
**Information technology — High efficiency
coding and media delivery in
heterogeneous environments —**

**Part 8:
Conformance Specification for HEVC**

*Technologies de l'information — Codage à haute efficacité et livraison
des médias dans des environnements hétérogènes —
Partie 8: Spécification de conformité du codage vidéo à haute efficacité*

[ISO/IEC 23008-8:2015](https://standards.iso.org/iso-iec-23008-8-2015)

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

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HEVC Conformance Testing

1 Scope

This Recommendation | International Standard¹ specifies a set of tests and procedures designed to indicate whether encoders or decoders meet the normative requirements specified in Rec. ITU-T H.265 | ISO/IEC 23008-2.

2 Normative references

2.1 General

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this Recommendation | International Standard. At the time of publication, the editions indicated were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations and Standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

2.2 Identical Recommendations | International Standards

- None.

2.3 Paired Recommendations | International Standards equivalent in technical content

- Recommendation ITU-T H.265 (in force), *High efficiency video coding*.
- ISO/IEC 23008-2: in force, *Information technology – High efficiency video coding and media delivery in heterogeneous environment – Part 2: High Efficiency Video Coding*.
- Recommendation ITU-T H.265.2 (in force), *High efficiency coding reference software*.
- ISO/IEC 23008-5: in force, *Information technology – High efficiency video coding and media delivery in heterogeneous environment – Part 2: High Efficiency Video Coding Reference Software*.

2.4 Additional references

- None.

3 Definitions

For the purposes of this Recommendation | International Standard, the terms, definitions, abbreviations and symbols specified in Rec. ITU-T H.265 | ISO/IEC 23008-2 (particularly in clauses 3) apply. The following terms are further clarified for purposes herein as follows.

3.1 bitstream: A Rec. ITU-T H.265 | ISO/IEC 23008-2 video bitstream.

3.2 decoder: A Rec. ITU-T H.265 | ISO/IEC 23008-2 video decoder, i.e., an embodiment of the decoding process specified by Rec. ITU-T H.265 | ISO/IEC 23008-2. The decoder does not include the display process, which is outside the scope of this Recommendation | International Standard.

¹ This Recommendation | International Standard includes an electronic attachment containing the conformance bitstreams identified within the text.

3.3 encoder: An embodiment of a process, not specified in this Recommendation | International Standard (except in regard to identification of the reference software encoder), that produces a bitstream.

3.4 reference software decoder: The software decoder provided in Rec. ITU-T H.265.2 | ISO/IEC 23008-5.

3.5 reference software encoder: The software encoder provided in Rec. ITU-T H.265.2 | ISO/IEC 23008-5.

4 Abbreviations and acronyms

For the purposes of this Recommendation | International Standard, relevant abbreviations and acronyms are specified in clause 4 of Rec. ITU-T H.265 | ISO/IEC 23008-2.

5 Conventions

For the purposes of this Recommendation | International Standard, relevant conventions are specified in clause 5 of Rec. ITU-T H.265 | ISO/IEC 23008-2.

6 Conformance testing for ITU-T H.265 | ISO/IEC 23008-2

6.1 Introduction

The following clauses 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 annex to this Recommendation | International Standard and the reference software decoder specified in Rec. ITU-T H.265.2 | ISO/IEC 23008-5.

6.2 Bitstream conformance

Bitstream conformance for Rec. ITU-T H.265 | ISO/IEC 23008-2 is specified by clause C.4 of Rec. ITU-T H.265 | ISO/IEC 23008-2.

6.3 Decoder conformance

Decoder conformance for Rec. ITU-T H.265 | ISO/IEC 23008-2 is specified by clause C.5 of Rec. ITU-T H.265 | ISO/IEC 23008-2.

6.4 Procedure to test bitstreams

A bitstream that claims conformance with Rec. ITU-T H.265 | ISO/IEC 23008-2 shall pass the following normative test.

The bitstream shall be decoded by processing it with the reference software decoder. 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. 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.265 | ISO/IEC 23008-2.

Successfully passing the reference software decoder test provides only a strong presumption that the bitstream under test is conforming to the video layer, i.e., that it does indeed meet all the requirements for the video layer (except Annexes C, D and E) specified in Rec. ITU-T H.265 | ISO/IEC 23008-2 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.265 | ISO/IEC 23008-2 including the hypothetical reference decoder (HRD) conformance (based on Annexes C, D and E). These 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.265 | ISO/IEC 23008-2 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 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.265 | ISO/IEC 23008-2.

A verifier may not necessarily perform all stages of the decoding process specified in Rec. ITU-T H.265 | ISO/IEC 23008-2 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 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 specified profile, tier, and level is required in Annex A of Rec. ITU-T H.265 | ISO/IEC 23008-2 to properly perform the decoding process.

