1 This Recommendation deals with sets of octave-band and one-third-octave-band filters (filter sets), i.e. devices capable of providing, or designed for operation with devices capable of providing, time-average levels of frequency-band-filtered spectral information for a wide variety of signals, for example, time-varying, intermittent, and steady; broadband and discrete frequency; and long and short durations. The Recommendation contains an appropriate test scheme for pattern evaluation and verification and a test report format for pattern evaluation.

1.2 Devices to which the requirements of this Recommendation apply include bandpass filter sets that are integral components of a measurement system or specific instrument. The requirements apply to filter sets that operate in real time over the complete frequency range of the system or instrument, or over a portion of the frequency range.

2 Construction and maximum permissible errors (mpe)

2.1 Filter sets which are submitted to the control of legal metrology services shall comply with the requirements formulated in the International Standard of the International Electrotechnical Commission, "*Electroacoustics - Octave-band and fractional-octave-band filters*", IEC 61260, first edition 1995.

The filters shall conform to the tolerances stated in IEC 61260:1995 which are considered as the maximum permissible errors on pattern evaluation, initial and subsequent verification.

The filter classes covered are the same as class 0 and class 1 in IEC 61260:1995.

Note: For editorial reasons, terms such as "maximum permissible value" are used instead of "maximum permissible error" in some parts of Annex B.

2.2 When different values for mpes in service and on verification are prescribed by national regulations, the values of the mpes in service shall be equal to 1.25 times those fixed for verification, expressed in decibels and rounded up to the next full tenth of a decibel.

Note: Mpes in service are the extreme values of the error (positive and negative) permitted by the legal requirements for a measuring instrument when it is in service.

Reasons for the prescription of different values for mpes in service and on verification might be the long-term stability of the instrument under test, unfavorable environmental in-service conditions, etc.

2.3 The characteristics to be examined for pattern evaluation and verification are listed in Annex A.

2.4 A test report format for pattern evaluation is given in Annex B.

2.5 Laboratories may use their own form of report for periodic verification.

3 Stability

The materials used in the construction of the filters shall ensure sufficient stability to enable the instrument to conform to the specifications given in IEC 61260 when the device is set up in accordance with the manufacturer's instruction manual.

4 Markings and instruction manual

4.1 Devices shall clearly and indelibly bear the following markings:

a) Manufacturer's or supplier's name or trade mark;

b) Supplier's model designation and serial number;

c) Reference to IEC 61260 by marking "IEC 61260:1995" (or equivalent national standard);

d) Filter class; and

e) The pattern approval sign in conformity with national regulations, if the device is submitted for verification.

4.2 Each device shall be accompanied by an instruction manual which shall include all the information listed in clause 7 of IEC 61260:1995.

4.3 Accessories which are part of the main instrument shall be unambiguously identifiable by a list affixed to the instrument, or in an attached document or in any other appropriate manner.

5 Marks

It shall be possible to protect, by means of seals or marks, the parts and components of devices that are not intended to be user accessible.

A suitable place for the application of verification marks shall be provided.

Annex A

Extent of the procedures for pattern evaluation and verification of octave-band and one-third-octave-band filters

(Mandatory)

Preferably at least two specimens of the same pattern should be submitted for pattern evaluation.

	Characteristics of filters (Corresponding clauses of IEC 61260:1995 in parentheses)	Pattern evaluation	Verification
a) Electrical properties			
A.1	Relative attenuation (4.4, 5.3)	×	× [a] (for selected groups of filters at selected test frequencies)
A.2	Filter integrated response (4.5, 5.3.3, 5.4)	×	
A.3	Linear operating range (4.6, 5.5)	×	×
A.4	Real-time operation (4.7, 5.6)	×	
A.5	Anti-alias filters (4.8, 5.7)	×	
A.6	Summation of output signals (4.9, 5.8)	×	× [b]
A.7	Flat frequency response (4.10, 5.9)	×	×
A.8	Battery power supply (4.15)	×	
b) Sensitivity to environmental influences			
A.9	Temperature (4.14.1, 5.10)	×	
A.10	Relative humidity (4.14.2, 5.10)	×	

[a] For filters based on analog implementation, every octave-band and one-third-octave-band filter has to be tested.

