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INFORMATION TECHNOLOGY – DIGITAL COMPRESSION AND CODING OF CONTINUOUS-TONE STILL IMAGES: COMPLIANCE TESTING

ITU-T Recommendation T.83

(Previously "CCITT Recommendation")

Foreword

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. Some 179 member countries, 84 telecom operating entities, 145 scientific and industrial organizations and 38 international organizations participate in ITU-T which is the body which sets world telecommunications standards (Recommendations).

The approval of Recommendations by the Members of ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, 1993). In addition, the World Telecommunication Standardization Conference (WTSC), which meets every four years, approves Recommendations submitted to it and establishes the study programme for the following period.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC. The text of ITU-T Recommendation T.83 was approved on 11th of November 1994. The identical text is also published as ISO/IEC International Standard 10918-2.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Summary

This Recommendation | International Standard, *Digital Compression and Coding of Continuous-tone Still Images*, is published as two parts:

ITU-T Rec. T.81 | ISO/IEC 10918-1 "*Requirements and guidelines*" sets out requirements and implementation guidelines for continuous-tone still image encoding and decoding processes, and for the coded representation of compressed image data. These processes and representations are intended to be generic, that is, to be applicable to a broad range of applications for colour and grayscale still images within communications and computer systems.

This part, ITU-T Rec. T.83 | ISO/IEC 10918-2 "*Compliance testing*" sets out tests for determining whether implementations comply with the requirements for the various encoding and decoding processes specified in ITU-T Rec. T.81 | ISO/IEC 10918-1. ITU-T Rec. T.83 | ISO/IEC 10918-2 also specifies tests for determining whether any specific instance of compressed data complies with the ITU-T Rec. T.81 | ISO/IEC 10918-1 specification for compressed data format.

Introduction

This Recommendation | International Standard, *Digital Compression and Coding of Continuous-tone Still Images*, is published as two parts:

– ITU-T Rec. T.81 | ISO/IEC 10918-1: *Requirements and guidelines.*

– ITU-T Rec. T.83 | ISO/IEC 10918-2: *Compliance testing.*

ITU-T Rec. T.81 | ISO/IEC 10918-1 sets out requirements and implementation guidelines for continuous-tone still image encoding and decoding processes, and for the coded representation of compressed image data. These processes and representations are intended to be generic, that is, to be applicable to a broad range of applications for colour and grayscale still images within communications and computer systems.

This part, ITU-T Rec. T.83 | ISO/IEC 10918-2, sets out tests for determining whether implementations comply with the requirements for the various encoding and decoding processes specified in ITU-T Rec. T.81 | ISO/IEC 10918-1. ITU-T Rec. T.83 | ISO/IEC 10918-2 also specifies tests for determining whether any specific instance of compressed data complies with the ITU-T Rec. T.81 | ISO/IEC 10918-1 specification for compressed data format.

The committee which has prepared this Specification is the ISO/IEC JTC1/SC29/WG1 Sub Group on JPEG, also known as the Joint Photographic Experts Group (JPEG). Both the committee and the two parts of this Specification continue to be known informally by the name JPEG.

The "joint" in JPEG refers to the committee's collaboration with the ITU-T SG8 Rapporteur's Group on Recommendation Q.16. In this collaboration, WG1 has performed the work of selecting, developing, documenting, and testing the generic compression processes.

ITU-T SG8 has provided the requirements which these processes must satisfy to be useful for specific image communications applications such as facsimile, videotex, and audiographic conferencing.

This Specification is presented in accordance with the rules of ITU-T and ISO/IEC JTC1 established by "Rules for presentation of ITU-T | ISO/IEC common text".

Annexes A, B, C, and D form an integral part of this Specification. Annexes E, F, G, and H are for information only.

INTERNATIONAL STANDARD

ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – DIGITAL COMPRESSION AND CODING OF CONTINUOUS-TONE STILL IMAGES: COMPLIANCE TESTING

1 Scope

This Recommendation | International Standard is concerned with compliance tests for the continuous-tone still image encoding processes, decoding processes, and compressed data formats specified in ITU-T Rec. T.81 | ISO/IEC 10918-1.

This Specification:

- specifies compliance tests for the ITU-T Rec. T.81 | ISO/IEC 10918-1 compressed data formats;
- specifies compliance tests for the ITU-T Rec. T.81 | ISO/IEC 10918-1 encoding processes;
- specifies compliance tests for the ITU-T Rec. T.81 | ISO/IEC 10918-1 decoding processes;
- specifies a method for constructing application-specific compliance tests;
- gives guidance and examples on how to implement these tests in practice.

This Specification specifies normative generic compliance tests for the ITU-T Rec. T.81 | ISO/IEC 10918-1 encoding and decoding processes. These compliance tests are applicable to “stand-alone” generic implementations of one or more of the encoding and decoding processes specified in ITU-T Rec. T.81 | ISO/IEC 10918-1. Among the purposes of these tests is to ensure that generic encoder (and decoder) implementations compute the discrete cosine transform (DCT) and quantization functions with sufficient accuracy.

2 Normative references

The following ITU-T 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 editions of the Recommendations and Standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU-T maintains a list of the currently valid ITU-T Recommendations.

2.1 Additional references

- ISO 5807:1985, *Information processing – Documentation symbols and conventions for data, program and system flowcharts, program network charts and system resources charts*.

3 Definitions, abbreviations, symbols, and conventions

3.1 Definitions

For the purposes of this Specification, the following definitions apply.

3.1.1 **(coding) process 1:** Coding process with baseline sequential DCT, 8-bit sample precision.

3.1.2 **(coding) process 2:** Coding process with extended sequential DCT, Huffman coding, 8-bit sample precision.

3.1.3 **(coding) process 3:** Coding process with extended sequential DCT, arithmetic coding, 8-bit sample precision.

3.1.4 **(coding) process 4:** Coding process with extended sequential DCT, Huffman coding, 12-bit sample precision.

3.1.5 (coding) process 5: Coding process with extended sequential DCT, arithmetic coding, 12-bit sample precision.

3.1.6 (coding) process 6: Coding process with spectral selection only, Huffman coding, 8-bit sample precision.

3.1.7 (coding) process 7: Coding process with spectral selection only, arithmetic coding, 8-bit sample precision.

3.1.8 (coding) process 8: Coding process with spectral selection only, Huffman coding, 12-bit sample precision.

3.1.9 (coding) process 9: Coding process with spectral selection only, arithmetic coding, 12-bit sample precision.

3.1.10 (coding) process 10: Coding process with full progression, Huffman coding, 8-bit sample precision.

3.1.11 (coding) process 11: Coding process with full progression, arithmetic coding, 8-bit sample precision.

3.1.12 (coding) process 12: Coding process with full progression, Huffman coding, 12-bit sample precision.

3.1.13 (coding) process 13: Coding process with full progression, arithmetic coding, 12-bit sample precision.

3.1.14 (coding) process 14: Coding process with lossless, Huffman coding, 2- through 16-bit sample precision.

3.1.15 (coding) process 15: Coding process with lossless, arithmetic coding, 2- through 16-bit sample precision.

3.1.16 (coding) process 16: Coding process with extended sequential DCT, Huffman coding, 8-bit sample precision in hierarchical mode.

3.1.17 (coding) process 17: Coding process with extended sequential DCT, arithmetic coding, 8-bit sample precision in hierarchical mode.

3.1.18 (coding) process 18: Coding process with extended sequential DCT, Huffman coding, 12-bit sample precision in hierarchical mode.

3.1.19 (coding) process 19: Coding process with extended sequential DCT, arithmetic coding, 12-bit sample precision in hierarchical mode.

3.1.20 (coding) process 20: Coding process with spectral selection only, Huffman coding, 8-bit sample precision in hierarchical mode.

3.1.21 (coding) process 21: Coding process with spectral selection only, arithmetic coding, 8-bit sample precision in hierarchical mode.

3.1.22 (coding) process 22: Coding process with spectral selection only, Huffman coding, 12-bit sample precision in hierarchical mode.

3.1.23 (coding) process 23: Coding process with spectral selection only, arithmetic coding, 12-bit sample precision in hierarchical mode.

3.1.24 (coding) process 24: Coding process with full progression, Huffman coding, 8-bit sample precision in hierarchical mode.

3.1.25 (coding) process 25: Coding process with full progression, arithmetic coding, 8-bit sample precision in hierarchical mode.

3.1.26 (coding) process 26: Coding process with full progression, Huffman coding, 12-bit sample precision in hierarchical mode.

3.1.27 (coding) process 27: Coding process with full progression, arithmetic coding, 12-bit sample precision in hierarchical mode.

3.1.28 (coding) process 28: Coding process with lossless, Huffman coding, 2- through 16-bit sample precision in hierarchical mode.

3.1.29 (coding) process 29: Coding process with lossless, arithmetic coding, 2- through 16-bit sample precision in hierarchical mode.

3.1.30 compliance test: The procedures specified in this Specification which determine whether or not an embodiment of an encoding process, compressed data stream, or decoding process complies with ITU-T Rec. T.81 | ISO/IEC 10918-1.

3.1.31 compressed image test data (stream): Compressed image data generated to test a particular coding process. (Distributed as part of the compliance test data.)

3.1.32 compressed image validation data (stream): Compressed image data generated for validation of a particular coding process. (Distributed as part of the compliance test data.)

3.1.33 compressed test data (stream): Either compressed image test data or table specification test data or both.

3.1.34 decoder reference test data: Quantized DCT coefficient data generated by the reference FDCT and reference quantizer from the reconstructed image data output by the reference decoder, the input to which is the compressed image test data to be used in the DCT-based decoder compliance tests. The format of the quantized DCT coefficient data is a file for each component; each component is a two dimensional array of 8×8 blocks stored left-to-right, top-to-bottom order; each 8×8 block has 64 coefficients stored in zigzag order; and each coefficient is represented by two bytes, the most significant byte first. This data includes the blocks which are padded to complete an MCU on the right and bottom of the image. (Distributed as part of the compliance test data.)

3.1.35 encoder reference test data: Quantized DCT coefficient data generated by the reference FDCT and reference quantizer from the source image test data to be used in the DCT-based encoder compliance tests. (Distributed as part of the compliance test data.).

3.1.36 generic: Applicable to a broad range of applications, i.e. application independent.

3.1.37 orthogonal representation: The 2-dimensional row-column format illustrated in Figure A.5 in ITU-T Rec. T.81 | ISO/IEC 10918-1.

3.1.38 quantized coefficient validation data: Quantized DCT coefficient data generated from the source image validation test data to be used in the DCT-based encoder validation tests. (Distributed as part of the compliance test data.).

3.1.39 reference DCT-based decoder: An embodiment of the DCT-based decoding processes which generates the decoder reference test data. It consists of an entropy decoder, a dequantizer, and the reference IDCT.

3.1.40 reference DCT-based encoder: An embodiment of the DCT-based encoding processes which generated the DCT-based compressed image test data streams. It consists of the reference FDCT, the reference quantizer, and an entropy encoder.

3.1.41 reference forward discrete cosine transform; reference FDCT: A double precision (64-bit) floating point embodiment of the FDCT described in A.3.3 of ITU-T Rec. T.81 | ISO/IEC 10918-1.

3.1.42 reference inverse discrete cosine transform; reference IDCT: A double precision (64-bit) floating point embodiment of the IDCT described in A.3.3 of ITU-T Rec. T.81 | ISO/IEC 10918-1.

3.1.43 reference quantizer: An embodiment of the quantization described in A.3.4 in ITU-T Rec. T.81 | ISO/IEC 10918-1.

3.1.44 source image test data: The data sets to be used as input to the encoder compliance tests. This data is a sequence of pseudo-random numbers generated with uniform distribution over the range from 0 to 255. The algorithm used to generate this data is described in Annex A of CCITT Recommendation H.261. (This data is distributed as part of the compliance test data.).

3.1.45 table specification test data (stream): Table specification data generated to test decoder compliance with abbreviated format compressed data. (Distributed as part of the compliance test data.)

