International Standard

ISO/IEC 18181-3

Second edition
2025-01

Information technology — JPEG XL image coding system —

Part 3: Conformance testing

Technologies de l'information — Système de codage d'images JPEG XL —

Partie 3: Essai de conformité

Reference number
ISO/IEC 18181-3:2025(en)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ..... **iv**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Testing procedures **1**
5 Decoder conformance **2**
6 Encoder conformance **2**
Annex A (normative) **Core conformance** **3**
Annex B (normative) **Extended conformance** **5**
Annex C (informative) **Description of the test corpora** **7**
Bibliography **9**

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

ISO and IEC draw attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO and IEC take no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO and IEC had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents and https://patents.iec.ch. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

This second edition cancels and replaces the first edition (ISO/IEC 18181-3:2022), which has been technically revised.

The main changes are as follows:

— Decoder conformance was separated into core conformance and extended conformance;

— Test cases were updated to reflect the second editions of ISO/IEC 18181-1 and ISO/IEC 18181-2;

— References were updated accordingly.

A list of all parts in the ISO/IEC 18181 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Information technology — JPEG XL image coding system —

Part 3: Conformance testing

1 Scope

This document specifies the conformance testing of the ISO/IEC 18181 series, also known as JPEG XL.

NOTE Other desirable aspects of implementation (including robustness and performance) are outside the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 18181-1:2024, *Information technology — JPEG XL image coding system — Part 1: Core coding system*

ISO/IEC 18181-2:2024, *Information technology — JPEG XL image coding system — Part 2: File format*

ISO 15076-1[1)], *Image technology colour management — Architecture, profile format and data structure — Part 2: Based on ICC.1:2022*

ISO/IEC 60559, *Information technology — Microprocessor Systems — Floating-Point arithmetic*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
core conformance
producing decoded samples within the specified tolerances

3.2
extended conformance
conforming to all the testing procedures, including those related to metadata and JPEG bitstream reconstruction

4 Testing procedures

A set of test cases is defined in this document. Each test case consists of a JPEG XL bitstream, a reference decoded image, and possibly additional tests. For each test case, core conformance tests (as defined in Annex A) establish precision tolerances on the decoded samples, as compared to a reference image.

1) Under development. Stage at the time of publication: ISO/DIS 15076-1:2024.

Extended conformance tests (as defined in Annex B) include additional decoder functionality such as extraction of metadata and JPEG-1 bitstream reconstruction.

The electronic attachments (https://standards.iso.org/iso-iec/18181/-3/ed-2/en/) of this document consist of a `testcases/` subdirectory, containing multiple subdirectories, each of which contains a single test case for conformance testing.

5 Decoder conformance

A decoder shall be considered conforming to Level 5 of the Main profile if it is conforming to all the test cases specified in the `testcases/main_level5.txt` file in the electronic attachment to this document.

A decoder shall be considered conforming to Level 10 of the Main profile if it is conforming to all the test cases specified in the `testcases/main_level10.txt` file in the electronic attachment to this document.

The tests described in this document are necessary, but not sufficient to determine complete decoder conformance to all aspects of the ISO/IEC 18181-1 and ISO/IEC 18181-2 specifications.

For core conformance, all test cases shall pass the tests described in Annex A.

NOTE 1 Core conformance to Level 5 of the Main profile suffices to implement an application that can correctly and accurately render RGB or greyscale JPEG XL images intended for end-user image delivery. In order to facilitate testing, decoders can generate NPY files as described in Annex A.2. If implementations do not directly support this output format, generating such files from the decoder output in a sample value preserving postprocessing step is sufficient to pass the conformance tests. For example, if the decoder produces a (possibly animated) PNG file (with a sufficiently high bit depth), this still suffices to test core conformance. However, for testing core conformance to Level 10 of the Main profile, PNG output does not suffice since it is limited to 16-bit precision.

For extended conformance, all test cases shall pass both the tests described in Annex A and in Annex B.

NOTE 2 The extended conformance tests assess functionality that is not necessary for displaying an image, but that is nevertheless useful for authoring or archival purposes.