[b] Tests are only required for filters based on analog implementation and for selected groups of filters.

Annex B

Test report format

(Mandatory for application within the *OIML Certificate System*)

This *Test report format* presents, in a standardized way, the results of the various tests and examinations to which a pattern of an octave-band or one-third-octave-band filter shall be submitted when being considered for approval. These tests are listed in Annex A to this Recommendation.

In the case of the application of this Recommendation:

- to the *OIML Certificate System for Measuring Instruments*, **use of this *Test report format* is mandatory**.
- in national regulations (and in other cases), **use of this *Test report format* is informative**. However, in this case:
  - it is **strongly recommended** that all metrology services or laboratories evaluating patterns of octave-band or one-third-octave-band filters according to national regulations based on this Recommendation should use this *Test report format* directly, or after translation into a language other than English or French;
  - it is **even more strongly recommended** that this *Test report format* is used directly in English or French, or in both languages, whenever test results may be transmitted by the country performing these tests to the approval authorities of another country, for example under bi- or multi-lateral cooperation agreements.

Explanatory notes

Meaning of symbols and expressions used in the tables:

+	Pass*
–	Fail*
n/a	Not applicable
mpe	Maximum permissible error as specified in clause 2 of this Recommendation (mpe values are ± if not indicated otherwise)

The "Summary of the tests" and the tables on "Markings and instruction manual" shall be completed according to this example:

+	–	
X		Pass
	X	Fail
n/a	n/a	Not applicable

"Date" in the test report refers to the date on which the test was performed.

Note concerning page numbering in this publication

In addition to the sequential numbering at the bottom of each page, a space has been left at the top of each page (starting on page 8) for numbering the report pages established following this model. In particular, some tests shall be repeated several times, each test being reported individually on a separate page following the relevant format. For a given report, it is advisable to complete the sequential numbering of each page by indicating the total number of pages in the report.

**Note:* "Pass" and "Fail" have the same meaning as "Approved" and "Not approved" respectively as used in previous Recommendations developed by OIML TC 13 (e.g. R 122 Annex C, R 58, R 88, etc.)

Application no.: ..... Date: .....

TEST REPORT

General information concerning the pattern

Manufacturer: .....

Supplier: .....

Applicant: .....

Model: ..... Serial number: .....

Software version, if applicable: .....

Filter class (specified in the instruction manual): .....

Filter design implementation: ☐ digital ☐ analogue

Sampling frequency (or frequencies): ..... Hz

Filter design-realization method: ..... (e.g. finite impulse response, elliptic, Chebyshev or Butterworth)

Reference attenuation: ..... dB

Reference level range: from ..... dB to ..... dB

Reference for levels in decibels: ..... (e.g. 20 µPa or 1 µV)

Octave frequency ratio for filter design, G: ☐ $10^{3/10}$ ☐ 2

Reference input signal level on reference level range for flat frequency response: ..... dB

Frequency range for flat frequency response: from ..... Hz to ..... Hz

Number of analysis channels: .....

For each nominal filter bandwidth provided, range of nominal midband frequencies for real-time operation: from ..... Hz to ..... Hz

Temperature range: from ..... °C to ..... °C

Relative humidity (RH) range for continuous operation: from ..... % to ..... %

Batteries (if applicable): Type ..... Nominal voltage ..... V Required number .....

Designations of the filter(s) in accordance with IEC 61260:1995

Filter designation	Nominal midband frequency, Hz	
	from	to
Octave		
One-third-octave		

Nominal lower and upper boundaries of the linear operating ranges and corresponding maximum root-mean-square sinusoidal input voltages

Level range control setting dB	Level range dB		Maximum root-mean-square sinusoidal input voltage V
	Nominal lower boundary	Nominal upper boundary	

The above table is to be extended for all level ranges provided in the device and for different bandwidths and midband frequencies as stated in the instruction manual.

