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Part 4: Conformance Testing

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Partie 4: Tests de conformité

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Foreword

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This document was prepared by ITU-T (as ITU-T REC. T.803) and drafted in accordance with its editorial rules, in collaboration with Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

This third edition cancels and replaces the second edition (ISO/IEC 15444-4:2004), which has been technically revised.

The main changes are as follows:

— addition of the criteria to be achieved to claim compliance with Rec. ITU-T 814 | ISO/IEC 15444-15.

A list of all parts in the ISO/IEC 15444 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.

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1 Scope

This Recommendation | International Standard specifies the framework, concepts, methodology for testing, and criteria to be achieved to claim compliance to Rec. ITU-T T.800 | ISO/IEC 15444-1 or Rec. ITU-T T.814 | ISO/IEC 15444-15. It provides a framework for specifying abstract test suites (ATSs) and for defining the procedures to be followed during compliance testing.

This Recommendation | International Standard:

- specifies compliance testing procedures for encoding and decoding using Rec. ITU-T T.800 | ISO/IEC 15444-1 and Rec. ITU-T T.814 | ISO/IEC 15444-15;
- specifies codestreams, decoded images, and error metrics to be used with the testing procedures;
- specifies ATSs;
- provides guidance for creating an encoder compliance test

This Recommendation | International Standard does not include the following tests:

Acceptance testing: the process of determining whether an implementation satisfies acceptance criteria and enables the user to determine whether or not to accept the implementation. This includes the planning and execution of several kinds of tests (e.g., functionality, quality, and speed performance testing) that demonstrate that the implementation satisfies the user requirements.

Performance testing: measures the performance characteristics of an implementation under test (IUT) such as its throughput and responsiveness, under various conditions.

Robustness testing: the process of determining how well an implementation processes data which contains errors.

2 References

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.

- Recommendation ITU-T T.800 (2019) | ISO/IEC 15444-1:2019, *Information technology – JPEG 2000 image coding system: Core coding system.*
- Recommendation ITU-T T.814 (2019) | ISO/IEC 15444-15:2019, *Information technology – JPEG 2000 image coding system: High-throughput JPEG 2000*.

3 Definitions

For the purposes of this Recommendation | International Standard, the terms and definitions given in Rec. ITU-T T.800 | ISO/IEC 15444-1, Rec. ITU-T T.814 | ISO/IEC 15444-15 and the following apply.

3.1 **abstract test suite (ATS)**: Generic compliance testing concepts and procedures for a given requirement.

3.2 **arithmetic coder**: An entropy coder that converts variable length strings to variable length codes (encoding) and vice versa (decoding).

3.3 **big endian**: An order of bytes with the most significant byte first.

3.4 **bit**: A contraction of the term "binary digit"; a unit of information represented by a 0 or a 1.

3.5 **bit-depth**: The number of bits required to represent an original component of an image.

3.6 **bit-plane**: A two-dimensional array of bits. In this Recommendation | International Standard, a bit-plane refers to all the bits of the same magnitude in all coefficients or samples. This could refer to a bit-plane in a component, tile- component, code-block, region of interest, or other.

3.7 **bitstream**: The actual sequence of bits resulting from the coding of a sequence of symbols. It does not include the markers or marker segments in the main and tile-part headers or the end of codestream marker. It does include any packet headers and in stream markers and marker segments not found within the main or tile-part headers.

3.8 **box**: A portion of the file format defined by a length and unique box type. Boxes of some types may contain other boxes.

3.9 **byte**: Eight bits.

3.10 **Cclass**: Defines a level of performance for a decoder. Also provides guidance for encoders to produce codestreams that are easily decodable by compliant decoders.

3.11 **code-block**: A rectangular grouping of coefficients from the same sub-band of a tile-component.

3.12 **coder**: An embodiment of either an encoding or decoding process.

3.13 **codestream**: A collection of one or more bitstreams and the main header, tile-part headers, and the end of codestream required for their decoding and expansion into image data. This is the image data in a compressed form with all of the signalling needed to decode. This does not include the file format.

3.14 **coding pass**: A procedure accessing coefficients in a code-block where the context and bit are determined. Typically, there are three different coding passes for each bit-plane, each coefficient will be represented in exactly one of the three passes. For an encoder a coding pass examines coefficients and augments a bitstream. For a decoder a coding pass reads a bitstream and updates coefficients.

3.15 **coefficient**: The values that are the result of a transformation.

3.16 **component**: A two-dimensional array of samples. An image typically consists of several components (e.g., red, green, and blue).