6 Encoder conformance

As specified in ISO/IEC 18181-1:2024, any encoding process is acceptable so long as it produces a valid codestream. Thus, an encoder shall be considered conforming if it produces output files which are successfully decoded by a conforming decoder as described in Clause 5. More precisely, the steps for testing encoder conformance are as follows:

a) Select a test image that represents the type of imagery that the encoder is designed to compress. The reference decoded images provided for decoder conformance tests are acceptable but not required.

b) Encode with the encoder under test.

c) Send the codestream to the reference decoder.

d) An encoder is found to be conforming if a conforming decoder can fully decode the image.

e) Repeat steps a) through d) for all parameters for which the encoder is designed. These parameters should be varied to the extent to which the encoder will be used.

f) Repeat steps a) through e) for several test images, sampling the breadth of imagery types (small image size, large image size, odd image sizes, number of components, component bit depths, component sampling) the encoder is designed to compress.

The above procedure provides a necessary, but not sufficient criterion to determine complete encoder conformance to all aspects of the ISO/IEC 18181-1 and ISO/IEC 18181-2 specifications.

Annex A
(normative)

Core conformance

A.1 Test case structure

Each test case subdirectory contains

— a JSON file (ISO/IEC 21778) named `test.json`

— a JPEG XL file (ISO/IEC 18181-2:2024) named `input.jxl`

— a NPY file (A.2) named `reference_image.npy`

— an ICC profile file named `reference.icc`. The contents of this file shall be conformant to ISO 15076-1.

Collectively, the NPY and ICC file are known as the reference image for that test case.

The JSON file specifies the tests to be performed as part of this test case.

The NPY file contains sample values for the image frames, represented as a four-dimensional array with dimensions (`num_frames`, `height`, `width`, `num_channels`) respectively. The data format stored in these arrays 32-bit float and shall be conformant to ISO/IEC 60559.

`reference.icc` represents the colour space of the data in the NPY file.

A.2 Numpy file format

A NPY file begins with the sequence of bytes `0x93 0x4e 0x55 0x4d 0x50 0x59` (byte 93 followed by `NUMPY` in ASCII), followed by the sequence of bytes `0x01 0x00`, followed by two bytes representing a 16-bit little-endian integer LEN that represents the length of the rest of the header.

The rest of the header contains the newline-terminated ASCII (ISO/IEC 646) string `{'descr': '<f4', 'fortran_order': False, 'shape': (X, Y, Z, W), }`, where X, Y, Z, W represent integers in their usual base-10 textual representation.

The NPY file represents an array with dimensions (X, Y, Z, W). The rest of the file contains X x Y x Z x W 32-bit floating point numbers as specified in ISO/IEC 60559, with little endian byte ordering, in raster order with the W dimension varying faster, i.e. floating point number in position (x, y, z, w) is stored in the 4 bytes starting at position 4·(x·Y·Z·W + y·Z·W + z·W + w) after the header.

A.3 Image similarity

Samples are compared in the colour space specified by the reference ICC profile `reference.icc`, with nominal values in the interval [0, 1]. For core conformance, clamping is to be applied to values outside this range, in both the decoded and in the reference image. For extended conformance, no such clamping is to be applied.

An image is similar to the reference image if and only if the following three conditions are met:

— The image dimensions $W \times H$, number of frames and number of channels are identical. A decoded sample at position (x, y) of channel c of frame f is denoted by $D(f, c, x, y)$; the corresponding reference sample is denoted by $R(f, c, x, y)$;

— The peak error is bounded: for each frame f and each channel c, the maximum absolute error $max_{x=0}^{W-1} max_{y=0}^{H-1} |D(f,c,x,y) - R(f,c,x,y)|$ is smaller or equal to a given threshold;

— The root mean square error is bounded: for each frame f and each channel c, the value of $\sqrt{\frac{1}{WH}\sum_{x=0}^{W-1}\sum_{y=0}^{H-1}(D(f,c,x,y)-R(f,c,x,y))^2}$ is smaller or equal to a given threshold.