6.5.2 Contents of the bitstream file

The conformance bitstreams are included in this Recommendation | International Standard as an electronic attachment. The following information is included in a single zipped file for each such bitstream.

- bitstream; [ISO/IEC 23008-8:2015](https://standards.iteh.org/catalog/standards/sist/b306d18d-67ba-43f7-b9a2-46bbc2faa1e2/iso-iec-23008-8-2015)
- decoded pictures or hashes of decoded pictures (may not be present); <https://standards.iteh.org/catalog/standards/sist/b306d18d-67ba-43f7-b9a2-46bbc2faa1e2/iso-iec-23008-8-2015>
- short description of the bitstream;
- trace file (results while decoding the bitstream, in ASCII format).

In cases where the decoded pictures or hashes of decoded pictures are not available, the reference software decoder shall be used to generate the necessary reference decoded pictures from the bitstream.

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.265 | ISO/IEC 23008-2.

For output order conformance, it is a requirement that all of the decoded pictures specified for output in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2 shall be output by a conforming decoder in the specified order and that the values of the decoded samples in all of the pictures that are output shall be (exactly equal to) the values specified in clause 8 of Rec. ITU-T H.265 | ISO/IEC 23008-2.

For output timing conformance, it is a requirement that a conforming decoder shall also output the decoded samples at the rates and times specified in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2.

The display process, which ordinarily follows the output of the decoding process, is outside the scope of this Recommendation | International Standard.

6.5.4 Recommendations (informative)

This clause does not form an integral part of this Recommendation | International Standard.

In addition to the requirements, it is desirable that conforming decoders implement various informative recommendations specified in Rec. ITU-T H.265 | ISO/IEC 23008-2 that are not an integral part of that Recommendation | International Standard. This clause discusses some of these recommendations.

It is recommended that a conforming decoder be able to resume the decoding process as soon as possible after the loss or corruption of part of a bitstream. In most cases it is possible to resume decoding at the next start code or slice header. It is recommended that a conforming decoder be able to perform concealment for the coding tree blocks or video packets for which all the coded data has not been received.

6.5.5 Static tests for output order conformance

Static tests of a video decoder require testing of the decoded samples. This clause will explain how this test 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 that 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 test will check that the values of the samples decoded by the decoder under test shall be identical to the values of the samples decoded by the reference decoder. When a hash of the values of the samples of the decoded pictures is attached to the bitstream file, a corresponding hash operation performed on the values of the samples of the decoded pictures produced by the decoder under test shall produce the same results.

6.5.6 Dynamic tests for output timing conformance

Dynamic tests are applied to check that all the decoded samples are output and that the timing of the output of the decoder's decoded samples conforms to the specification of clause 8 and Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2, and to verify that the HRD models (as specified by the CPB and DPB specification in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2) are not violated 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 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.265 | ISO/IEC 23008-2, 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 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 `initial_cpb_removal_delay`, `initial_cpb_removal_delay_offset`, `cpb_removal_delay` and `dpb_removal_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_flag` shall be inferred to be equal to 1.
- `low_delay_hrd_flag` shall be inferred to be equal to 0.
- `cbr_flag` 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 corresponding table of clause 6.7, where the bitstream is listed. If this is missing, then a frame rate of either 25 or $30000 \div 1001$ can be inferred.

- time_scale shall be set equal to 90 000 and the value of num_units_in_tick shall be computed based on field rate (twice the frame rate).
- The bit rate of the bitstream shall be inferred to be equal to the maximum value for the level specified in Table A-1 in Rec. ITU-T H.265 | ISO/IEC 23008-2.
- CPB and DPB sizes shall be inferred to be equal to the maximum value for the level specified in Table A-1 in Rec. ITU-T H.265 | ISO/IEC 23008-2.

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 initial_cpb_removal_delay shall be inferred to be equal to the total CPB buffer size divided by the bit rate divided by 90000 (rounded downwards) and initial_cpb_removal_delay_offset shall be inferred to be equal to zero.
- The first access unit is removed at time $t = \text{initial_cpb_removal_delay} \div 90000$ and subsequent access units are removed at intervals based on the frame distance, i.e., $2 * (90000 \div \text{num_units_in_tick})$ or the field distance, i.e., $(90000 \div \text{num_units_in_tick})$, depending on whether the pictures in the bitstream are indicated to represent complete frames or individual fields of such frames.
- Using these inferences, the CPB will not overflow or underflow and the DPB will not overflow.