3.2 Abbreviations

The abbreviations used in this Specification are listed below.

3.2.1 arith.: An abbreviation for arithmetic coding.

3.2.2 Huff.: An abbreviation for Huffman coding.

3.3 Symbols

The symbols used in this Specification are listed below.

3.3.1 $\mathbf{B_{ij}}$**:** quantization value at the *i*th row and *j*th column in the quantization tables defined in Annex B, appears in Annex E.

3.3.2 DF: differential frame flag, appears in flow charts in clause 5.

3.3.3 **E_{ij}:** quantization value at the ith row and jth column in the quantization tables used in testing for greater accuracy defined in Annex E.

3.3.4 **F:** the scale factor used to generate E_{ij} from B_{ij} as defined in E.1.

3.3.5 **FS:** first scan in frame flag, appears in flow charts in clause 5.

3.3.6 **G:** guaranteed in compressed data, appears in Tables 1 to 5 in clause 5.

3.3.7 **H-L:** hierarchical lossless processes, appears in Table G.1.

3.3.8 **H-S:** hierarchical sequential DCT-based processes without final lossless scans, appears in Table G.1.

3.3.9 **HP:** hierarchical progression flag, appears in flow charts in clause 5.

3.3.10 **LL:** lossless processes, appears in Table G.1.

3.3.11 **o:** optional in compressed data, appears in tables in clause 5.

3.3.12 **P(FULL):** full progressive DCT-based processes with both spectral selection and successive approximation, appears in Table G.1.

3.3.13 **P(SA):** progressive DCT-based successive approximation processes, appears in Table G.1.

3.3.14 **P(SS):** progressive DCT-based spectral selection processes, appears in Table G.1.

3.3.15 **RI:** restart interval flag, appears in flow charts in clause 5.

3.3.16 **S(B):** baseline sequential DCT-based process, appears in Table G.1.

3.3.17 **S(E):** extended sequential DCT-based processes, appears in Table G.1.

3.4 Conventions

The flowcharts use the conventions given in ISO 5807. One of the conventions is that arrows are not needed when the flow is from left-to-right and from top-to-bottom. Arrows are sometimes used in such cases to increase clarity.

4 General

The purpose of this clause is to give an informative overview of this Specification and the principles underlying it. Another purpose is to introduce some of the terms which are defined in clause 3. (Terms defined in clause 3 of ITU-T Rec. T.81 | ISO/IEC 10918-1 continue to apply in this Specification.)

ITU-T Rec. T.83 | ISO/IEC 10918-2 concerns compliance testing for embodiments of the elements specified in ITU-T Rec. T.81 | ISO/IEC 10918-1. For encoders and decoders – embodiments of the ITU-T Rec. T.81 | ISO/IEC 10918-1 encoding and decoding processes – this document makes a distinction between GENERIC embodiments and APPLICATION-SPECIFIC embodiments. For the former, compliance tests themselves are specified herein; for the latter, this document specifies a method for defining compliance tests. Compliance tests are also specified for compressed data streams – embodiments of the ITU-T Rec. T.81 | ISO/IEC 10918-1 compressed data formats.

NOTE – Like many compliance tests, those described in this Specification for generic encoders and decoders are not exhaustive tests of their respective functional specifications. Therefore, passing these tests does not guarantee complete functional correctness. This observation has two implications:

1) the tests do not fully guarantee complete interoperability between independently-implemented encoders and decoders; and

2) the tests for embodiments of the DCT-based processes do not guarantee that encoders or decoders will have some well defined image-quality-producing capability. These limitations are discussed in more detail below.

4.1 Purpose of the compliance tests

The purpose of compliance tests is to provide designers, manufacturers, or users of a product with a set of procedures for determining whether the product meets a specified set of requirements with some confidence. In addition, the compliance tests specified herein are intended to achieve the following specific goals:

- increase the likelihood of compressed data interchange;
- decrease the likelihood that DCT-based encoders or decoders will yield reduced image quality as a result of computing the DCT or quantization procedures with insufficient accuracy;
- help implementors to meet the ITU-T Rec. T.81 | ISO/IEC 10918-1 requirements for encoders and decoders as fully as possible.

4.2 Compressed data compliance tests

The aim of the compliance tests specified in clause 5 is to determine whether a particular compressed image data stream or table-specification data stream meets the interchange format or abbreviated format requirements specified in ITU-T Rec. T.81 | ISO/IEC 10918-1. These tests are performed on the compressed data.

4.3 Encoder and decoder compliance tests

This subclause summarizes the considerations which have led to the encoder and decoder compliance tests set out in this Specification.

4.3.1 Encoder versus decoder requirements

ITU-T Rec. T.81 | ISO/IEC 10918-1 imposes more requirements on decoders than on encoders. This difference is based on the philosophy that any encoder should be allowed to produce only compressed images with a limited range of parameter values, but that decoders must handle images with broad ranges of parameters in order to facilitate interchange. Specifically, a decoder is required to handle either

a) the full range and combination of the parameter values specified by its coding process (in which case it qualifies as a generic decoder); or

b) a subset of the same defined by some application (in which case it is an application-specific decoder – see 4.3.2).

4.3.2 Generic versus application-specific decoders

Each coding process specified in ITU-T Rec. T.81 | ISO/IEC 10918-1 is defined for a fairly broad range of parameters. It is recognized, however, that many applications may require only a limited subset of these. For example, a simple picture database might use only grayscale images of fixed dimensions.

Consequently, the committee which prepared this Specification has defined a distinction between generic and application-specific decoders. The former concept is important to facilitate interchange as applications become increasingly inter-connected, and for hardware or software decoder products which can be embedded within many different applications. The latter concept allows application-oriented standards bodies to define a subset of a ITU-T Rec. T.81 | ISO/IEC 10918-1 coding process as its requirements.

This distinction, along with the decoder requirements philosophy in 4.3.1, means that the compliance test for generic decoders should exercise, as much as possible, the full range and combination of the parameter values specified by its coding process. It also means that a compliance test for application-specific decoders should exercise only the combination and range specified by the application.

Although comprehensive in many ways, the compliance tests for generic decoders do not test the full allowed range of all parameters. Many parameters have larger allowed ranges than it is feasible to test. Also, for some parameters, e.g. Number of samples per line (X) and Number of lines (Y), it is not desirable to test their full allowed range since few applications require functionality over the entire range.

According to the encoder requirements philosophy, any encoder may operate on limited ranges of parameter values only, suggesting that encoders are by nature application-specific. Therefore, there is no concept of a generic encoder, and no defined encoder compliance test intended to exercise different parameter values. (The only generic aspect of encoder compliance concerns DCT accuracy, as explained in 4.3.3.)

4.3.3 Computational accuracy of DCT and quantization

In ITU-T Rec. T.81 | ISO/IEC 10918-1, the FDCT, quantizer, and IDCT are defined as ideal mathematical formulae. Because these formulae imply infinite precision, implementors must decide how to approximate them. Efficiency or cost considerations may encourage lower-accuracy approximations, but it is the combination of the DCT and the table-based method of quantization – which accommodates psychovisual thresholding – that gives the DCT-based processes their excellent image-quality-producing capability. This capability may be degraded if the DCT and quantization procedures are computed with insufficient accuracy. Therefore, this Specification provides a method of compliance testing aimed at discouraging such degradation.

Because there is no point in requiring that the FDCT be computed with greater accuracy than necessary for the subsequent quantization procedure, the compliance testing method for DCT-based encoders is concerned with the accuracy of the quantized DCT coefficients. (Basing the test on quantized coefficients also meets the practical constraint that, for product implementations, unquantized coefficients are typically not externally observable.) For symmetry, the method of decoder compliance testing imposes IDCT/dequantization accuracy requirements which are consistent with those imposed on the FDCT/quantization.

It is important to note that required accuracy is a function of the quantization tables used in these tests. A table with larger (coarser) quantization values will make for a less stringent test than one with smaller (finer) values. Therefore, passing the accuracy test means that the encoder or decoder is likely to perform comparably to an encoder or decoder with an ideal FDCT or IDCT, but only when using the specific quantization table employed in the test. An encoder which passes the test with a moderately coarse quantization table will not be guaranteed to perform as well, with a finer quantization table, as an ideal encoder.

For the generic DCT-based compliance tests specified herein, a set of quantization tables requiring moderate accuracy is specified. Encoders and decoders which achieve this accuracy will yield image quality sufficient for many applications, without incurring undue computational burden. Applications requiring greater or lesser accuracy may specify different quantization tables for application-specific compliance tests.

4.3.4 Summary – Generic compliance test considerations

The compliance tests for generic decoders have been defined to exercise the full range and combination of parameter values specified by the coding process being tested. The compliance tests for generic decoders have been designed so that decoders which satisfy the requirements of these tests are likely to be suitable for use within many different applications or for interchanging data between applications.

The generic compliance tests for DCT-based encoders and decoders define quantization tables requiring a level of computational accuracy which will yield image quality sufficient for many applications.

4.3.5 Procedures for constructing application-specific compliance tests

Application-specific compliance tests are used for testing compliance of application-specific decoders, i.e. decoders which implement a subset of a coding process, or for testing the accuracy of encoders and decoders for use in applications which have greater or lesser accuracy requirements than specified by the generic compliance tests. Application-specific compliance tests are constructed by applications standards bodies to satisfy the requirements of a particular application. This Specification contains the procedures for constructing application-specific compliance tests.

Two different procedures are defined for construction of application-specific compliance tests: one for DCT-based processes and one for lossless processes. Application-specific compliance tests for DCT-based processes may specify quantization tables which are selected according to the accuracy requirements of the application.

4.4 Availability of compliance test data

Standardized compliance test data is used to perform the encoder and decoder compliance tests. There are two types of compliance test data which are used by the encoder compliance tests: source image test data and encoder reference test data. Similarly, there are two types of compliance test data which are used by the decoder compliance tests: compressed test data and decoder reference test data.

The compliance test data for the encoder compliance tests and the generic decoder compliance tests are available on 3 diskettes and are included with the copy of this ITU-T Recommendation | ISO/IEC International Standard for parties who wish to determine compliance of an encoder or decoder. The diskettes were created under MS-DOS operating system (version 3.0 or newer), and are of the 1.4 M-byte high-density double-sided 96 tracks per inch MS-DOS format.

5 Compressed data format compliance testing

In order to determine compressed data format compliance, the test procedures in 5.1, 5.2 or 5.3 shall be performed. These test procedures utilize the common additional procedures in 5.4.

There are separate tests for the following compressed data streams:

a) Compressed image data encoded by non-hierarchical processes in interchange format (see 5.1.1);

b) Compressed image data encoded by hierarchical processes in interchange format (see 5.1.2);

c) Compressed image data encoded by non-hierarchical processes in abbreviated format (see 5.2.1);

d) Compressed image data encoded by hierarchical processes in abbreviated format (see 5.2.2);

e) Compressed data in abbreviated format for table specifications (see 5.3).

Twenty-nine coding processes are defined in each of the first paragraphs of ITU-T Rec. T.81 | ISO/IEC 10918-1, Annexes F, G, H, and J. They are assigned numbers in ITU-T T.83 | ISO/IEC 10918-2, clause 3 (Definitions) as "(coding) process *n*" where *n* is an integer from 1 to 29.

ITU-T Rec. T.81 | ISO/IEC 10918-1, Annex B, contains the syntax requirements for the compressed data. ITU-T Rec. T.81 | ISO/IEC 10918-1, B.1.3 and Figure B.1, give the conventions for the syntax figures. The markers are identified by the marker assignments in ITU-T Rec. T.81 | ISO/IEC 10918-1, Table B.1.

Tables 1, 3, and 5 in this clause give specific references to syntax requirements for markers. Markers and marker segments which are required in the compressed data are denoted 'G'. Those that may optionally be present in the compressed data are denoted 'o'. A dash (–) indicates non-compliance if the particular marker or marker segment is present in the compressed data for that coding process.

If a marker is present, its parameters are required and not optional.