For the purposes of this comparison, the channels are assumed to be ordered as follows (for color images): the first three channels are the RGB channels (in the order R, G, B); then, channel 3+i is the i-th extra channel (see `metadata.ec_info`, ISO/IEC 18181-1:2024, Annex D.3.1). In the case of greyscale images, there is only a single channel.

A.4 Conformance on a single test case

The JSON file for a given test case represents the test configuration for that test case.

The JSON file represents this configuration using a key-value format, where keys are strings and values are strings, numbers, arrays or nested key-value pairs.

For core conformance, only the `frames` key matters. Its value is an array of per-frame criteria. The array length equals the number of frames in `reference_image.npy`. For each array entry, conformance is tested by checking similarity of the i-th decoded frame with the i-th frame in `reference_image.npy`. For the purposes of this document, the i-th decoded frame is defined to be the i-th frame with a FrameType of either **kRegular** or **kSkipProgressive** and either a non-zero duration or `is_last` set to true, after any blending and orientation is applied. This corresponds to frames that are meant to be displayed to the end user.

If the total number of decoded frames is not equal to the length of the array, the decoder is non-conforming. The keys in the i-th entry of the array influence conformance testing at follows:

— The key `rms_error` specifies the threshold for the root mean square error of any channel.

— The key `peak_error` specifies the threshold for the peak error of any channel.

NOTE The JPEG XL codestream (ISO/IEC 18181-1:2024) is specified in infinite-precision, mathematical arithmetic. Practical implementations are likely to use finite-precision arithmetic that only approximates of the specified computations. In order to give implementations sufficient freedom for alternative implementation strategies, while also requiring a sufficiently precise image reconstruction (depending on the profile and level), image similarity is defined in terms of tolerances for the decoded samples. For some test cases, mathematically lossless reconstruction is in fact required since they have a peak error bound that is lower than the integer quantization step.

Annex B
(normative)

Extended conformance

Besides the files mentioned in Annex A, each test case subdirectory can additionally contain

— a NPY file named `reference_preview.npy`

— an ICC profile file `original.icc`

— a JPEG-1 file named `reconstructed.jpeg`

`original.icc` represents the ICC profile of the samples that were used to create the JPEG XL file; this is metadata that may be present in the JPEG XL file.

`reconstructed.jpg` contains the original JPEG-1 file that was losslessly recompressed to a JPEG XL file containing a `jbrd` box.

Besides the per-frame error thresholds for core conformance (Annex A), the JSON file `test.json` contains additional test criteria that apply only to extended conformance.

In the array `frames`, the following per-frame information shall match the output of the decoder:

— The value of the key `name`, if present, is a UTF-8 encoded string that specifies the name of the frame (`frame_header.name` in ISO/IEC 18181-1:2024, Annex F.2). If it differs in either content or length from the decoded value, the decoder is not conformant.

— The value of the key `duration`, if present, specifies the amount of time (in seconds) that the frame should be displayed for (`frame_header.duration` in ISO/IEC 18181-1:2024, Annex F.2). The decoder is not conformant if this duration differs from the duration reported by the decoder by more than 0.0001 seconds.

— The value of the key `timecode`, if present, is an integer that specifies the timecode of the frame (`frame_header.timecode` in ISO/IEC 18181-1:2024, Annex F.2). If it differs from the decoded value, the decoder is not conformant.

If the `preview` key is present, its corresponding value is a single instance of the per-frame information that is used for the "frames" key. It is to be interpreted in the same way, except that it refers to the `reference_preview.npy` file and the decoded preview image (`preview_frame` in ISO/IEC 18181-1:2024, Annex A.1).

If the `original_icc` key is present, the file `original.icc` shall be compared to the original ICC profile reconstructed by the decoder. The decoder is not conformant if it reports that the original ICC profile of the samples represented by the JPEG XL file (`icc` in ISO/IEC 18181-1:2024, Annex A.1) differs from the file `original.icc`, either in length or in contents.

If the `reconstructed_jpeg` key is present, the file `reconstructed.jpg` shall be compared to the JPEG-1 file reconstructed by the decoder, according to the procedure described in Annex A of ISO/IEC 18181-2:2024 The decoder is not conformant if the reconstructed JPEG-1 file differs from `reconstructed.jpg`, either in length or in contents.