Note: The above level range and input voltage data apply for nominal filter bandwidths of ..... and nominal midband frequencies from ..... Hz to ..... Hz.

Summary of the tests

Clause	Test	+	–	Remarks	Page number in test report
(a) Electrical properties					
B.1	Relative attenuation				
B.2	Filter integrated response				
B.3	Linear operating range				
B.4	Real-time operation				
B.5	Anti-alias filter				
B.6	Summation of output signals				
B.7	Flat frequency response				
B.8	Battery power supply				
(b) Sensitivity to environmental influences					
B.9	Temperature				
B.10	Relative humidity				
(c) Markings and instruction manual					
B.11	Inscriptions and markings				
B.12	Instruction manual				

(a) Electrical properties

B.1 Relative attenuation (IEC 61260:1995, 4.4, 5.3)

Reference attenuation (IEC 61260:1995, 4.3): ..... dB
(Specified by the manufacturer)

Input test signal rms voltage for testing on reference level range: V

Input and output terminating impedances to be noted (if applicable): ..... Ω

Filter class: ..... Nominal midband frequency: ..... Hz

Bandwidth designator, 1/*b*: .....

Analysis channel number(s): .....

Upper boundary of the reference level range: ..... dB
(as determined from linearity tests in B.3)

Number of test-signal frequencies, *S*, per filter bandwidth: .....

Averaging times for measurements of signal levels: ..... s

Normalized frequency $f/f_m = \Omega$	Measured relative attenuation (Filter attenuation minus reference attenuation) dB	Minimum permissible relative attenuation dB	Maximum permissible relative attenuation dB	Result	
				+	–

The above table is repeated for each filter in each filter set, and should be extended to accommodate all test frequencies. Normalized frequencies as well as minimum and maximum permissible attenuations are calculated according to equations (10) to (12) of IEC 61260:1995.

Note: If the device under test has both a visual readout indicator and an accessible voltage or signal output, the test may be confined to the voltage or signal output, if verified that this voltage or signal output is equivalent to the readout displayed.

Comments: .....
.....
.....
.....

B.2 Filter integrated response (IEC 61260:1995, 4.5, 5.3.3, 5.4)

For a bandpass filter, filter integrated response ΔB in decibels, shall be determined from:

$$\Delta B = 10 \lg(B_e / B_r) \tag{1}$$

where:

B_e is the normalized effective bandwidth;
B_r is the normalized reference bandwidth from IEC 61260:1995 equation (9) for the same midband frequency.

For any filter of exact midband frequency f_m, normalized effective bandwidth is represented by:

$$B_e = \int_0^\infty 10^{-0.1\,\Delta A(f/f_m)}\, d(f/f_m) \tag{2}$$

where $\Delta A(f/f_m)$ is the continuous relative-attenuation filter response, in decibels. In practice, the integral in equation (2) is evaluated numerically; see 5.4 of IEC 61260:1995.

For each filter in a filter set, the recommended procedure for numerical integration of equation (2) is by the trapezoidal rule for summation of elemental areas according to

$$B_e = \sum_{i=-N}^{i=N} \frac{1}{2}\left\{ 10^{-0.1\,\Delta A(f_i/f_m)} + 10^{-0.1\,\Delta A(f_{i+1}/f_m)} \right\} \left[(f_{i+1}/f_m) - (f_i/f_m) \right] \tag{3}$$

where:

$\Delta A(f_i/f_m)$ is the relative attenuation in decibels measured at the i^{th} normalized test frequency as given in the tabulated data noted in B.1;

N shall be equal to or greater than $5S = 120$ for any filter bandwidth and filter class;

S is the number of test-signal frequencies per filter bandwidth.

Application no.: ..... Date: .....

Bandwidth designator, 1/*b*: .....

Nominal midband frequency, f_{nom}	Filter integrated response* ΔB	Maximum permissible value dB		Result	
Hz	dB	Class 0	Class 1	+	–
		± 0.15	± 0.3		
		± 0.15	± 0.3		
		± 0.15	± 0.3		

* Based on results collected in the table in subclause B.1

The above table is repeated for each filter bandwidth designator available in the device under test.

