



International
Standard

ISO/IEC 23090-15

**Information technology — Coded
representation of immersive media —**

Part 15:

**Conformance testing for versatile
video coding**

*Technologies de l'information — Représentation codée de média
immersifs —*

Partie 15: Essai de conformité pour le codage vidéo polyvalent

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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).

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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*, in collaboration with ITU-T Study Group 16 (as Rec. ITU-T H.266.1).

This second edition cancels and replaces the first edition (ISO/IEC 23090-15:2022), which has been technically revised.

The main changes are as follows:

- addition of bitstreams for the 12-bit and 16-bit profiles that were added in ISO/IEC 23090-3:2022.

A list of all parts in the ISO/IEC 23090 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 — Coded representation of immersive media —

Part 15: Conformance testing for versatile video coding

1 Scope

This document specifies a set of tests and procedures designed to indicate whether encoders or decoders meet the requirements specified in Rec. ITU-T H.266 | ISO/IEC 23090-3.

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.

Rec. ITU-T H.266 | ISO/IEC 23090-3:2022, *Information technology – Coded representation of immersive media – Part 3: Versatile video coding*

Rec. ITU-T H.266.2 | ISO/IEC 23090-16, *Information technology – Coded representation of immersive media – Part 16: Reference software for versatile video coding*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in Rec. ITU-T H.266 | ISO/IEC 23090-3 and the following 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

bitstream

sequence of bits that conforms to specified syntax requirements or sequence of bits to be tested for conformance to such syntax requirements

3.2

decoder

embodiment of a specified decoding process or process to be tested for conformance to such a decoding process specification

3.3

encoder

embodiment of a process that produces a *bitstream* (3.1)

3.4

reference software decoder

particular *decoder* (3.2) provided as a software package for use as an example available for study, as a potential starting basis for the development of other decoders, as a way of testing *bitstreams* (3.1) for conformance to a decoding process specification, or as a reference for comparison with the behaviour of other decoders

3.5

reference software encoder

particular *encoder* (3.3) provided as a software package for use as an example available for study, as a potential starting basis for the development of other encoders, or as a reference for comparison with the behaviour of other encoders

3.6

VVCv1 tools

coding tools included in the Multilayer Main 10 4:4:4 profile of versatile video coding (VVC)

Note 1 to entry: Specified in Rec. ITU-T H.266 | ISO/IEC 23090-3.

3.7

VVCv2 tools

EPP, ERRC, PRRC, ETSRC, and RLSCP coding tools added in the VVC operation range extensions

Note 1 to entry: Specified in Rec. ITU-T H.266 | ISO/IEC 23090-3:2022.

4 Abbreviated terms

AFF	Affine motion model
ALF	Adaptive loop filter
AMVP	Adaptive motion vector prediction
AMVR	Adaptive motion vector resolution
BDOF	Bi-directional optical flow
BCW	Bi-predictive with CU weights
CABAC	context-adaptive binary arithmetic coding
CCALF	Cross-component ALF
CCLM	Cross-component linear model
CIIP	Combined inter/intra prediction
CST	Chroma separate tree
CTC	Common test conditions
DCT	Discrete cosine transform
DMVR	Decoder-side motion vector refinement
DPB	Decoded picture buffer
DQ	Dependent quantization
DST	Discrete sine transform

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EPP	Extended precision processing
ERRC	Extended regular residual coding
ETSRC	Extended transform skip residual coding
FTP	File transfer protocol
GPM	Geometric partitioning mode
IBC	Intra block copy mode
ISP	Intra sub-partitioning
JCCR	Joint coding of chroma residuals
LFNST	Low frequency non-separable transform
LMCS	Luma mapping with chroma scaling
MIP	Matrix based intra prediction
MMVD	Merge with MVD
MPM	Most probable mode
MRL	Multiple reference line
MTS	Multi transform selection
MVCOMP	Motion vector compression
MVD	Motion vector difference
NUT	NAL unit type
PDPC	Position-dependent (intra) prediction combination
PERP	Padded equirectangular projection
PROF	Prediction refinement using optical flow
PRRC	Persistent regular residual coding
RA	Random access
RLSCP	Reversed last significant coefficient position
RPR	Reference picture resampling
RRC	Regular residual coding
SAD	Sum of absolute differences
SAO	Sampled adaptive offset
SBT	Sub-block transform
SCC	Screen content coding
SDH	Sign data hiding

SbTMVP	Sub-block-based temporal motion vector prediction
SMVD	Symmetric MVD
TMVP	Temporal motion vector prediction
VVC	Versatile video coding
WP	Weighted prediction
WPP	Wavefront parallel processing

5 Conventions

The conventions in Clause 5 of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022 apply.