The ITU-T Rec. T.81 | ISO/IEC 10918-1 references in the left-most columns of Tables 1, 3 and 5 indicate where the syntax requirements for each marker segment are stated.

There is no significance to the order of markers in the tables.

NOTES

1 The tests are partial as they check mainly the syntactical correctness of the data. Passing the test does not ensure that the compressed data comply with all the requirements of ITU-T Rec. T.81 | ISO/IEC 10918-1.

2 The flow charts do not use most values of the parameters. Future extensions may include more elaborate test procedures based on parameters' values.

3 There is no requirement in this Specification that any tester shall implement the procedures in precisely the manner specified by the flow charts in this clause. It is necessary only that a tester implement the equivalent function specified in this clause.

4 For simplicity of exposition, the buffer holding the compressed data is assumed to be large enough to contain the entire compressed data stream.

5 In any case that there is conflict between this clause and ITU-T Rec. T.81 | ISO/IEC 10918-1, ITU-T Rec. T.81 | ISO/IEC 10918-1 shall take precedence.

5.1 Interchange Compressed Image Data Format Syntax Compliance Tests

5.1.1 Non-hierarchical coding processes syntax compliance test

Figure 1 gives the non-hierarchical coding processes syntax compliance test main procedure.

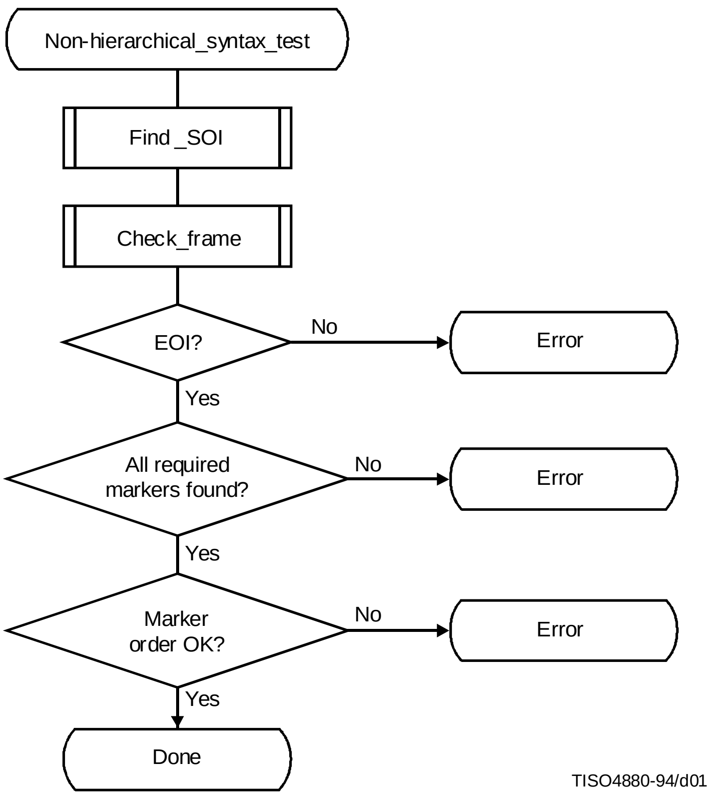


Figure 1 – Non-hierarchical syntax test procedure

“All required makers found” means that all markers designated with ‘G’ in the Table 1 column of the process under test were found. A missing required marker makes the compressed data under test non-compliant with the syntax. All other markers found should have an ‘o’ in the column for the corresponding process. A marker found in the compressed data which has a (–) in the column for the corresponding process or is missing from the table makes the compressed data under test non-compliant with the syntax.

The high-level syntax in ITU-T Rec. T.81 | ISO/IEC 10918-1 B.2.1 and ITU-T Rec. T.81 | ISO/IEC 10918-1, Figure B.2 specifies the required order for the “Marker order OK?” test for non-hierarchical coding processes.

Table 2 specifies the parameter column in ITU-T Rec. T.81 | ISO/IEC 10918-1, Tables B.2 through B.11 that should be used to determine the allowed range of parameter values in marker segments for non-hierarchical processes.

Table 1 – Marker syntax requirements for non-hierarchical coding processes

<table>
<tr><td colspan="4">ITU-T Rec. T.81 | ISO/IEC 10918-1</td><td colspan="15">Process</td></tr>
<tr><td></td><td>Reference</td><td>Figure</td><td>Table</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td></tr>
<tr><td>SOI</td><td>B.2.1</td><td>B.2</td><td></td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td></tr>
<tr><td>EOI</td><td>B.2.1</td><td>B.2</td><td></td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td></tr>
<tr><td>RST_m</td><td>B.2.1</td><td>B.2</td><td></td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>SOS</td><td>B.2.3</td><td>B.4</td><td>B.3</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td></tr>
<tr><td>DNL</td><td>B.2.5</td><td>B.12</td><td>B.10</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td colspan="4">Non-differential frames</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>SOF_0</td><td>B.2.2</td><td>B.3</td><td>B.2</td><td>G</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>SOF_1</td><td>B.2.2</td><td>B.3</td><td>B.2</td><td>–</td><td>G</td><td>–</td><td>G</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>SOF_2</td><td>B.2.2</td><td>B.3</td><td>B.2</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>G</td><td>–</td><td>G</td><td>–</td><td>G</td><td>–</td><td>G</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>SOF_3</td><td>B.2.2</td><td>B.3</td><td>B.2</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>G</td><td>–</td></tr>
<tr><td>SOF_9</td><td>B.2.2</td><td>B.3</td><td>B.2</td><td>–</td><td>–</td><td>G</td><td>–</td><td>G</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>SOF_{10}</td><td>B.2.2</td><td>B.3</td><td>B.2</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>G</td><td>–</td><td>G</td><td>–</td><td>G</td><td>–</td><td>G</td><td>–</td><td>–</td></tr>
<tr><td>SOF_{11}</td><td>B.2.2</td><td>B.3</td><td>B.2</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>G</td></tr>
<tr><td colspan="4">Tables/miscellaneous</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>DQT</td><td>B.2.4.1</td><td>B.6</td><td>B.4</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>G</td><td>o</td><td>o</td></tr>
<tr><td>DHT</td><td>B.2.4.2</td><td>B.7</td><td>B.5</td><td>G</td><td>G</td><td>o</td><td>G</td><td>o</td><td>G</td><td>o</td><td>G</td><td>o</td><td>G</td><td>o</td><td>G</td><td>o</td><td>G</td><td>o</td></tr>
<tr><td>DAC</td><td>B.2.4.3</td><td>B.8</td><td>B.6</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>DRI</td><td>B.2.4.4</td><td>B.9</td><td>B.7</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>COM</td><td>B.2.4.5</td><td>B.10</td><td>B.8</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>APP_n</td><td>B.2.4.6</td><td>B.11</td><td>B.9</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
</table>

Table 2 – Parameter column in ITU-T Rec. T.81 | ISO/IEC 10918-1, Annex B tables for non-hierarchical processes

	Sequential DCT		Progressive	Lossless
	Baseline	Extended	DCT	
Non-differential frames				
SOF_0	G	–	–	–
SOF_1	–	G	–	–
SOF_2	–	–	G	–
SOF_3	–	–	–	G
SOF_9	–	G	–	–
SOF_{10}	–	–	G	–
SOF_{11}	–	–	–	G

5.1.2 Hierarchical coding processes syntax compliance test

Figure 2 gives the hierarchical coding processes syntax compliance test main procedure.

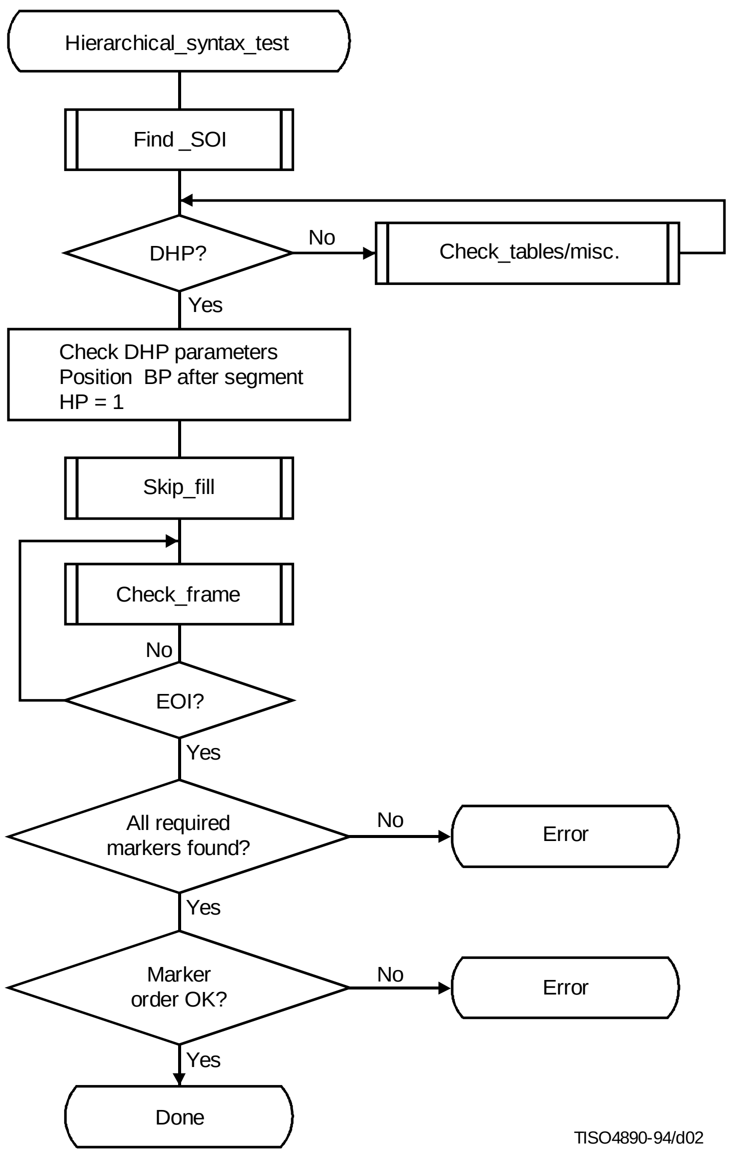


Figure 2 – Hierarchical syntax test procedure

The “Check DHP parameters” procedure is not specified here and is left to the tester. The tester should use the references given in Table 3 in the line containing DHP. The appropriate column to be used to check that the parameters' values are valid can be found in Table 4.