Comments: .....
.....
.....
.....

B.3 Linear operating range (IEC 61260:1995, 4.6, 5.5)

Note: Level linearity tests should be performed before measurements of relative attenuation. Errors caused by level nonlinearities could be misinterpreted as errors in relative attenuation and, hence, an error in filter integrated response.

Bandwidth designator, 1/*b*: .....

Level range overlap (if applicable): ..... dB ..... (+/-) (See 4.6.2, IEC 61260:1995)

Manufacturer specified max. input voltage: V

Averaging time: ..... s

Reference level difference: ..... dB

Input signals: ☐ discrete-frequency sinusoids ☐ combination of sinusoidal signals as recommended in the instruction manual (see 5.5.4 of IEC 61260:1995)

Nominal midband frequency, f_{nom}: ..... Hz

Level range measured: from ..... dB to ..... dB

Nominal attenuation of level range control: ..... dB

Additional settings: .....

Input signal level	Measured output signal level	Level difference	Level linearity error	Maximum permissible value dB		Result	
dB	dB	dB	dB	Class 0	Class 1	+	–
				± 0.3	± 0.4		
				± 0.3	± 0.4		
				± 0.3	± 0.4		
				± 0.3	± 0.4		
				± 0.3	± 0.4		

The above table is repeated for at least the lowest and highest nominal midband frequencies (required in 5.5.1 of IEC 61260:1995) of the applicable octave-band and one-third-octave-band filters for all level ranges available in the device. If flat frequency response is provided, the above table is repeated for at least the lowest and highest frequencies (required in 5.5.1 of IEC 61260:1995) of the range of flat frequency listed in "General information" (as indicated by the manufacturer). Depending on the linear operating range, the tables may have to be extended by 20 lines.

Comments: .....
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.....
.....

B.4 Real-time operation (IEC 61260:1995, 4.7, 5.6)

For each filter bandwidth available, the range of nominal midband frequencies over which the filters in the filter set operate in real time shall be determined from a sweep of a constant-amplitude sinusoidal signal, the logarithm of the frequency of which is varied at a constant rate.

Filter class: .....

Bandwidth designator, 1/*b*: .....

Input signal level, L_{in}: ..... dB

Reference attenuation, A_{ref}: ..... dB

Sweep frequency range: f_{start}: ..... Hz f_{end}: ..... Hz

Sweep time, T_{sweep}: ..... s

Averaging time, T_{avg}: ..... s

Theoretical output time-averaged signal level, L_c: ..... dB

The difference, δ, between a measured output time-average signal level, L_o, and the corresponding constant theoretical output time-average signal level, L_c, and the measured filter integrated response, ΔB, is given by:

$$\delta = L_o - \Delta B - L_c \qquad (4)$$

Nominal midband frequency, f_{nom} Hz	Measured level, L_o dB	Measured filter integrated response, ΔB dB	Difference, δ dB	Maximum permissible value dB	Result	
					+	–
				± 0.3		
				± 0.3		
				± 0.3		
				± 0.3		

Depending on the synchronization between the operation of the filters, some non-real-time filters may respond correctly on the sweep test. It may, therefore, be necessary to repeat the above tests up to a maximum of three times to establish real-time operation.

Note: Any one of the tests failing the requirements may be considered as evidence of non-real-time operation. In a multi-channel device, testing shall be performed for the condition in which all channels of the device are operating simultaneously and measurements will be performed on at least one channel.

Range of nominal midband frequencies for real-time operation: from ..... Hz to ..... Hz

Comments: .....
.....
.....
.....

B.5 Anti-alias filter (IEC 61260:1995, 4.8, 5.7)

Filter class: .....

Bandwidth designator, 1/*b*: .....