6.5.7 Decoder conformance test of a particular profile, tier, and level

In order for a decoder of a particular profile, tier, and level to claim output order conformance to Rec. ITU-T H.265 | ISO/IEC 23008-2 as specified by this Recommendation | International Standard, the decoder shall successfully pass the static test specified in clause 6.5.5 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.265 | ISO/IEC 23008-2 as specified by this Recommendation | International Standard, the decoder shall successfully pass both the static test specified in clause 6.5.5 and the dynamic test specified in clause 6.5.6 with all the bitstreams of the normative test suites for testing decoders of this particular profile, tier, and level. Table 1 specifies the normative test suites for each profile, tier, and level combination. The test suite for a particular profile, tier, and level combination is the list of bitstreams that are marked with an 'X' in the column corresponding to that profile, tier, and level combination. In the column 'Main tier', 'X' indicate the bitstream is for Main tier. A decoder conformed to Main tier shall be capable of decoding the specified bitstreams, among the testing profile-level combination, indicated by 'X' at 'Main tier' column in Table 1. A decoder conformed to High tier shall be capable of decoding all the specified bitstreams, among the testing profile-level combination, in Table 1.

'X' indicates that the bitstream is designed to test both the dynamic and static conformance of the decoder.

The bitstream column specifies the bitstream used for each test.

A decoder that conforms to the Main profile, Main Still Picture profile, or Main 10 profile at a specific level shall be capable of decoding the specified bitstreams in Table 1.

6.6 Specification of the test bitstreams

6.6.1 General

Some characteristics of each bitstream listed in Table 1 are specified in this clause. In Table 1, the value "29.97" shall be interpreted as an approximation of an exact value of $30000 \div 1001$ and the value "59.94" shall be interpreted as an approximation of an exact value of $60000 \div 1001$.

6.6.2 Test bitstreams – Block structure

6.6.2.1 Test bitstreams #STRUCT_A

Specification: All slices are coded as I, P or B slices. Each picture contains one slice. Various CTU and maximum CU sizes are used.

Functional stage: Test the reconstruction process of slices.

Purpose: Check that the decoder can properly decode I, P and B slices with various CTU and maximum CU sizes.

6.6.2.2 Test bitstreams #STRUCT_B

Specification: All slices are coded as I, P or B slices. Each picture contains one slice. Various CTU and minimum CU sizes are used.

Functional stage: Test the reconstruction process of slices.

Purpose: Check that the decoder can properly decode I, P and B slices with various CTU and minimum CU sizes.

6.6.3 Test bitstreams – Intra coding

6.6.3.1 Test bitstreams #IPRED_A, #IPRED_B, and #IPRED_C

Specification: All slices are coded as I slices. Each picture contains one slice. All intra prediction modes (35 modes for each of luma 32x32, luma 16x16, luma 8x8, luma 4x4, chroma 16x16, chroma 8x8 and chroma 4x4, for a total 245 modes) are used. The IPRED_B bitstream contains only one picture, and conforms to the Main Still Picture profile.

Functional stage: Test the reconstruction process of I slices.

Purpose: Check that the decoder can properly decode I slices with all intra prediction modes.

6.6.3.2 Test bitstreams #CIP_A

Specification: The bitstream contains one I slice and one B slice, using one slice per picture. Both SAO and the deblocking filter are disabled.

Functional stage: Test the reference sample substitution process for intra sample prediction.

Purpose: Check that the decoder can properly decode slices of coded pictures containing intra TUs with unavailable samples for intra prediction.

6.6.3.3 Test bitstreams #CIP_B

Specification: The bitstream contains an I-picture and 4 P-pictures. Each picture contains only one slice. constrained_intra_pred_flag is equal to 1.

Functional stage: Test the reference sample substitution process for intra sample prediction.

Purpose: Check that the decoder can properly decode slices of coded pictures containing intra TUs with unavailable samples for intra prediction.

6.6.3.4 Test bitstreams #CIP_C

Specification: The bitstream contains one I slice and one B slice, using more than one slice per picture. Both SAO and the deblocking filter are disabled.

Functional stage: Test the reference sample substitution process for intra sample prediction.

Purpose: Check that the decoder can properly decode slices of coded pictures containing intra TUs with unavailable samples for intra prediction.

6.6.4 Test bitstreams – Inter frame coding

6.6.4.1 Test bitstreams #MERGE_A

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `five_minus_max_num_merge_cand` is set equal to 4.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode with the maximum number of merging candidates equal to any value permitted by the standard (i.e. 1, 2, 3, 4, 5).

6.6.4.2 Test bitstreams #MERGE_B

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `five_minus_max_num_merge_cand` is set equal to 3.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode with the maximum number of merging candidates equal to any value permitted by the standard (i.e. 1, 2, 3, 4, 5).

6.6.4.3 Test bitstreams #MERGE_C

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `five_minus_max_num_merge_cand` is set equal to 2.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode with the maximum number of merging candidates equal to any value permitted by the standard (i.e. 1, 2, 3, 4, 5).