Table 3 – Marker syntax requirements for hierarchical coding processes

ITU-T Rec. T.81 | ISO/IEC 10918-1				Process													
	Reference	Figure	Table	16	17	18	19	20	21	22	23	24	25	26	27	28	29
SOI	B.3.1	B.13		G	G	G	G	G	G	G	G	G	G	G	G	G	G
EOI	B.3.1	B.13		G	G	G	G	G	G	G	G	G	G	G	G	G	G
RST_m	B.2.1	B.2		o	o	o	o	o	o	o	o	o	o	o	o	o	o
SOS	B.2.3	B.4	B.3	G	G	G	G	G	G	G	G	G	G	G	G	G	G
DNL	B.2.5	B.12	B.10	o	o	o	o	o	o	o	o	o	o	o	o	o	o
DHP	B.3.2	B.13	B.2	G	G	G	G	G	G	G	G	G	G	G	G	G	G
EXP	B.3.3	B.14	B.11	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Non-differential frames																	
SOF_0	B.2.2	B.3	B.2	o	o	–	–	o	o	–	–	o	o	–	–	–	–
SOF_1	B.2.2	B.3	B.2	o	–	G	–	o	–	o	–	o	–	o	–	–	–
SOF_2	B.2.2	B.3	B.2	–	–	–	–	o	–	o	–	o	–	o	–	–	–
SOF_3	B.2.2	B.3	B.2	–	–	–	–	–	–	–	–	–	–	–	–	G	–
SOF_9	B.2.2	B.3	B.2	–	o	–	G	–	o	–	o	–	o	–	o	–	–
SOF_{10}	B.2.2	B.3	B.2	–	–	–	–	–	o	–	o	–	o	–	o	–	–
SOF_{11}	B.2.2	B.3	B.2	–	–	–	–	–	–	–	–	–	–	–	–	–	G
Differential frames																	
SOF_5	B.2.2	B.3	B.2	o	–	o	–	o	–	o	–	o	–	o	–	–	–
SOF_6	B.2.2	B.3	B.2	–	–	–	–	o	–	o	–	o	–	o	–	–	–
SOF_7	B.2.2	B.3	B.2	o	–	o	–	o	–	o	–	o	–	o	–	o	–
SOF_{13}	B.2.2	B.3	B.2	–	o	–	o	–	o	–	o	–	o	–	o	–	–
SOF_{14}	B.2.2	B.3	B.2	–	–	–	–	–	o	–	o	–	o	–	o	–	–
SOF_{15}	B.2.2	B.3	B.2	–	o	–	o	–	o	–	o	–	o	–	o	–	o
Tables/miscellaneous																	
DQT	B.2.4.1	B.6	B.4	G	G	G	G	G	G	G	G	G	G	G	G	o	o
DHT	B.2.4.2	B.7	B.5	G	o	G	o	G	o	G	o	G	o	G	o	G	o
DAC	B.2.4.3	B.8	B.6	o	o	o	o	o	o	o	o	o	o	o	o	o	o
DRI	B.2.4.4	B.9	B.7	o	o	o	o	o	o	o	o	o	o	o	o	o	o
COM	B.2.4.5	B.10	B.8	o	o	o	o	o	o	o	o	o	o	o	o	o	o
APP_n	B.2.4.6	B.11	B.9	o	o	o	o	o	o	o	o	o	o	o	o	o	o

Table 4 – Parameter column in ITU-T Rec. T.81 | ISO/IEC 10918-1, Annex B tables for hierarchical processes

	Sequential DCT		Progressive	Lossless
	Baseline	Extended	DCT	
Non-differential frames				
SOF_0	G	–	–	–
SOF_1	–	G	–	–
SOF_2	–	–	G	–
SOF_3	–	–	–	G
SOF_9	–	G	–	–
SOF_{10}	–	–	G	–
SOF_{11}	–	–	–	G
Differential frames				
SOF_5	–	G	–	–
SOF_6	–	–	G	–
SOF_7	–	–	–	G
SOF_{13}	–	G	–	–
SOF_{14}	–	–	G	–
SOF_{15}	–	–	–	G

BP is the pointer to the compressed data stream bytes. After checking parameters, BP is positioned after the segment. HP is the hierarchical progression flag.

An EOI marker determines the end of the compressed data stream. If an EOI marker has not been found before BP points outside the compressed data, the compressed data stream under test is non-compliant.

The "All required makers found" test means that all markers designated with 'G' in the column of the process of Table 3 for hierarchical processes were found. A missing required marker makes the compressed data under test non-compliant with the syntax. All other markers found should have an 'o' in the column for the corresponding process. A marker found in the compressed data which has a (–) in the column for the corresponding process makes the compressed data under test non-compliant with the syntax.

The high-level syntax in ITU-T Rec. T.81 | ISO/IEC 10918-1, B.3.1 and ITU-T Rec. T.81 | ISO/IEC 10918-1, Figure B.13 specifies the required order for the "Marker order OK?" test for hierarchical coding processes.

Table 4 specifies the parameter column in ITU-T Rec. T.81 | ISO/IEC 10918-1, Tables B.2 through B.11, that should be used to determine the allowed range of parameter values in marker segments for hierarchical processes.

5.2 Abbreviated Compressed Data Format Syntax Requirements

5.2.1 Abbreviated format non-hierarchical coding processes syntax compliance test

The compliance testing for abbreviated format compressed image data syntax is the same as for the interchange format compressed image data given in 5.1.1 except that some or all of the table specifications may be omitted (see ITU-T Rec. T.81 | ISO/IEC 10918-1 B.4). If all of the tables are removed from a marker segment, the marker and its length parameter are also removed.

5.2.2 Abbreviated format hierarchical coding processes syntax compliance test

The compliance testing for abbreviated format compressed image data syntax is the same as for the interchange format compressed image data given in 5.1.2 except that some or all of the table specifications may be omitted (see ITU-T Rec. T.81 | ISO/IEC 10918-1, B.4). If all of the tables are removed from a marker segment, the marker and its length parameter are also removed.

5.3 Abbreviated format for table specification data syntax compliance test

Figure 3 gives the abbreviated format for table specification data syntax compliance test main procedure.

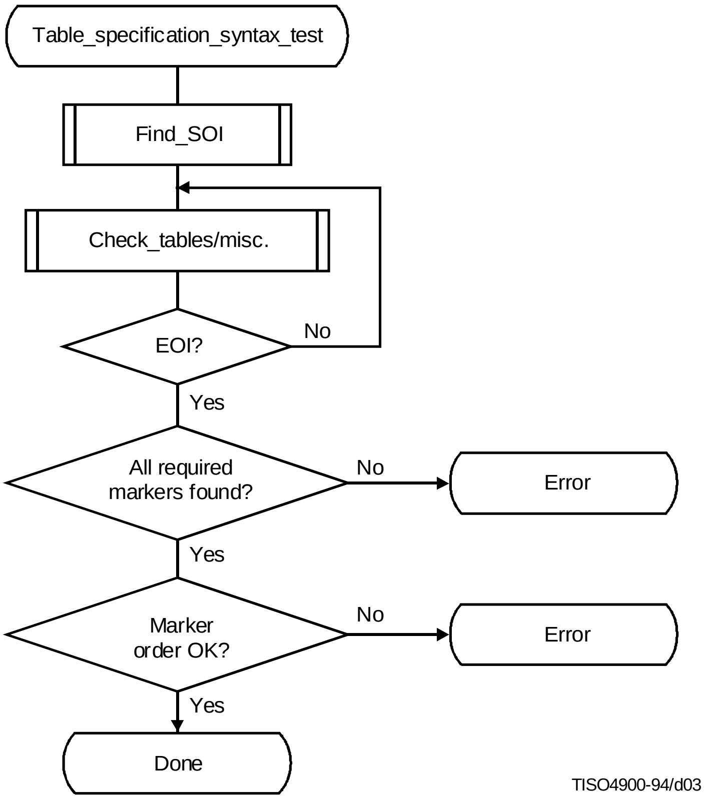


Figure 3 – Table specification syntax test procedure

An EOI marker determines the end of the compressed data stream. If an EOI marker has not been found before BP points outside the compressed data, the compressed data stream under test is non-compliant.

The "All required makers found" test means that all markers designated with 'G' in the column of the process of Table 5 for abbreviated format for table specifications were found. A missing required marker makes the compressed data under test non-compliant with the syntax. All other markers found should have an 'o' in the column for the corresponding process. A marker found in the compressed data which has a (–) in the column for the corresponding process or is missing from Table 5 makes the compressed data under test non-compliant with the syntax.

The high-level syntax in ITU-T Rec. T.81 | ISO/IEC 10918-1 B.5 and ITU-T Rec. T.81 | ISO/IEC 10918-1, Figure B.15, specifies the required order for the "Marker order OK?" test for abbreviated format for table-specification data.

Table 5 – Marker syntax requirements for abbreviated format for table specification data

ITU-T Rec. T.81 | ISO/IEC 10918-1				
Marker	Reference	Figure	Table	
SOI	B.5	B.15		G
EOI	B.5	B.15		G
Tables/miscellaneous				
DQT	B.2.4.1	B.6	B.4	o
DHT	B.2.4.2	B.7	B.5	o
COM	B.2.4.5	B.10	B.8	o
APP_n	B.2.4.6	B.11	B.9	o

5.4 Additional procedures

Figure 4 gives the "Find_SOI" procedure in which the SOI marker is identified. This determines the start of the compressed data stream.

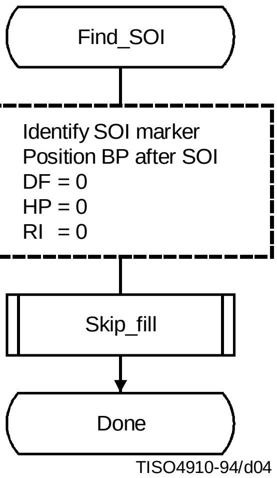


Figure 4 – Procedure to find the SOI marker

The procedure of identifying the SOI marker skips any preceding fill bytes and may require information about where the compressed data starts which is outside of this Specification. A failure to find SOI at the start of the compressed data makes the compressed data under test non-compliant.

The hierarchical-progression flag (HP), the differential-frame flag (DF), and restart-interval flag (RI) are cleared. They will be set by a DHP marker, an EXP marker, and a DRI marker, respectively. The HP and DF flags allow some procedures to be shared for the testing of both non-hierarchical and hierarchical processes.

Figure 5 shows the "Skip_fill" procedure.

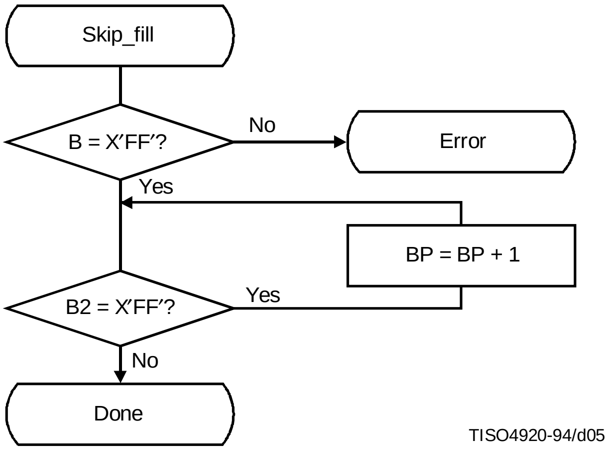


Figure 5 – Skip fill bytes procedure

First, the byte B pointed to by BP shall be an X'FF' byte. Then BP is incremented past any extra "fill" X'FF' bytes so that it will point to last X'FF' byte. Note that B2 is the byte next to B and is pointed to by BP + 1.

Figure 6 gives the "Check_frame" procedure.

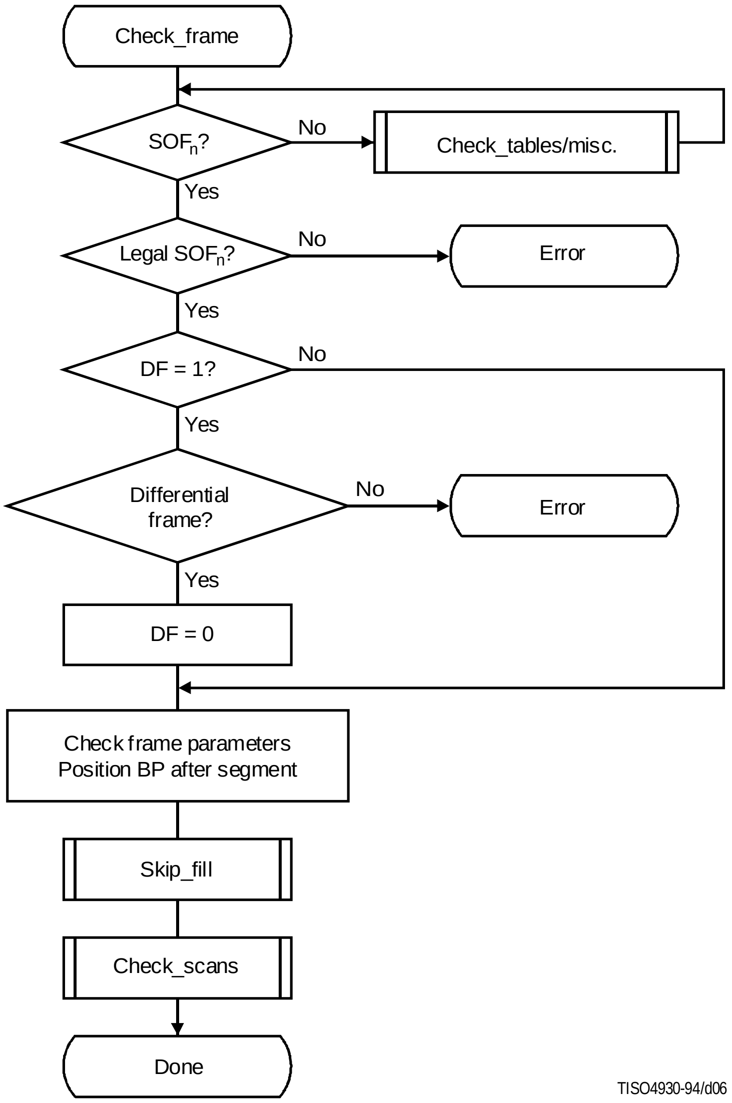


Figure 6 – The procedure for checking a frame for all coding processes

The "Legal SOFn?" test verifies that, in Table 1 for non-hierarchical processes, and Table 3 for hierarchical processes, the intersection of the column of the given process number and the line of the found SOF_n marker code, is designated by either 'G' or 'o'.