Level of input signal at upper boundary for the linear operating range on reference level range, L_i: ..... dB

Nominal midband frequency, f_{nom} Hz	Sampling frequency, f_s Hz	Test signal frequency, $f_s - f_{nom}$ Hz	Measured output signal level, L_o dB	$L_o - (L_i - \Delta)$ (see note) dB	Result	
					+	–

The above table is repeated for octave-band and one-third-octave-band filters as applicable. Each table shall contain at least the number of nominal midband frequencies specified in 5.7.2 of IEC 61260:1995.

Note: Δ is the greatest value of the minimum relative attenuation from Table 1, IEC 61260:1995

Comments: .....
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.....
.....

B.6 Summation of output signals (IEC 61260:1995, 4.9, 5.8)

Filter class: .....

Bandwidth designator, 1/*b*: .....

At any frequency between the lower and upper bandedge frequencies of the j^{th} filter with exact midband frequency f_m, the difference $\Delta P(f_i)$ in decibels between the level of the input signal minus the reference attenuation and the level of the summed output signals is determined from the relationship:

$$\Delta P(f_i) = 10 \lg \left[10^{-0.1 \Delta A_{j-1}} + 10^{-0.1 \Delta A_j} + 10^{-0.1 \Delta A_{j+1}} \right] \quad (5)$$

where:

ΔA_{j-1} is the relative attenuation measured at normalized frequency $G^{[i/(bS)+1/b]}$;

ΔA_j is the relative attenuation measured at normalized frequency $G^{[i/(bS)]}$; and

ΔA_{j+1} is the relative attenuation measured at normalized frequency $G^{[i/(bS)-1/b]}$.

Number of test-signal frequencies within the passband, *S*: .....

Exact midband frequency of filter, *j*: ..... Hz
(Exact midband frequencies are calculated by means of equation (3) in 3.5 of IEC 61260:1995).

Index, *x*, for identifying the bandpass filter: .....

Application no.: ..... Date: .....

Test signal frequency, f_i Hz	Relative attenuation at f_i, dB			$\Delta P(f_i)$ dB	Maximum permissible value dB		Result	
	Filter $(j-1)$ ΔA_{j-1}	Filter (j) ΔA_j	Filter $(j+1)$ ΔA_{j+1}		Class 0	Class 1	+	–
					± 1	+ 1 – 2		
					± 1	+ 1 – 2		
					± 1	+ 1 – 2		
					± 1	+ 1 – 2		

The above table is to be repeated for each octave-band and one-third-band-octave-band filter in the filter set.

Note: The above test signal frequencies and the corresponding relative attenuations can be taken from the measurements of relative attenuation in B.1.

Comments: .....
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.....
.....

B.7 Flat frequency response (IEC 61260:1995, 4.10, 5.9)

Filter class: .....

Reference input signal level for the reference level range (re .....): ..... dB

Output signal level at 1 kHz: ..... dB

Reference level range: from ..... dB to ..... dB

Relative attenuation at reference frequency: ..... dB

Frequency range: from ..... Hz to ..... Hz				
Test frequency[a]	Relative attenuation[a]	Limits on relative attenuation[b]	Result	
Hz	dB	dB	+	–

[a] Refers to 5.9, IEC 61260:1995
[b] Refers to 4.10, IEC 61260:1995

Maximum input signal (IEC 61260:1995, 4.11)

Manufacturer specified maximum rms input voltage: V

Comments: .....
.....
.....
.....

B.8 Battery power supply (IEC 61260:1995, 4.15)

For devices that require a battery power supply, the manufacturer shall provide a suitable means to check that the power supply is adequate, at the time of checking, to operate the device according to all the requirements of IEC 61260:1995. The test method is to be described in this test report. (See 7(s) in IEC 61260:1995).

The device conforms to the specifications of IEC 61260:1995 when the battery voltage low indication is not activated for the test described:

Result	
+	–

Comments: .....
.....
.....
.....

(b) Sensitivity to environmental influences

B.9 Temperature (IEC 61260:1995, 4.14.1 and 5.10)

Filter class: ..... Bandwidth designator, 1/*b*:.....