3.17 **compressed image data**: Part or all of a codestream. Can also refer to a collection of bitstreams in part or all of a codestream.

3.18 **compliance**: Fulfilment of the specified requirements, as defined in this Recommendation | International Standard, for a given Profile and Cclass.

3.19 **compliance test procedure**: The process of assessing compliance.

3.20 **context**: Function of coefficients previously decoded and used to condition the decoding of the present coefficient.

3.21 **decoder**: An embodiment of a decoding process, and optionally a colour transformation process.

3.22 **decoding process**: A process that takes as its input all or part of a codestream and outputs all or part of a reconstructed image.

3.23 **decomposition level**: A collection of wavelet sub-bands where each coefficient has the same spatial impact or span with respect to the source component samples. These include all sub-bands of the same two-dimensional sub-band decomposition. For the last decomposition level, the LL sub-band is also included.

3.24 **discrete wavelet transformation (DWT)**: A transformation that iteratively transforms one signal into two or more filtered and decimated signals corresponding to different frequency bands. This transformation operates on spatially discrete samples.

3.25 **encoder**: An embodiment of an encoding process, and optionally a colour transformation process.

3.26 **encoding process**: A process that takes as its input all or part of a source image data and outputs a codestream.

3.27 **executable test suite (ETS)**: Set of executable test cases that support the abstract test cases.

3.28 **file format**: A codestream and additional support data and information not explicitly required for the decoding of the codestream. Examples of such support data include text fields providing titling, security and historical information, data to support placement of multiple codestreams within a given data file, and data to support exchange between platforms or conversion to other file formats.

3.29 **fully decode**: Applying Rec. ITU-T T.800 | ISO/IEC 15444-1 to produce an image from a codestream where all coded data in the codestream has been used to produce the image.

3.30 guard bits: Additional most significant bits that have been added to sample data.

3.31 header: Either a part of the codestream that contains only markers and marker segments (main header and tile part header) or the signalling part of a packet (packet header).

3.32 image: The set of all components.

3.33 image data: The component samples making up an image. Image data can refer to either the source image data or the reconstructed image data.

3.34 implementation: A realization of a specification.

3.35 implementation compliance statement (ICS): Statement of specification options and the extent to which they have been implemented by an implementation under test.

3.36 implementation under test (IUT): An implementation that is being evaluated for compliance.

3.37 irreversible: A transformation, progression, system, quantization, or other process that, due to systemic or quantization error, prevents lossless recovery.

3.38 JP2 file: The name of a file in the file format described in this Recommendation | International Standard. Structurally, a JP2 file is a contiguous sequence of boxes.

3.39 JPEG: Joint Photographic Experts Group – The joint ISO/ITU committee responsible for developing standards for continuous-tone still picture coding. It also refers to the standards produced by this committee: Rec. ITU-T T.81 | ISO/IEC 10918-1, Rec. ITU-T T.83 | ISO/IEC 10918-2, Rec. ITU-T T.84 | ISO/IEC 10918-3 and Rec. ITU-T T.87 | ISO/IEC 14495-1.

3.40 LL sub-band: The sub-band obtained by forward horizontal low-pass filtering and vertical low-pass filtering. This sub-band contributes to reconstruction with inverse vertical low-pass filtering and horizontal low-pass filtering.

3.41 layer: A collection of compressed image data from coding passes of one, or more, code-blocks of a tile-component. Layers have an order for encoding and decoding that has to be preserved.

3.42 lossless: A descriptive term for the effect of the overall encoding and decoding processes in which the output of the decoding process is identical to the input to the encoding process. Distortion-free restoration can be assured. All of the coding processes or steps used for encoding and decoding are reversible.

3.43 lossy: A descriptive term for the effect of the overall encoding and decoding processes in which the output of the decoding process is not identical to the input to the encoding process. There is distortion (measured mathematically). At least one of the coding processes or steps used for encoding and decoding is irreversible.

3.44 main header: A group of markers and marker segments at the beginning of the codestream that describe the image parameters and coding parameters that can apply to every tile and tile-component.

3.45 marker: A two-byte code in which the first byte is hexadecimal FF (0xFF) and the second byte is a value between 1 (0x01) and hexadecimal FE (0xFE).

3.46 marker segment: A marker and associated (not empty) set of parameters.

3.47 packet: A part of the codestream comprising a packet header and the compressed image data from one layer of one precinct of one resolution level of one tile-component.

3.48 packet header: Portion of the packet that contains signalling necessary for decoding that packet.