If the EXP marker has set the DF flag to 1 (in hierarchical processes only), a differential frame must follow.

The "Check_frame parameters" procedure is not specified here and is left to the tester. The tester should use the references given in Table 1 in the line containing the found SOF_n for non-hierarchical coding processes. Table 2 gives the column which is used to determine allowed range of parameter values based on the SOF_n marker for non-hierarchical coding processes. The tester should use the references for hierarchical coding processes given in Table 4 in the line containing the SOF_n for hierarchical frames. Table 4 also gives the column which is used to determine allowed range of parameter values based on the SOF_n marker for differential frames.

Figure 7 gives the "Check_tables/misc." procedure for all processes.

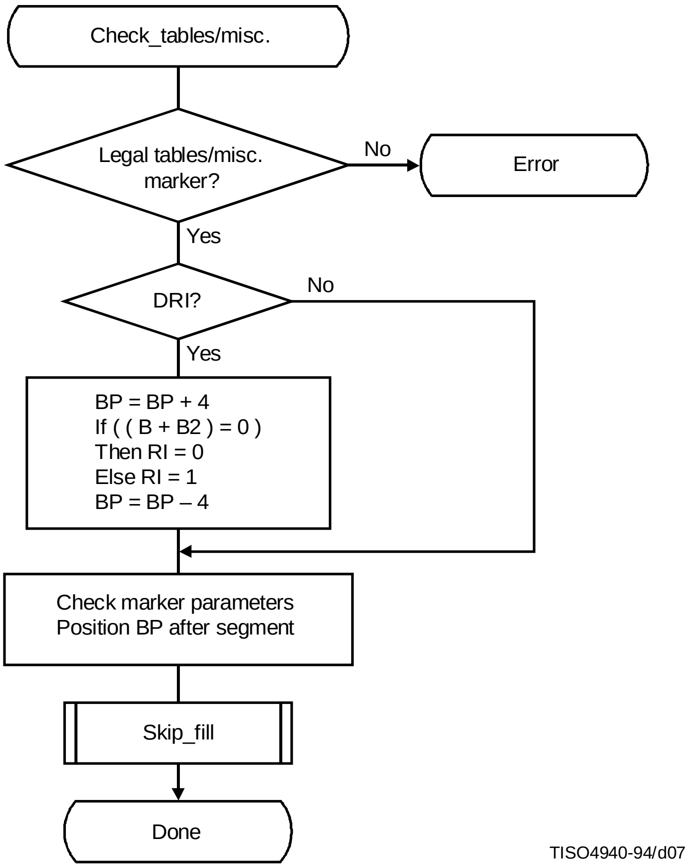


Figure 7 – Procedure to check the tables/miscellaneous markers

The "Legal tables/misc. marker?" test verifies that, in Table 1 for non-hierarchical processes, Table 3 for hierarchical processes, and Table 5 for abbreviated format for table specifications, under the tables/miscellaneous caption, the intersection of the column of the given process number and the line of the marker code to be checked, is designated by either 'G' or 'o'.

If the marker is DRI (Define Restart Interval), four is added to BP so that B points at the most significant byte and B2 at the least significant byte of the parameter Ri in order to use them to set the restart-interval flag RI. Then, four is subtracted from BP to reposition BP at the DRI marker.

The "Check marker parameters" procedure is not specified here and is left to the tester. The tester should use the references given in Table 1 for non-hierarchical processes, Table 3 for hierarchical processes, and Table 5 for abbreviated format for table specifications, in the line containing the found table/misc. marker. The appropriate column to be used to check that the parameters' values are valid can be found in Table 2 for non-hierarchical processes and Table 4 for hierarchical processes.

Figure 8 gives the "Check_scans" procedure for all coding processes.

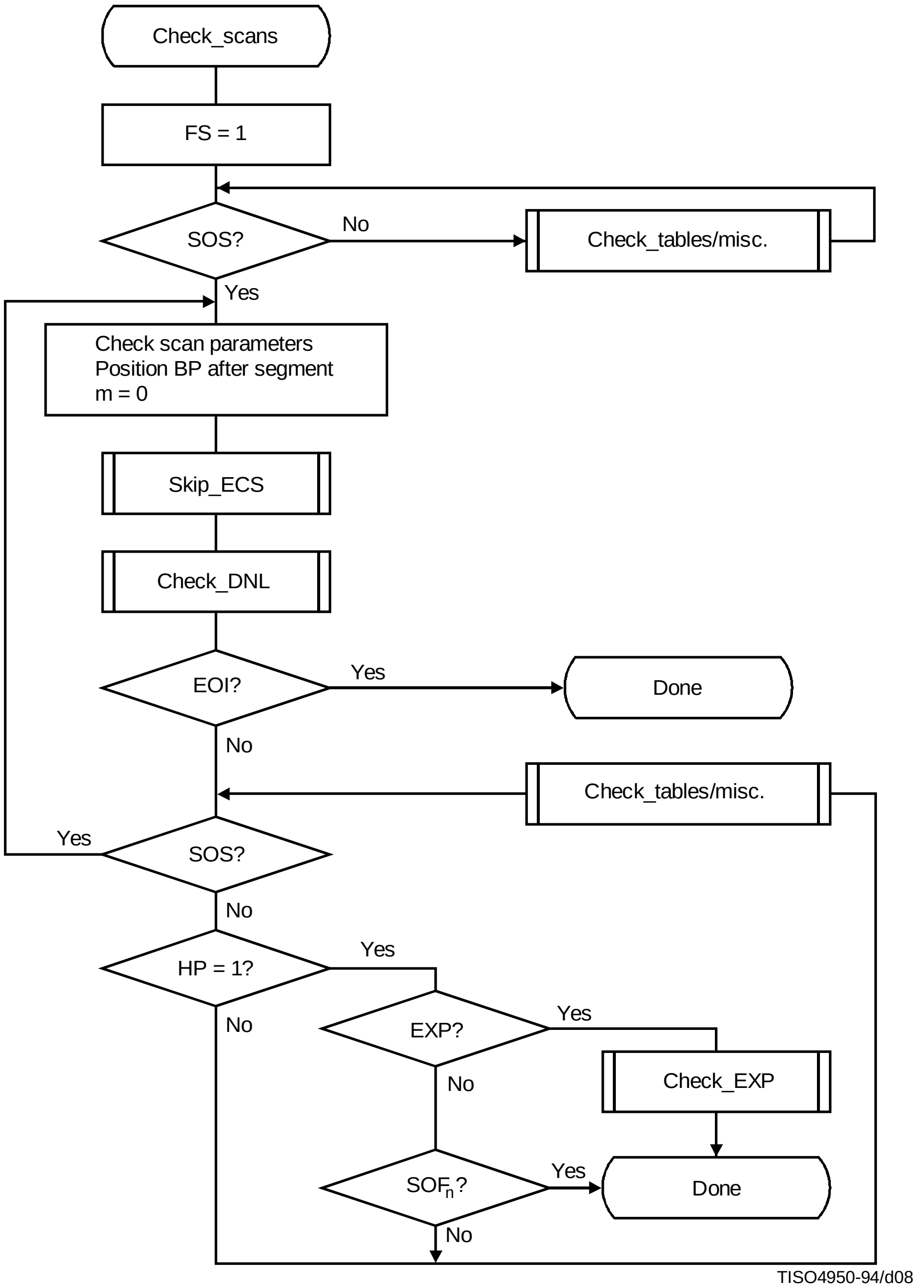


Figure 8 – The procedure for checking scans

FS is the first-scan-in-frame flag needed for syntax checking of the DNL marker in the "Check_DNL" procedure.

The "Check scan parameters" procedure is not specified here and is left to the tester. The tester should use the references given in Table 1 for non-hierarchical processes and Table 3 for hierarchical processes on the line containing SOS. The appropriate column to be used to check that the parameters' values are valid can be found in Table 2 for non-hierarchical processes and Table 4 for hierarchical processes.

An EOI marker determines the end of the compressed data stream. If an EOI marker has not been found before BP points outside the compressed data, the compressed data stream under test is non-compliant.

Figure 9 gives the "Skip_ECS" procedure.

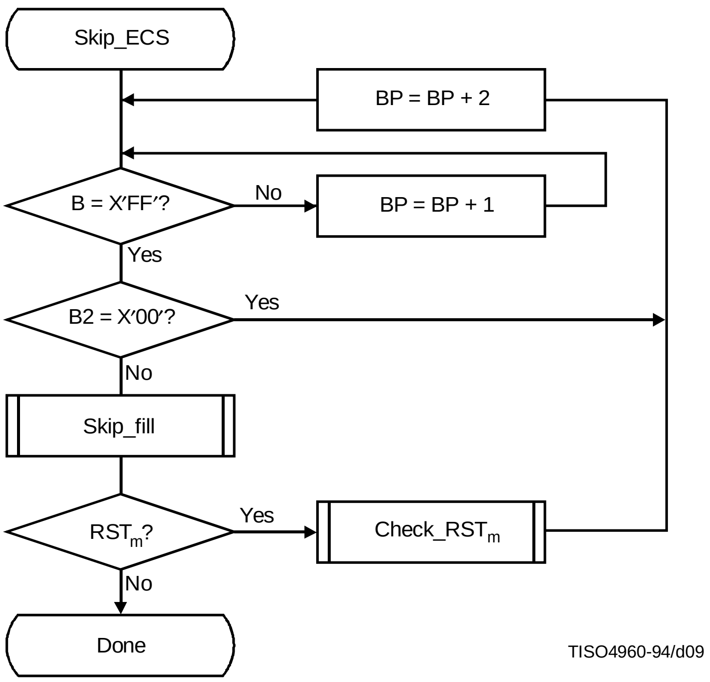


Figure 9 – Skip over entropy-coded segment procedure

Figure 10 gives the "Check_DNL" procedure.

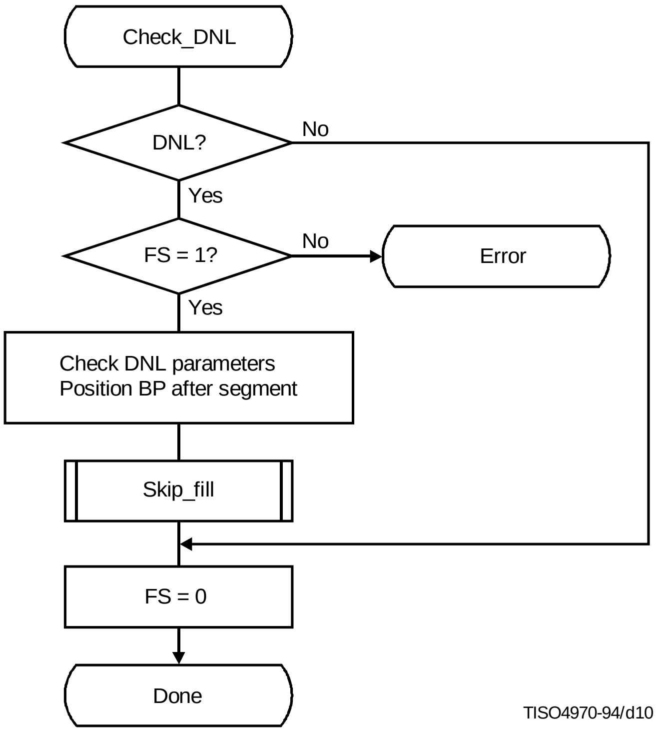


Figure 10 – Check DNL procedure

The "Check DNL parameters" procedure is not specified here and is left to the tester. The tester should use the references given in Table 1 for non-hierarchical processes, and in Table 3 for hierarchical processes, in the line containing DNL. The appropriate column to be used to check that the parameters' values are valid can be found in Table 2 for non-hierarchical processes and Table 4 for hierarchical processes.