Reference input signal level on the reference level range (re .....): ..... dB

Reference attenuation in the passband of all filters in all filter sets: ..... dB

Nominal midband frequency, f_{nom}	I Relative attenuation under reference environmental conditions	II Measured relative attenuation over the minimum temperature range, at RH 65 % ± 5 % dB						
Hz	dB		0 °C	10 °C	20 °C	30 °C	40 °C	50 °C

Nominal midband frequency, f_{nom}	I - II (from the table above) dB							Maximum permissible value dB		Result	
Hz		0 °C	10 °C	20 °C	30 °C	40 °C	50 °C	Class 0	Class 1	+	–
								± 0.15	± 0.3		
								± 0.15	± 0.3		
								± 0.15	± 0.3		

Time required to reach equilibrium with the prevailing conditions at each temperature: ..... s

Notes: 1 The temperature range may be extended for filters that are incorporated in sound level meters. If tested in an extended range, failure of the filter set to meet the required maximum permissible errors does not constitute a failure of the pattern evaluation.
Testing at 23 °C and 50 % relative humidity (RH) is also recommended.

2 Tests should be performed at least for the lowest and highest nominal midband frequencies of all octave-band and one-third-octave-band filters available in the device.

Comments: .....
.....
.....
.....

B.10 Relative humidity (IEC 61260:1995, 4.14.2, 5.10)

Filter class: ..... Bandwidth designator, 1/*b*: .....

Reference input signal level on the reference level range (re .....): ..... dB

Range of relative humidity (RH) for continuous operation: from ..... % to ..... %

Reference attenuation in the passband of all filters in all filter sets: ..... dB

Nominal midband frequency, f_{nom} Hz	I Relative attenuation under reference environmental conditions dB	II Measured relative attenuation at RH 75 % and 40 °C* dB

* After 24 hours exposure at RH 75 %

Nominal midband frequency, f_{nom}	II - I (from the table above)	Maximum permissible value dB		Result	
Hz	dB	Class 0	Class 1	+	–
		± 0.15	± 0.3		
		± 0.15	± 0.3		
		± 0.15	± 0.3		

Note: Tests should be performed at least for the lowest and highest nominal midband frequencies of all octave-band and one-third-octave-band filters available in the device.

Comments: .....
.....
.....
.....

(c) Markings and instruction manual

B.11 Inscriptions and markings

Requirement as specified in OIML R 130, subclause	Inscriptions and markings	+	−	Remarks
4.1 (a)	Manufacturer's or supplier's name or trademark			
4.1 (b)	Model designation and serial number			
4.1 (c)	Marking IEC 61260:1995			
4.1 (d)	Class			
4.3	List of accessories, where appropriate			
5	Seal or marks to protect			
5	Place for verification mark			

Comments: .....
.....
.....
.....

B.12 Instruction manual (IEC 61260:1995, 7)

Subclause of IEC 61260:1995 containing requirement	**Information**	+	–	Remarks
7(a)	Statement of conformance of all filter bandwidths			
7(b)	Analytical method of implementation			
7(c)	Sampling frequencies			
7(d)	List of nominal midband frequencies and bandwidths for all analysis channels			
7(e)	Base-ten or base-two system			
7(f)	Reference level range			
7(g)	Reference input signal level			
7(h)	Reference attenuation			
7(i)	Lower and upper boundaries of linear operating ranges and tolerances maintained outside ranges			
7(j)	Recommendations on operation of the device to ensure the measurements are made within the linear operating range			
7(k)	Ranges of nominal midband frequencies and other relevant information for real-time operation			
7(l)	Frequency range for flat response if applicable			
7(m)	Maximum rms sinusoidal input voltage for each level range			
7(n)	Terminating impedance information			
7(o)	Temperature and exposure time limits			
7(p)	Operational limitations in proximity of alternating magnetic fields			
7(q)	Operational limitations in proximity of electrostatic discharge			
7(r)	Operational limitation for radio frequency electromagnetic fields			
7(s)	Recommended means to check battery, if appropriate			
7(t)	Information for operation with sound level meters, if appropriate			
7(u)	Warm-up period			
7(v)	Any additional pertinent information			