6.6.4.4 Test bitstreams #MERGE_D

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `five_minus_max_num_merge_cand` is set equal to 1.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode with the maximum number of merging candidates equal to any value permitted by the standard (i.e. 1, 2, 3, 4, 5).

6.6.4.5 Test bitstreams #MERGE_E

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `five_minus_max_num_merge_cand` is set equal to 0.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode with the maximum number of merging candidates equal to any value permitted by the standard (i.e. 1, 2, 3, 4, 5).

6.6.4.6 Test bitstreams #MERGE_F

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `sps_temporal_mvp_enable_flag` is equal to 0 and `five_minus_max_num_merge_cand` is equal to 0.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode when the temporal merging candidate is not included in the merge candidate set.

6.6.4.7 Test bitstreams #MERGE_G

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `five_minus_max_num_merge_cand` is set equal to 0.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode with merge index ranging from 0 to 4.

6.6.4.8 Test bitstreams #PMERGE_A

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `log2_parallel_merge_level_minus2` is set equal to 0.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode parallel merge level values permitted by the standard (i.e. 2, 3, 4, 5, 6 for luma CTB size 64x64).

6.6.4.9 Test bitstreams #PMERGE_B

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `log2_parallel_merge_level_minus2` is set equal to 1.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode parallel merge level values permitted by the standard (i.e. 2, 3, 4, 5, 6 for luma CTB size 64x64).

6.6.4.10 Test bitstreams #PMERGE_C

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `log2_parallel_merge_level_minus2` is set equal to 2.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode the parallel merge level values permitted by the standard (i.e. 2, 3, 4, 5, 6 for luma CTB size 64x64).

6.6.4.11 Test bitstreams #PMERGE_D

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `log2_parallel_merge_level_minus2` is set equal to 3.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode the parallel merge level values permitted by the standard (i.e. 2, 3, 4, 5, 6 for luma CTB size 64x64).

6.6.4.12 Test bitstreams #PMERGE_E

Specification: All slices are coded as I or B slices. Each picture contains only one slice. `log2_parallel_merge_level_minus2` is set equal to 4.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode the parallel merge level values permitted by the standard (i.e. 2, 3, 4, 5, 6 for luma CTB size 64x64).

6.6.4.13 Test bitstreams #AMVP_A

Specification: All slices are coded as I or P slices. Each picture contains only one slice.

num_ref_idx_l0_default_active_minus1 is equal to 0, num_ref_idx_l1_default_active_minus1 is equal to 0 and num_ref_idx_active_override_flag is equal to 0.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode when motion vector scaling is not needed for spatial motion vector prediction candidate generation (all inter-coded PUs within the same slice have the same inter_pred_idc and ref_idx_l0).

6.6.4.14 Test bitstreams #AMVP_B

Specification: All slices are coded as I or B slices. Each picture contains only one slice. Multiple reference pictures are used. For some slices, num_ref_idx_l0_default_active_minus1 is equal to 3 and num_ref_idx_active_override_flag is equal to 0. For other B slices,

num_ref_idx_l0_default_active_minus1 is equal to 1, num_ref_idx_l1_default_active_minus1 is equal to 1 and num_ref_idx_active_override_flag is equal to 0.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode when motion vector scaling is not needed for spatial motion vector prediction candidate generation.

6.6.4.15 Test bitstreams #AMVP_C

Specification: All slices are coded as I or P slices. Each picture contains only one slice.

Functional stage: Test the reconstruction process of motion vector prediction, specifically, motion vector prediction during the low delay condition.

Purpose: Check that the decoder can properly decode when motion vector scaling is not needed for spatial motion vector prediction candidate generation.

6.6.4.16 Test bitstreams #TMVP_A

Specification: Each picture contains only one slice. slice_temporal_mvp_enable_flag is set equal to 0 for pictures 0 to 8 and 1 for pictures 9 to 16.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode for different slice_temporal_mvp_enable_flag values.

6.6.4.17 Test bitstreams #MVDL1ZERO_A

Specification: The bitstream contains multiple B slices per picture. Mvd_l0_zero_flag is set equal to 1. Randomized on and off switching of the mvd_l1_zero_flag for multiple B slices.

Functional stage: Test the reconstruction process of motion vector prediction.

Purpose: Check that the decoder can properly decode when the parsing of list 1 motion vector difference for bi-prediction varies according to values of mvd_l1_zero_flag.

6.6.4.18 Test bitstreams #MVCLIP_A

Specification: Each picture contains only one slice. Motion vector prediction and merge candidate motion vectors are clipped to 16-bit values. Clipped motion vector prediction and merge candidates are selected.