3.49 parser: Reads and identifies components of the codestream down to the code-block level.

3.50 partial decoding: Producing an image from a subset of an entire codestream.

3.51 precinct: A rectangular region of a transformed tile-component, within each resolution level, used for limiting the size of packets.

3.52 precision: Number of bits allocated to a particular sample, coefficient, or other binary numerical representation.

3.53 progression: The order of a codestream where the decoding of each successive bit contributes to a "better" reconstruction of the image. What metrics make the reconstruction "better" is a function of the application. Some examples of progression are increasing resolution or improved sample fidelity.

3.54 profile: A subset of technology, from Rec. ITU-T T.800 | ISO/IEC 15444-1, that meets the needs of a given application with limits on parameters within a selected technology. This is a codestream limitation.

3.55 **quantization**: A method of reducing the precision of the individual coefficients to reduce the number of bits used to represent them. This is equivalent to division while compressing and multiplying while decompressing. Quantization can be achieved by an explicit operation with a given quantization value (scalar quantization) or by dropping (truncating) coding passes from the codestream.

3.56 **reconstructed image**: An image that is the output of a decoder.

3.57 **reference grid**: A regular rectangular array of points used to define other rectangular arrays of data. The reference grid is used to determine the number of samples in tile-components for example.

3.58 **region of interest (ROI)**: A collection of coefficients that are considered of particular relevance by some user-defined measure.

3.59 **reversible**: A transformation, progression, system, or other process that does not suffer systemic or quantization error and therefore allows for lossless signal recovery.

3.60 **reversible filter**: A particular filter pair used in the wavelet transformation which allows lossless compression.

3.61 **sample**: One element in the two-dimensional array that comprises a component.

3.62 **selective arithmetic coding bypass**: A coding style where some of the code-block passes are not coded by the arithmetic coder. Instead, the bits to be coded are appended directly to the bitstream without coding.

3.63 **shift**: Multiplication or division of a number by powers of two. Division of an integer via shift implies truncation toward minus infinity of the non-integer portion.

3.64 **sign bit**: A bit that indicates whether a number is positive (value 0) or negative (value 1).

3.65 **sign-magnitude notation**: A binary representation of an integer where the distance from the origin is expressed with a positive number and the direction from the origin (positive or negative) is expressed with a separate single sign bit.

3.66 **source image**: An image used as input to an encoder.

3.67 **sub-band**: A group of transform coefficients resulting from the same sequence of low-pass and high-pass filtering operations, both vertically and horizontally.

3.68 **testing**: The process of evaluating compliance.

3.69 **tile**: A rectangular array of points on the reference grid, registered with an offset from the reference grid origin and defined by a width and height.

3.70 **tile-component**: All the samples of a given component in a tile.

3.71 **tile-part**: A portion of the codestream with compressed image data for some, or all, of a tile. The tile-part may include one or more packets that make up the coded tile.

3.72 **tile-part header**: A group of markers and marker segments at the beginning of each tile-part in the codestream that describe the tile-part coding parameters.

3.73 **transformation**: A mathematical mapping from one signal space to another.

3.74 **transform coefficient**: A value that is the result of a transformation.

4 Abbreviations and symbols

4.1 Abbreviations

For the purposes of this Recommendation | International Standard, the abbreviations given in Rec. ITU-T T.800 | ISO/IEC 15444-1 and the following apply.

ATS	Abstract Test Suite
BSET	subset of the ETS consisting of HTJ2K test codestreams that differ only by B_{MAGB} value
ETS	Executable Test Suite
HT	High Throughput
HTJ2K	High Throughput JPEG 2000
ICC	International Colour Consortium

ICS	Implementation Compliance Statement
ICT	Irreversible Component Transform
IDWT	Inverse Discrete Wavelet Transformation
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
IUT	Implementation Under Test
J2K	JPEG 2000[1]
JPEG	Joint Photographic Experts Group
MAGB	Magnitude Bound
MSE	Mean Squared Error
RCT	Reversible Component Transform
ROI	Region Of Interest
sRGB	standard Red–Green–Blue
TCS	Test Codestream

4.2 Symbols

For the purposes of this Recommendation | International Standard, the following symbols apply.