6 Conformance testing for ITU-T H.266 | ISO/IEC 23090-3

6.1 General

The conformance testing data for Rec. ITU-T H.266 | ISO/IEC 23090-3 is available at: <https://standards.iso.org/iso-iec/23090-15/ed-2/en/>

The following subclauses specify normative tests for verifying conformance of video bitstreams as well as decoders. Those normative tests make use of test data (bitstream test suites) provided as an electronic attachment to this document and the reference software decoder specified in Rec. ITU-T H.266.2 | ISO/IEC 23090-16.

6.2 Bitstream conformance

Bitstream conformance for Rec. ITU-T H.266 | ISO/IEC 23090-3 is specified by Clause C.4 of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022.

6.3 Decoder conformance

Decoder conformance for Rec. ITU-T H.266 | ISO/IEC 23090-3 is specified by Clause C.5 of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022.

6.4 Procedure to test bitstreams

A bitstream that is claimed to conform to Rec. ITU-T H.266 | ISO/IEC 23090-3 shall pass the following normative test. This test should not be applied to bitstreams that are known to contain errors introduced by transmission, as such errors are highly likely to result in bitstreams that lack conformance to Rec. ITU-T H.266 | ISO/IEC 23090-3.

The bitstream under test shall be decoded by processing it with the reference software decoder specified in Rec. ITU-T H.266.2 | ISO/IEC 23090-16. When processed by the reference software decoder, the bitstream shall not cause any error or non-conformance messages to be reported by the reference software decoder. When the bitstream under test contains decoded picture hash SEI messages, the hash values signalled in the decoded picture hash SEI messages in the bitstream shall match those calculated by the reference software decoder.

Successfully passing this test provides only a strong presumption that the bitstream under test does indeed meet all the requirements specified in Rec. ITU-T H.266 | ISO/IEC 23090-3 that are tested by the reference software decoder.

Additional tests may be necessary to more thoroughly check that the bitstream properly meets all the requirements specified in Rec. ITU-T H.266 | ISO/IEC 23090-3, including hypothetical reference decoder

(HRD) conformance (based on Annexes C and D). Such complementary tests may be performed using other video bitstream verifiers that perform more complete tests than those implemented by the reference software decoder.

Rec. ITU-T H.266 | ISO/IEC 23090-3 contains several informative recommendations that are not an integral part of that Recommendation | International Standard. When testing a bitstream for conformance, it may also be useful to test whether or not the bitstream follows those recommendations.

To check the correctness of a bitstream, it is necessary to parse the entire bitstream and to extract all the syntax elements and other values derived from those syntactic elements and used by the decoding process specified in Rec. ITU-T H.266 | ISO/IEC 23090-3.

A bitstream verifier may not necessarily perform all stages of the decoding process specified in Rec. ITU-T H.266 | ISO/IEC 23090-3 in order to verify bitstream correctness. Many tests can be performed on syntax elements in a state prior to their use in some processing stages.

6.5 Procedure to test decoder conformance

6.5.1 Conformance bitstreams

A bitstream that conforms to Rec. ITU-T H.266 | ISO/IEC 23090-3 has values of `general_profile_idc`, `general_tier_flag`, and `general_level_idc` corresponding to a set of specified constraints on a bitstream for which a decoder conforming to a corresponding specified profile, tier, and level is required in Annex A of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022 to properly perform the decoding process.

6.5.2 Contents of the bitstream file

The associated conformance testing bitstreams are included with this document as an electronic attachment. The following information is included in a single zipped file for each such bitstream.

- *.bit – bitstream (provided for all bitstreams)
- *.txt – description (provided for all bitstreams)
- *.yuv.md5 – MD5 checksum of the complete decoded yuv file (provided for all bitstreams)
- *.md5 – MD5 checksum of the bitstream file (provided for all bitstreams)
- *.opl – output picture log (provided for all bitstreams)
- *.cfg – config file used to generate bitstream with VTM encoder software (not provided for all bitstreams, not applicable if a VTM encoder release version was not used)

6.5.3 Requirements on output of the decoding process and timing

Two classes of decoder conformance are specified:

- output order conformance; and
- output timing conformance.