Figure 11 gives the "Check_EXP" procedure.

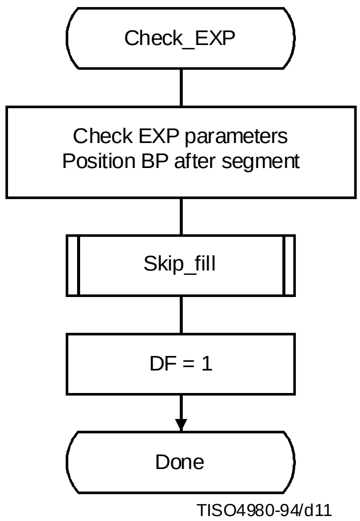


Figure 11 – Check EXP procedure

The "Check EXP parameters" procedure is not specified here and is left to the tester. The tester should use the references given in Table 3 for hierarchical processes, in the line containing EXP. The parameters' values are independent of the process. DF is set to check that the next SOF_n is a differential SOF marker.

Figure 12 gives the "Check-RST_m" procedure.

If the restart-interval flag (RI) is zero, RST_m markers are not allowed. The three least significant bits of the RST_m marker shall agree with the modulo counter m.

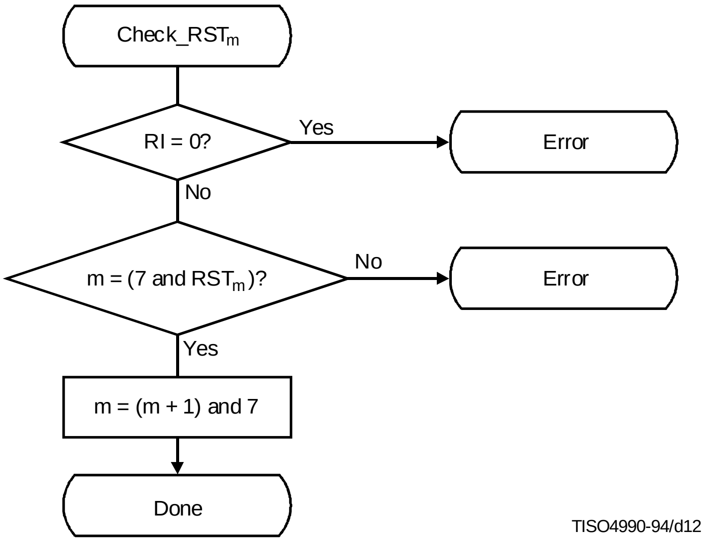


Figure 12 – Check restart marker procedure

6 Encoder compliance tests

An encoder is considered compliant to an encoding process if it satisfies the requirements stated in clause 6 of ITU-T Rec. T.81 | ISO/IEC 10918-1 and satisfies the requirements on accuracy for the compliance tests defined for that process in this Specification.

6.1 Compliance tests for DCT-based encoders

In order to determine compliance of DCT-based encoders, the test procedure set forth in A.1.1 and A.1.2 shall be performed. An encoder is found to be compliant if the resulting test data meet the requirements on accuracy specified in A.1.2.

6.2 Compliance tests for lossless encoders

No lossless encoder compliance tests are defined or required.

6.3 Availability of compliance test data

Source image test data and encoder reference test data are available from ISO/IEC and ITU (see 4.4) to parties who wish to determine compliance of a DCT-based encoder.

7 Decoder compliance tests

A decoder is considered compliant to a decoding process if it satisfies the requirements stated in clause 7 of ITU-T Rec. T.81 | ISO/IEC 10918-1 and satisfies the requirements on accuracy for the compliance tests defined for that process in this Specification.

7.1 Compliance tests for DCT-based decoders

In order to determine compliance of DCT-based decoders, the test procedure set forth in A.1.3 and A.1.4 shall be performed. A decoder is found to be compliant if the resulting test data, for all the tests specified for a particular process in 7.4, 7.5, 7.7.1 or 7.7.2, meet the requirements on accuracy specified in A.1.4.

7.2 Compliance tests for lossless decoders

In order to determine compliance of lossless decoders, the test procedure set forth in A.2.2 shall be performed. A decoder is found to be compliant if the resulting test data, for all the tests specified for a particular process in 7.6 or 7.7.3, exactly match the decoder reference test data.

7.3 Availability of compliance test data

Compressed image test data and decoder reference test data are available from ISO/IEC and ITU (for contact points see 4.4) to parties who wish to determine compliance of a DCT-based decoder.

7.4 Compliance tests for DCT-based sequential mode decoding processes (Tests A, B, C, D, E and F)

A list of the compliance tests for processes which utilize the DCT-based sequential mode of operation follow below:

- *Process 1* Baseline DCT, 8-bit sample precision.
  Required tests: A, B.
- *Process 2* Extended sequential DCT, Huffman decoding, 8-bit sample precision.
  Required tests: A, B, C.
- *Process 3* Extended sequential DCT, arithmetic decoding, 8-bit sample precision.
  Required tests: A, B, D.
- *Process 4* Extended sequential DCT, Huffman decoding, 12-bit sample precision.
  Required tests: A, B, C, E.
- *Process 5* Extended sequential DCT, arithmetic decoding, 12-bit sample precision.
  Required tests: A, B, D, F.

Compliance for baseline decoders (Process 1) requires successful completion of two tests, tests A and B. Each test defines its own compressed image test data structure. The testing procedure shall be repeated for each test using the specified compressed image test data as test input and the output data produced by each test must satisfy the requirements on accuracy for all DCT-based decoders.

The structure of the compressed image test data used by the baseline process tests (Tests A and B) are described below:

- *Test A*:

  Compressed image test data stream A1**:**

  - Interchange format syntax
  - 4 components
  - A single interleaved scan
  - Restart interval = 1/2 block row - 1

- *Test B*:

  Compressed image test data stream B1**:**

  - Abbreviated format syntax
  - Huffman and quantization tables
  - No entropy coded segments

Compressed image test data stream B2**:**

- Abbreviated format syntax
- 255 components non-interleaved

Test A specifies a compressed image test data stream which conforms to the syntax of the Interchange Format. Test B employs two compressed image test data streams (B1 and B2) which conform to the abbreviated format syntax. These two compressed image test data streams must be decoded in succession, with compressed image test data stream B2 immediately following the EOI marker of compressed image test data stream B1. The output test data produced after compressed image test data stream B2 is decoded must satisfy the requirements on accuracy for all DCT-based decoders.

All other tests defined for the DCT-based sequential processes (tests C, D, E and F) employ two compressed image test data streams as input: one interleaved and one non-interleaved. Each of the two compressed image test data streams is tested separately. See Annex C for a specification of the compressed image test data streams utilized.

7.5 Compliance tests for DCT-based progressive mode decoding processes (Tests G, H, I, J, K, L, M and N)

A list of the compliance tests for decoding processes which utilize the DCT-based progressive mode of operation follow below:

- *Process 6* Spectral selection only, Huffman decoding, 8-bit sample precision.
  Required tests: A, B, C, G.
- *Process 7* Spectral selection only, arithmetic decoding, 8-bit sample precision.
  Required tests: A, B, D, H.
- *Process 8* Spectral selection only, Huffman decoding, 12-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, C, E, G, I.
- *Process 9* Spectral selection only, arithmetic decoding, 12-bit sample precision.
  Required tests: A, B, D, F, H, J.
- *Process 10* Full progression, Huffman decoding, 8-bit sample precision.
  Required tests: A, B, C, G, K.
- *Process 11* Full progression, arithmetic decoding, 8-bit sample precision.
  Required tests: A, B, D, H, L.
- *Process 12* Full progression, Huffman decoding, 12-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, C, E, G, I, K, M.
- *Process 13* Full progression, arithmetic decoding, 12-bit sample precision.
  Required tests: A, B, D, F, H, J, L, N.

The tests defined for the DCT-based progressive processes each employ a single compressed image test data stream to be used as input. See Annex C for a specification of the compressed image test data utilized.

7.6 Compliance tests for lossless mode decoding processes (Tests O and P)

A list of the compliance tests for processes which utilize the lossless mode of operation follow below:

- *Process 14* Lossless, Huffman decoding, 2- through 16-bit sample precision.
  Required tests: O.
- *Process 15* Lossless, arithmetic decoding, 2- through 16-bit sample precision.
  Required tests: P.

The required tests of each lossless mode process each utilize two compressed image test data streams having different sample precision: 8 and 16 bits respectively. Also, the compressed image test data streams have different encoding order: interleaved and non-interleaved. Each of the two compressed image test data streams is tested separately. See Annex C for a specification of the compressed image test data utilized.

7.7 Compliance tests for hierarchical mode decoding processes

Hierarchical compliance tests utilize compressed image test data comprized of several stages as input. Every stage within a particular hierarchical compliance test employs one of the processes numbered 2-15, as modified for hierarchical mode.

Every hierarchical compliance test designates that a decoder shall pass additional tests which address functional subsets of the current test.

7.7.1 Compliance tests for hierarchical mode with DCT-based sequential decoding processes (Tests Q and R)

A list of the compliance tests for decoders which utilize DCT-based sequential processes in the hierarchical mode of operation follow below:

- *Process 16* Extended sequential DCT, Huffman decoding, 8-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, C, Q.
- *Process 17* Extended sequential DCT, arithmetic decoding, 8-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, D, R.
- *Process 18* Extended sequential DCT, Huffman decoding, 12-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, C, E, Q.
- *Process 19* Extended sequential DCT, arithmetic decoding, 12-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, D, F, R.

The tests which address DCT-based sequential configurations (Tests Q and R) utilize compressed image test data streams having 6 frames. See Annex C for a specification of the compressed image test data utilized.

When compliance test data becomes available, decoders capable of processing a final lossless stage shall also complete an additional test: Test S for Huffman decoders and test T for arithmetic decoders.

7.7.2 Compliance tests for hierarchical mode with DCT-based progressive processes (Tests Q and R)

A list of the compliance tests for decoders which utilize DCT-based progressive processes in the hierarchical mode of operation follow below:

- *Process 20* Spectral selection only, Huffman decoding, 8-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, C, G, Q.
- *Process 21* Spectral selection only, arithmetic decoding, 8-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, D, H, R.
- *Process 22* Spectral selection only, Huffman decoding, 12-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, C, E, G, I, Q.
- *Process 23* Spectral selection only, arithmetic decoding, 12-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, D, F, H, J, R.
- *Process 24* Full progression, Huffman decoding, 8-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, C, G, K, Q.

- *Process 25* Full progression, arithmetic decoding, 8-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, D, H, L, R.
- *Process 26* Full progression, Huffman decoding, 12-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, C, E, G, I, K, M, Q.
- *Process 27* Full progression, arithmetic decoding, 12-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: A, B, D, F, H, J, L, N, R.

When compliance test data becomes available, decoders capable of processing a final lossless stage shall also complete an additional test: test S for Huffman decoders and test T for arithmetic decoders.

7.7.3 Compliance tests for hierarchical mode with lossless decoding processes (Tests S and T)

A list of the compliance tests for decoders which utilize lossless processes in the hierarchical mode of operation follow below:

- *Process 28* Lossless, Huffman decoding, 2- through 16-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: O, S.
- *Process 29* Lossless, arithmetic decoding, 2- through 16-bit sample precision.
  Compliance test data for this process is not yet available and thus there is no normative compliance test at this time. When compliance test data becomes available, the required tests will be: P, T.