0x----	Denotes a hexadecimal number
B	Bit-depth precision for reversible 5-3
B_{MAGB}	Magnitude bound parameter for an HTJ2K codestream
C	Component guaranteed to be decoded
CAP	Capabilities
COC	Coding style Component
COD	Coding style Default
COM	Comment
CPF	Corresponding Profile
CRG	Component Registration
EPH	End of Packet Header
EOC	End of Codestream
H	image Height guarantee
L	Layer guarantee
L_{body}	code data buffering guarantee
M	decoded bit-plane guarantee
M_{MAGB}	Magnitude bound decoding guarantee
N_{cb}	code-block parsing guarantee
N_{comp}	component parsing guarantee
P	irreversible 9-7 Precision guarantee
PLM	Packet Length, Main header marker
PLT	Packet Length, Tile-part header marker
POC	Progression Order Change marker
PPM	Packed Packet headers, Main header marker

[1] As defined in Rec. ITU-T T.800 | ISO/IEC 15444-1.

PPT	Packed Packet headers, Tile-part header marker
PRF	Profile marker
QCC	Quantization Component marker
QCD	Quantization Default marker
RGN	Region of interest marker
SIZ	image and tile Size marker
SOC	Start Of Codestream marker
SOP	Start Of Packet marker
SOD	Start Of Data marker
SOT	Start Of Tile-part marker
T_L	Transform level guarantee
TLM	Tile-part Lengths marker
W	image Width guarantee

5 Conventions

The compliance files including test codestreams, JP2 files, JPH files, reference decoded images, and descriptive files are supplied in the form of a compressed file. File locations given in this Recommendation | International Standard are expressed relative to the top level of the directory tree. A Unix style file structure and delimiters are assumed.

This Recommendation | International Standard contains instructions for the use of these files. No support can be provided by ISO | ITU-T beyond that offered in this Recommendation | International Standard.

6 General description

Perhaps the most distinctive feature of JPEG 2000 is its emphasis on and support for scalability. An existing codestream may be accessed at a reduced resolution, at a reduced quality (higher compression), at a reduced number of components, and even over a reduced spatial region. Moreover, this Recommendation | International Standard supports a rich family of information progression sequences whereby the information may be reordered without introducing additional distortion. This enables a single compressed codestream to serve the needs of a diverse range of applications.

This Recommendation | International Standard also covers compliance for implementations of Rec. ITU-T T.814 | ISO/IEC 15444-15. To avoid confusion, the terms JPEG 2000 (J2K) and high throughput JPEG 2000 (HTJ2K) are used in this Recommendation | International Standard, where necessary, to differentiate between JPEG 2000 codestreams that conform to Rec. ITU-T T.800 | ISO/IEC 15444-1 and those that conform to Rec. ITU-T T.814 | ISO/IEC 15444-15, respectively. J2K codestreams can be reversibly transcoded to HTJ2K and vice-versa, without any loss in information. This property allows compliance for HTJ2K and J2K implementations to be treated in a very similar manner. In fact, all of the HTJ2K test codestreams and JPH files are provided zipped with this Specification at https://www.itu.int/net/itu-t/sigdb/speimage/ImageForm-s.aspx?val=10100803 or at https://standards.iso.org/iso-iec/15444/-4/ed-3/en have been obtained by reversibly transcoding corresponding J2K test codestreams and JP2 files available at the same location. The decoded output from an HTJ2K decoder is expected to conform to the same guidelines as the decoded output from a J2K decoder, processing the corresponding J2K codestream or JP2 file.

From the perspective of compliance, the main distinction between HTJ2K and J2K is that an HTJ2K codestream does not generally possess the same quality scalability attributes as the corresponding J2K codestream. An HTJ2K decoder cannot choose to stop the decoding of a code-block bit-stream at an arbitrary bit-plane, providing a fine grain trade-off between implementation complexity and reconstructed image quality. Considering this difference between HTJ2K and J2K, this Recommendation | International Standard provides multiple transcodings of J2K test codestreams, allowing implementations to be tested at multiple quality operating points.

JPEG 2000 encoders may employ only a fraction of the features supported by Rec. ITU-T T.800 | ISO/IEC 15444-1. Likewise, some decoders will not support all the features supported by this Recommendation | International Standard. It is impossible to provide test cases for all possible combinations of tools that an encoder or decoder may choose to implement. This Recommendation | International Standard provides abstract test procedures for JPEG 2000 encoders and decoders. A developer may designate the features that have been implemented and determine a set of test cases that applies to those features. For the greatest level of interoperability, there are explicit decoder test procedures. These tests are run for a particular Profile (defined in Rec. ITU-T T.800 | ISO/IEC 15444-1) and a particular compliance class defined herein. Passing the explicit tests allows a decoder to be labelled "Profile-x Cclass-y Compliant".