The output of the decoding process is specified in Clause 8 and Annex C of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022.

For output order conformance, it is a requirement that all of the cropped decoded pictures specified for output in Annex C of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022 shall be output by a conforming decoder in the specified order and that the values of the decoded samples of the cropped decoded pictures that are output shall be (exactly equal to) the values specified in Clause 8 of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022.

For output timing conformance, it is a requirement that a conforming decoder shall also output the cropped decoded pictures at the picture rates and times specified in Annex C of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022.

The display process, which ordinarily follows the output of the decoding process, is outside the scope of this document.

6.5.4 Static tests for output order conformance

Static tests of a video decoder require testing of the samples of the cropped decoded pictures that are output from the decoder and can be accomplished when the decoded samples at the output of the decoding process are available. It may not be possible to perform this type of test with a production decoder (due to the lack of an appropriate accessible interface in the design at which to perform the test). In such a case this test should be performed by the manufacturer during the design and development phase. Static tests are used for testing the decoding process.

The pictures that are output by the decoder under test are checked to ensure that the following requirements are fulfilled:

- The cropped decoded pictures that are output by the decoder under test shall correspond to those that are output by the reference software decoder.
- The cropped decoded pictures that are output by the decoder under test shall be output in the same order as those that are output by the reference software decoder.
- The values of the samples of the cropped decoded pictures that are output by the decoder under test shall be identical to those that are output by the reference software decoder.

To assist with the checking of the decoding process and the cropped decoded pictures, hash values for the cropped decoded pictures that are output by conforming decoders are provided in a corresponding output picture log file for each test bitstream that is used in the specified conformance tests, and most of these test bitstreams also contain decoded picture hash SEI messages that may be used for checking the results of the decoding process of the decoder under test.

6.5.5 Dynamic tests for output timing conformance

Dynamic tests are applied to check that all the decoded samples of the cropped decoded pictures are output and that the timing of the output of the decoder's decoded samples conforms to the specifications of Clause 8 and Annex C of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022, and to verify that the decoder under test can operate according to bitstream flow characteristics prescribed by the specified HRD models (as specified by the CPB and DPB specification in Annex C of Rec. ITU-T H.266 | ISO/IEC 23090-3:2022) when the bits of the bitstream are delivered at the proper rate.

The dynamic test is often easier to perform on a complete decoding system, which may include a systems decoder, a video decoder and a display process. It may be possible to record the output of the display process and to check that display order and timing of the cropped decoded pictures are correct at the output of the display process. However, since the display process is not within the normative scope of Rec. ITU-T H.266 | ISO/IEC 23090-3, there may be cases where the output of the display process differs in timing or value even though the video decoder is conforming. In this case, the output of the video decoder itself (before the display process) would need to be captured in order to perform the dynamic tests on the video decoder. In particular the output order and timing of the output of the cropped decoded pictures shall be correct.

If buffering period and picture timing SEI messages are included in the test bitstream, HRD conformance shall be verified using the values of `nal_initial_cpb_removal_delay`, `nal_initial_cpb_removal_offset`, `au_cpb_removal_delay_minus1` and `pic_dpb_output_delay` that are included in the bitstream.

If buffering period and picture timing SEI messages are not included in the bitstream, the following inferences shall be made to generate the missing parameters:

- `fixed_pic_rate_general_flag[i]` shall be inferred to be equal to 1.

- `low_delay_hrd_flag[i]` shall be inferred to be equal to 0.
- `cbr_flag[subLayerId][j]` shall be inferred to be equal to 0.
- The frame rate of the bitstream shall be inferred to be equal to the frame rate value specified in the .txt file for the bitstream. If this is missing, then a frame rate of either 25 or $30000 \div 1001$ can be inferred.
- The bit rate of the bitstream shall be inferred to be equal to the maximum value for the level specified in Table 136 in Rec. ITU-T H.266 | ISO/IEC 23090-3:2022.
- CPB and DPB sizes shall be inferred to be equal to the maximum value for the level specified in Table 135 in Rec. ITU-T H.266 | ISO/IEC 23090-3:2022.