The tests which address lossless configurations (tests S and T) utilize compressed image test data streams having 5 frames. See Annex C for a specification of the compressed image test data utilized.

7.8 Summary of decoder compliance test requirements

Assuming the availability of all compliance test data, Table 6 summarizes the tests required to determine compliance for each decoding process.

NOTE – The compressed image test data streams for the compliance tests of some processes are not available at this time and thus, there are no normative compliance tests for those processes. Therefore, Table 6 gives the tests required to determine compliance once all compliance test data becomes available. The decoding processes which have no normative compliance tests at this time are: processes 8, 12, and 16-29.

Table 6 – Decoder compliance test requirements for each process

	Test																			
Process	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	G	G																		
2	G	G	G																	
3	G	G		G																
4	G	G	G		G															
5	G	G		G		G														
6	G	G	G				G													
7	G	G		G				G												
8	G	G	G		G		G		G											
9	G	G		G		G		G		G										
10	G	G	G				G				G									
11	G	G		G				G				G								
12	G	G	G		G		G		G		G		G							
13	G	G		G		G		G		G		G		G						
14															G					
15																G				
16	G	G	G														G		o	
17	G	G		G														G		o
18	G	G	G		G												G		o	
19	G	G		G		G												G		o
20	G	G	G				G										G		o	
21	G	G		G				G										G		o
22	G	G	G		G		G		G								G		o	
23	G	G		G		G		G		G								G		o
24	G	G	G				G				G						G		o	
25	G	G		G				G				G						G		o
26	G	G	G		G		G		G		G		G				G		o	
27	G	G		G		G		G		G		G		G				G		o
28															G				G	
29																G				G

NOTE – Required tests are denoted “G”. Optional additional tests are denoted “o”.

Annex A

Procedures for determining generic encoder and decoder compliance

(This annex forms an integral part of this Recommendation | International Standard)

The compliance test procedures defined within this Specification require that output data sets generated by the device under test match reference data sets within the requirements on accuracy for the process being tested. Compliance test procedures for DCT-based processes are defined separately from the test procedures for lossless processes.

A.1 Compliance test procedures for DCT-based processes

This subclause describes the compliance tests for DCT-based processes. DCT-based process implementation accuracy is always assessed by comparison of quantized DCT data. Processes with 8-bit sample precision and the corresponding processes with 12-bit sample precision are tested using identical test procedures. However, DCT-based encoders are tested for compliance with processes having 12-bit sample precision by first left justifying the 8-bit source image test data within the 12-bit samples. Left justification can be accomplished by multiplying the 8-bit samples by 16.

A.1.1 DCT-based encoder compliance test procedure – Introduction

The encoder compliance test procedure for DCT-based processes creates a compressed image data set from the source image test data. The compressed image data is then entropy decoded using a reference entropy decoder and the decoded quantized DCT coefficients are compared with the DCT coefficients of the encoder reference test data. If the uncoded quantized DCT coefficients generated by the encoder under test are directly accessible (as possibly in a software implementation), the entropy encoding and reference entropy decoding steps may be omitted. If the quantized DCT coefficients are not directly accessible, then it is the responsibility of the implementor to provide a reference entropy decoder which is compatible with the generated compressed image data so that the necessary test data can be obtained.

The difference between the encoder implementation's quantized DCT coefficients and the encoder reference test data must not exceed the requirements on accuracy contained in A.1.2. These requirements apply to processes with 8-bit input precision and to processes with 12-bit input precision. A block diagram of the encoder testing procedure is shown in Figure A.1.

Standard data sets can be obtained from ISO/IEC and ITU (for contact points see 4.4) which contain the source image test data and the encoder reference test data to be subtracted from the output data produced by the device under test. Two encoder reference test data sets are available: one for processes employing 8-bit precision and one for processes with 12-bit input precision.

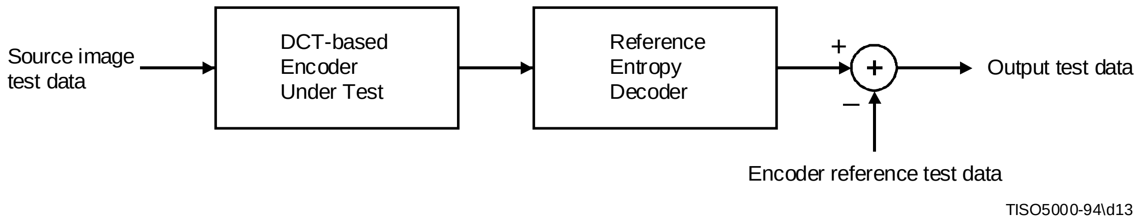


Figure A.1 – Testing procedure for a DCT-based encoder

A.1.2 Procedure for determining compliance of a DCT-based encoder

This procedure is used to determine whether a proposed implementation of a DCT-based encoder satisfies the requirements for compliance. The procedure is as follows:

1) With the supplied source image test data as input and using the quantization tables specified in Annex B, generate compressed image data using the encoder under test. The source image test data has four components designated A to D. The dimensions of the four components are listed in Annex C.

2) Decode the compressed image data using the reference entropy decoder to obtain the quantized transform coefficients for the encoder under test.

3) Subtract the decoded quantized DCT coefficients from the corresponding quantized DCT coefficients of the encoder reference test data supplied to obtain the error values. 8 × 8 blocks that were completed by extension, or blocks that were added to complete an MCU as defined in A.2.4 of ITU-T Rec. T.81 | ISO/IEC 10918-1 shall not be considered. The values of all absolute differences shall not exceed one.

A.1.3 DCT-based decoder compliance test procedure – Introduction

A DCT-based decoder is tested by first decoding the compressed image test data. The output image is then used as input to the reference FDCT and quantizer. The output of the reference FDCT and quantizer is then compared to the decoder reference test data. The reference FDCT and quantizer shall be constructed by the implementor according to the definitions in clause 3.

The quantized coefficients produced from the output image of the decoder under test shall meet the requirement on accuracy given in A.1.4.

These requirements apply to processes with 8-bit output precision and to processes with 12-bit output precision. A block diagram of the decoder testing procedure is shown in Figure A.2.

The compressed image test data and the decoder reference test data are available from ISO/IEC and ITU (for contact points see 4.4) to any parties who wish to determine compliance of a decoder. Two decoder reference test data sets are available: one for processes employing 8-bit output precision and one for processes with 12-bit output precision.

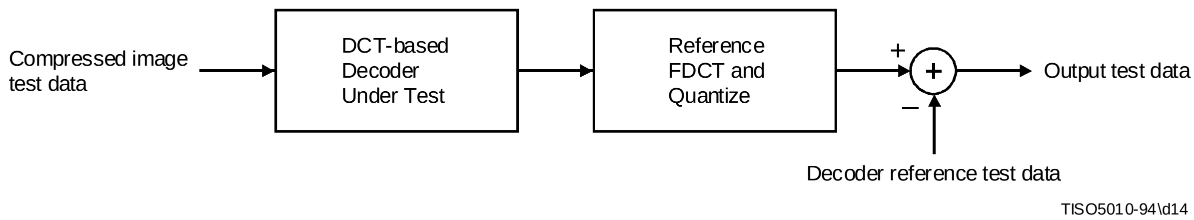


Figure A.2 – Testing procedure for a DCT-based decoder

A.1.4 Procedure for determining compliance of a DCT-based decoder

This procedure is used to determine whether a proposed implementation of a decoder satisfies the requirements for compliance. The procedure is as follows:

1) Decode the supplied compressed image test data using the decoder under test.

2) Calculate the quantized DCT coefficients from the decoded output image according to the FDCT and quantization procedures defined in Annex A of ITU-T Rec. T.81 | ISO/IEC 10918-1 implemented with double precision floating point accuracy.

3) For each quantized coefficient, subtract the reference quantized coefficient in the decoder reference test data supplied. 8 × 8 blocks that were completed by extension, or blocks that were added to complete an MCU as defined in A.2.4 of ITU-T Rec. T.81 | ISO/IEC 10918-1 shall not be considered. The values of all absolute differences shall not exceed one.

A.2 Compliance tests for lossless processes

This subclause describes the compliance test procedure for lossless processes. The lossless compliance tests require exact accuracy; output test data shall match the decoder reference test data with no differences.

A.2.1 Lossless encoder compliance test procedure

No lossless encoder compliance test procedure is defined.

A.2.2 Lossless decoder compliance test procedures

Lossless decoders are tested by decoding the compressed image test data produced by a reference encoder and comparing the output image with the image produced when the same compressed image data is decoded by a reference decoder. The output image produced by the decoder under test shall exactly match the decoder reference test data (no differences). The same requirements apply to all lossless decoders regardless of the output precision. A block diagram of the general lossless testing procedure is shown in Figure A.3.

The compressed image test data and the decoder reference test data are available from ISO/IEC and ITU (for contact points see 4.4) to any parties who wish to determine compliance of a lossless decoder process.

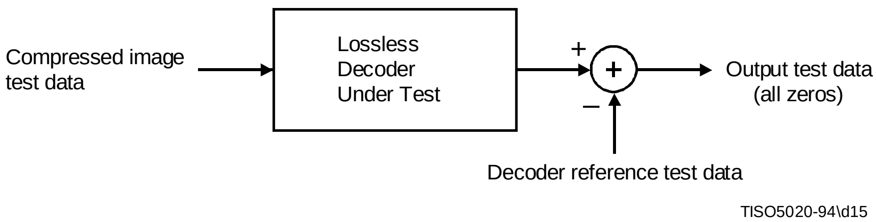


Figure A.3 – General testing procedure for a lossless decoder

Annex B

Quantization tables for generic compliance testing of DCT-based processes

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies the quantization tables used in compliance tests for all DCT-based processes. These quantization tables are used for compliance testing of generic encoders and decoders. The source image test data are comprised of four components designated A to D and are reused as needed.

The quantization tables are defined in Tables B.1 to B.4. The compliance tests for those processes having 8-bit sample precision use the values in these tables as shown. The compliance tests for those processes having 12-bit sample precision use the table values multiplied by 4. The tables are presented in orthogonal, not "zig-zag", representation.

The values of quantization table for component A are shown in Table B.1.

Table B.1 – Quantization table for component A

8	6	5	8	12	20	26	30
6	6	7	10	13	29	30	28
7	7	8	12	20	29	35	28
7	9	11	15	26	44	40	31
9	11	19	28	34	55	52	39
12	18	28	32	41	52	57	46
25	32	39	44	52	61	60	51
36	46	48	49	56	50	52	50

The values of quantization table for component B are shown in Table B.2.

Table B.2 – Quantization table for component B

9	9	12	24	50	50	50	50
9	11	13	33	50	50	50	50
12	13	28	50	50	50	50	50
24	33	50	50	50	50	50	50
50	50	50	50	50	50	50	50
50	50	50	50	50	50	50	50
50	50	50	50	50	50	50	50
50	50	50	50	50	50	50	50

The values of quantization table for component C are shown in Table B.3.

Table B.3 – Quantization table for component C

16	17	18	19	20	21	22	23
17	18	19	20	21	22	23	24
18	19	20	21	22	23	24	25
19	20	21	22	23	24	25	26
20	21	22	23	24	25	26	27
21	22	23	24	25	26	27	28
22	23	24	25	26	27	28	29
23	24	25	26	27	28	29	30

The values of quantization table for component D are shown in Table B.4.

Table B.4 – Quantization table for component D

16	16	19	22	26	27	29	34
16	16	22	24	27	29	34	37
19	22	26	27	29	34	34	38
22	22	26	27	29	34	37	40
22	26	27	29	32	35	40	48
26	27	29	32	35	40	48	58
26	27	29	34	38	46	56	69
27	29	35	38	46	56	69	83

Annex C

Compressed test data stream structure for generic decoder compliance tests

(This annex forms an integral part of this Recommendation | International Standard)

Decoder compliance tests define specific compressed image data to be used as test input. Compliance tests employ reference test data which are to be compared with the test data generated by the device under test.