If the `intensity_target` key is present, its value is a number that defines the intensity target of the decoded image (Table E.3 in ISO/IEC 18181-1:2024). If the decoded value differs by more than 0.0001, the decoder is not conformant. The `min_nits`, `relative_to_max_display` and `linear_below` keys are defined in a similar way.

If the `extra_channel_type` key is present, its value is an array of strings that has a length of `num_extra` (i.e. equal to the number of extra channels). The i-th entry of the array corresponds to the `type` value of the

ExtraChannelInfo bundle corresponding to that extra channel (`ec_info[i].type` in ISO/IEC 18181-1:2024). If any of those values differs from the decoded ones, the decoder is not conformant.

If the `bits_per_channel` key is present, its value is an array of integers representing the original bit depth. Its length is `num_channels - 2`; the first value corresponds to the bits per sample value of the color channels (`headers.bit_depth.bits_per_sample` in ISO/IEC 18181-1:2024), and the other values correspond to the bits per sample of the extra channels (`ec_info[i].bit_depth.bits_per_sample` in ISO/IEC 18181-1:2024). If the `exp_bits_per_channel` key is present, its value is an array of integers. Its length is `num_channels - 2`; the first value corresponds to the `bit_depth.exp_bits` value of the color channels and the other values correspond to the `ec_info[i].bit_depth.exp_bits` value of the extra channels.

Annex C
(informative)

Description of the test corpora

Table C.1 describes what combinations of coding tools and peak/mean error values are found in each of the test corpora. Coding tools and values are considered on a per-channel basis; for example, in the Level 5 test corpus it is possible to find an image with the three colour channel encoded with VarDCT and a peak/average error bound of 0.06 and 0.02, plus one extra channel encoded with 8-bit Modular (with no filters) and a peak/average error bound of 1/210.

In this table, "no filters" means that all the coding tools from Annexes J and K, in ISO/IEC 18181-1:2024 are not enabled for that channel. In contrast, "with filters" means that some of those tools are enabled. An X is present in the "Level 5"/ "Level 10" columns if images with this configuration can be found in the corresponding corpora.

Table C.1 — Summary of typical thresholds in the test corpora

	Level 5	Level 10	Peak error	RMSE
VarDCT, Modular with filters	X	X	0.06	0.02
VarDCT, Modular no filters	X	X	0.06	0.02
VarDCT, Modular with filters		X	0.004	$1/10^4$
VarDCT with no filters		X	0.004	$1/10^5$
Modular 8-bit, no filters, RGB	X	X	$1/2^{10}$	$1/2^{10}$
Modular 10-bit, no filters, RGB	X	X	$1/2^{12}$	$1/2^{12}$
Modular 12-bit, no filters, RGB	X	X	$1/2^{14}$	$1/2^{14}$
Modular 16-bit, no filters, RGB		X	$1/2^{18}$	$1/2^{18}$

Table C.2 lists the test cases and the relevant coding tools that are tested with them. The `main_level5.txt` file contains all the test cases that are indicated to be level 5 in the rightmost column; the `main_level10.txt` file contains all the test cases.

Table C.2 — Summary of test cases and relevant coding tools

test case	what it tests	level
`alpha_nonpremultiplied`	Modular mode, alpha channel, 12-bit	5
`alpha_premultiplied`	VarDCT mode, premultiplied alpha channel, 12-bit color, 16-bit alpha	10
`alpha_triangles`	Modular mode, alpha channel, 9-bit	5
`animation_icos4D`	VarDCT mode, alpha channel, animation	5
`animation_newtons_cradle`	Modular mode, Palette, animation	5
`animation_spline`	Splines, animation	5
`bench_oriented_brg`	Container, VarDCT mode, JPEG reconstruction, Orientation, ICC profile	5
`bicycles`	Modular mode, Squeeze, XYB	5
`bike`	VarDCT mode	5
`blendmodes`	Modular mode, various blend modes, 12-bit	5
`cafe`	Container, VarDCT mode, JPEG reconstruction, chroma upsampling	5