With the above inferences, the HRD shall be operated as follows:

- The CPB is filled starting at time $t = 0$, until it is full, before removal of the first access unit. This means that the `bp_nal_initial_cpb_removal_delay[i][j]` shall be inferred to be equal to the total CPB buffer size divided by the bit rate divided by 90000 (rounded downwards) and `bp_vcl_initial_cpb_removal_offset[i][j]` shall be inferred to be equal to zero.
- The first access unit is removed at time $t = \text{bp_nal_initial_cpb_removal_delay}[i][j] \div 90000$ and subsequent access units are removed at intervals based on the picture distance.
- Using these inferences with the accompanying bitstreams, the CPB will not overflow or underflow and the DPB will not overflow.

6.5.6 Decoder conformance test for a particular profile, tier, and level

In order for a decoder for a particular profile, tier, and level to claim output order conformance to Rec. ITU-T H.266 | ISO/IEC 23090-3, the decoder shall successfully pass the static test specified in [subclause 6.5.4](#) with all the bitstreams of the normative test suite specified for testing decoders of this particular profile, tier, and level combination.

In order for a decoder of a particular profile, tier, and level to claim output timing conformance to Rec. ITU-T H.266 | ISO/IEC 23090-3, the decoder shall successfully pass both the static test specified in [subclause 6.5.4](#) and the dynamic test specified in [subclause 6.5.5](#) with all the bitstreams of the normative test suite specified for testing decoders of this particular profile, tier, and level.

[Tables 1](#) through [19](#) specify the normative test suites. The profile, tier, and level combinations are described in the tables or in the .txt file associated with the bitstream.

6.6 Specification of the test bitstreams

6.6.1 General

Some characteristics of each bitstream are described in this clause.

6.6.2 Test bitstreams – Coding tools for Main 10 profile with 4:2:0 chroma format and 10 bit depth

6.6.2.1 Chroma separate tree (CST)

6.6.2.1.1 Test bitstream CST_A

Specification: All pictures are coded in I slices with CST enabled. CST is tested with all possible luma and chroma block sizes, and luma-chroma block size combinations (e.g., luma block size is larger than, equal to, or smaller than the corresponding chroma block size).

Functional stage: Reconstruction process.

Purpose: Check that the decoder can properly decode slices with CST enabled.

6.6.2.2 Dependent quantization (DQ)

6.6.2.2.1 Test bitstream DQ_A

Specification: The bitstream consists of three CVSs, with the following properties:

- The first CVS uses dependent quantization for all pictures, all non-related features (inter tools, ALF, ...) are disabled, and MTS and LFNST are disabled.
- The second CVS uses dependent quantization for all pictures, all non-related features (inter tools, ALF, ...) are disabled, and MTS (for intra) and LFNST are enabled.
- The third CVS exercises a picture-level selection between dependent quantization, sign data hiding, and standard quantization, all non-related features (inter tools, ALF, ...) are disabled, and MTS (for intra) and LFNST are enabled.

Functional stage: Dependent quantization.

Purpose: Check that the decoder can properly decode slices with DQ enabled.

6.6.2.2.2 Test bitstream DQ_B

Specification: The bitstream consists of three CVSs of resolution 1920 x 1080, with the following properties:

- The first CVS uses dependent quantization for all pictures, all non-related features (inter tools, ALF, ...) are disabled, and MTS and LFNST are disabled.
- The second CVS uses dependent quantization for all pictures, all non-related features (inter tools, ALF, ...) are disabled, and MTS (for intra) and LFNST are enabled.
- The third CVS exercises a picture-level selection between dependent quantization, sign data hiding, and standard quantization, all non-related features (inter tools, ALF, ...) are disabled, and MTS (for intra) and LFNST are enabled.

Functional stage: Dependent quantization.

Purpose: Check that the decoder can properly decode slices with DQ enabled.

6.6.2.3 Cross-component linear model (CCLM)

6.6.2.3.1 Test bitstream CCLM_A

Specification: The bitstream exercises corner cases for coding structures using CCLM with the following properties:

- POC0: Chroma CU size is 64x64.
- POC1: First split of CU is horizontal, i.e. CU size is 64x32.
- POC2: First split of CU is quad, i.e. CU size is 32x32.
- POC3: First and second split of CU are horizontal and vertical, respectively.
- POC4: First split of CU is vertical or ternary, i.e. none of condition is satisfied for CCLM.
- POC5: CU size is 64x64 and ISP is enabled.
- POC6: First luma split is something else than quad.

Functional stage: Intra prediction.

Purpose: Check that the decoder can properly decode slices with CCLM enabled.