This annex contains specifications of the structure of the compressed test data sets utilized by decoder compliance tests.

The compressed test data streams A1, C1, C2, ... T2 define parameter values in the frame header as follows:

Sample precision (P)	=	varies with test
Number of lines (Y)	=	257
Number of samples per line (X)	=	255
Number of components (Nf)	=	4
Component identifiers (C_i)	=	200 (component A)
		150 (component B)
		100 (component C)
		50 (component D)
Horizontal sampling factors (H_i)	=	1, 1, 3, 1
Vertical sampling factors (V_i)	=	1, 2, 1, 4
Quantization table selectors (Tq_i)	=	0, 1, 2, 3

Sample precision (P) utilized is either 8 or 12 for DCT-based processes, and is either 8 or 16 for lossless processes.

These compressed data streams describe an image which, after decoding, has components with the following dimensions:

Component A	85 samples × 65 lines
Component B	85 samples × 129 lines
Component C	255 samples × 65 lines
Component D	85 samples × 257 lines

These dimensions are derived from the number of lines (Y), number of samples per line (X), horizontal sampling factors (H_i), and the vertical sampling factors (V_i) parameters in the frame header.

The compressed test data stream B2 defines parameter values in the frame header as follows:

Sample precision (P)	=	8
Number of lines (Y)	=	257
Number of samples per line (X)	=	255
Number of components (Nf)	=	255
Component identifiers (C_i)	=	254 (component A)
		253 (component B)
		252 (component C)
		251 (component D)
		250 (component A)
		249 (component A)
		248 (component A)

(C_i decrements by 1 for each scan)

... 3 (component A)

2 (component B)

1 (component C)

0 (component D)

Horizontal sampling factors (H_i) = 1, 1, 3, 1, 1, 1, 1, ... 1, 1, 3, 1

Vertical sampling factors (V_i) = 1, 2, 1, 4, 1, 1, 1, ... 1, 2, 1, 4

Quantization table selectors (Tq_i) = 0, 1, 2, 3, 0, 0, 0, ... 0, 1, 2, 3

NOTE – The compressed test data streams employ a small number of different Huffman tables. This small number of Huffman tables do not guarantee functional correctness of decoders; any valid Huffman table as defined in ITU-T Rec. T.81 | ISO/IEC 10918-1, Annex C, for a particular Huffman process, shall be supported by generic decoders claiming compliance to that same process.

C.1 Non-Hierarchical decoder compliance tests

This subclause contains specifications of the structure of the compressed test data streams utilized by non-hierarchical decoder compliance tests.

C.1.1 Compressed test data stream structure for the baseline decoding process (Test A)

Compressed test data stream A1

SOI
COM • •
DQT (Pq = 0) quant tables
DRI restart interval (Ri = 5)
SOF_0 frame parameters (P = 8)
DHT (Th = 0 – 1) Huffman tables
APP0 • •
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EOI

(Interchange format for compressed data)

C.1.2 Compressed test data stream structure for the baseline decoding process (Test B)

Compressed test data stream B1

SOI
COM • •
DQT (Pq = 0) quant tables
DHT (Th = 0 – 1) Huffman tables
EOI

(Abbreviated format for table-specification data)

Compressed test data stream B2

SOI
COM • •
SOF$_0$ frame parameters (P = 8, Nf = 255)
DRI restart interval (Ri = 11)
SOS scan parameters (Ns = 1)
entropy-coded data segment (0)
• • •
entropy-coded data segment (15)
DQT (Pq = 0) quant tables
DHT (Th = 0 – 1) Huffman tables
DRI restart interval (Ri = 0)
SOS scan parameters (Ns = 1)
entropy-coded data segment (16)
• • •
entropy-coded data segment (255)
EOI

(Abbreviated format for compressed image data)

C.1.3 Compressed test data structure for the extended sequential Huffman decoding process, 8-bit sample precision (Test C)

Compressed test data stream C1

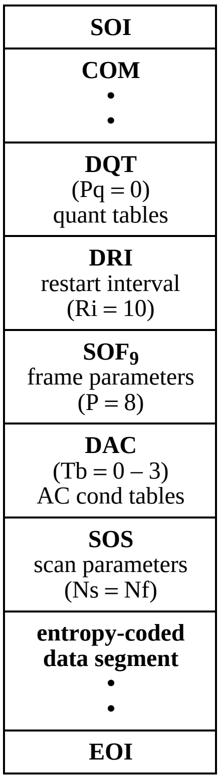
SOI
COM • •
DQT (Pq = 0) quant tables
DRI restart interval (Ri = 10)
SOF_1 frame parameters (P = 8)
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EOI

Compressed test data stream C2

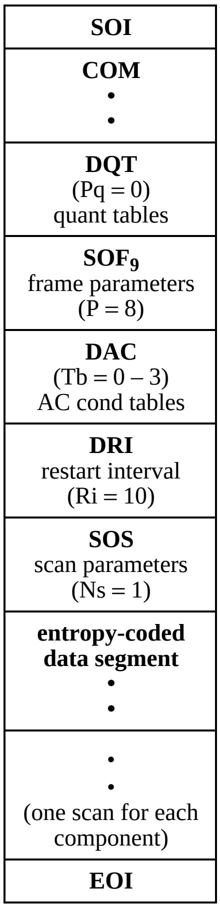
SOI
COM • •
DQT (Pq = 0) quant tables
SOF_1 frame parameters (P = 8)
DHT (Th = 0 – 3) Huffman tables
DRI restart interval (Ri = 10)
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
• • (one scan for each component)
EOI

C.1.4 Compressed test data structure for the extended sequential arithmetic decoding process, 8-bit sample precision (Test D)

Compressed test data stream D1

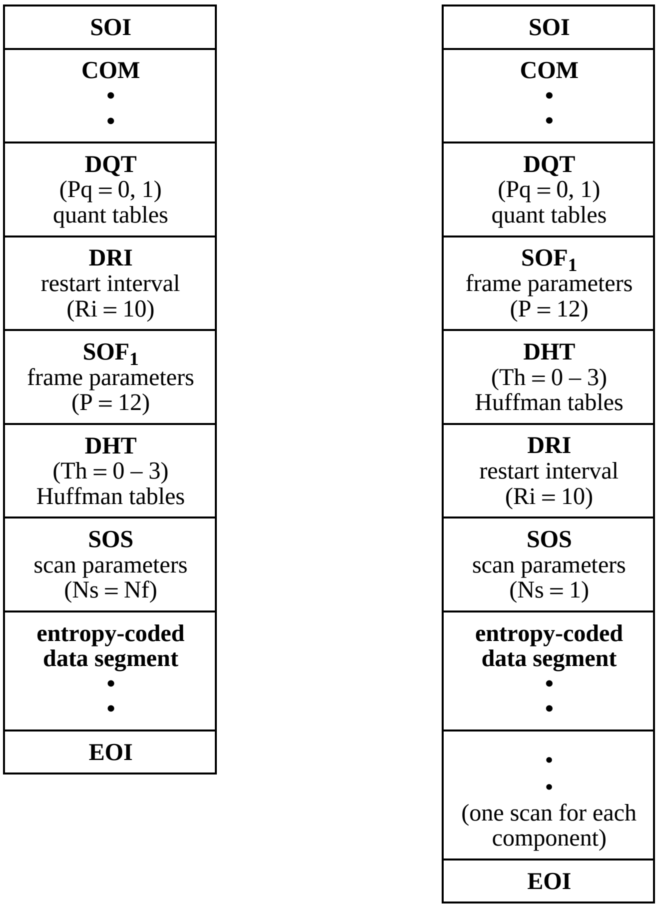


Compressed test data stream D2



C.1.5 Compressed test data structure for the extended sequential Huffman decoding process, 12-bit sample precision (Test E)

Compressed test data stream E1 **Compressed test data stream E2**



C.1.6 Compressed test data structure for the extended sequential arithmetic decoding process, 12-bit sample precision (Test F)

Compressed test data stream F1

SOI
COM • •
DQT (Pq = 0, 1) quant tables
DRI restart interval (Ri = 10)
SOF$_9$ frame parameters (P = 12)
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EOI

Compressed test data stream F2

SOI
COM • •
DQT (Pq = 0, 1) quant tables
SOF$_9$ frame parameters (P = 12)
DAC (Tb = 0 – 3) AC cond tables
DRI restart interval (Ri = 10)
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
• • (one scan for each component)
EOI

C.1.7 Compressed test data structure for the progressive spectral selection Huffman decoding process, 8-bit sample precision (Test G)

Compressed test data stream G1

SOI
COM • •
DQT (Pq = 0) quant tables
DRI restart interval (Ri = 10)
SOF_2 frame parameters (P = 8)
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 3, Ss = Se = 0, Ah = Al = 0)
entropy-coded **data segment** • •
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 1, Ss = Se = 0, Ah = Al = 0)
entropy-coded **data segment** • •
• • (total of 10 scans)
EOI

C.1.8 Compressed test data structure for the progressive spectral selection arithmetic decoding process, 8-bit sample precision (Test H)

Compressed test data stream H1

SOI
COM • •
DQT (Pq = 0) quant tables
DRI restart interval (Ri = 10)
SOF_{10} frame parameters (P = 8)
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 3, Ss = Se = 0, Ah = Al = 0)
entropy-coded data segment • •
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 1, Ss = Se = 0, Ah = Al = 0)
entropy-coded data segment • •
• • (total of 10 scans)
EOI

C.1.9 Compressed test data structure for the progressive spectral selection Huffman decoding process, 12-bit sample precision (Test I)

NOTE – The compressed image test data which has the structure specified by this subclause is not yet available.

Compressed test data stream I1

SOI
COM • •
DQT (Pq = 0, 1) quant tables
DRI restart interval (Ri = 10)
SOF_2 frame parameters (P = 12)
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 3, Ss = Se = 0, Ah = Al = 0)
entropy-coded data segment • •
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 1, Ss = Se = 0, Ah = Al = 0)
entropy-coded data segment • •
• • (total of 10 scans)
EOI

C.1.10 Compressed test data structure for the progressive spectral selection arithmetic decoding process, 12-bit sample precision (Test J)

Compressed test data stream J1

SOI
COM • •
DQT (Pq = 0, 1) quant tables
DRI restart interval (Ri = 10)
SOF_{10} frame parameters (P = 12)
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 3, Ss = Se = 0, Ah = Al = 0)
entropy-coded data segment • •
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 1, Ss = Se = 0, Ah = Al = 0)
entropy-coded data segment • •
• • (total of 10 scans)
EOI

C.1.11 Compressed test data structure for the full progressive Huffman decoding process, 8-bit sample precision (Test K)

Compressed test data stream K1

SOI
COM • •
DQT (Pq = 0) quant tables
DRI restart interval (Ri = 10)
SOF_2 frame parameters (P = 8)
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 1, Ss = Se = 0, Ah = 0, Al = 1)
entropy-coded data segment • •
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 3, Ss = Se = 0, Ah = 0, Al = 1)
entropy-coded data segment • •
• • (total of 15 scans)
EOI

C.1.12 Compressed test data structure for the full progressive arithmetic decoding process, 8-bit sample precision (Test L)

Compressed test data stream L1

SOI
COM • •
DQT (Pq = 0) quant tables
DRI restart interval (Ri = 10)
SOF$_{10}$ frame parameters (P = 8)
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 1, Ss = Se = 0, Ah = 0, Al = 1)
entropy-coded data segment • •
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 3, Ss = Se = 0, Ah = 0, Al = 1)
entropy-coded data segment • •
• • (total of 15 scans)
EOI

C.1.13 Compressed test data structure for the full progressive Huffman decoding process, 12-bit sample precision (Test M)

NOTE – The compressed image test data which has the structure specified by this subclause is not yet available.

Compressed test data stream M1

SOI
COM • •
DQT (Pq = 0, 1) quant tables
DRI restart interval (Ri = 10)
SOF_2 frame parameters (P = 12)
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 1, Ss = Se = 0, Ah = 0, Al = 1)
entropy-coded data segment • •
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 3, Ss = Se = 0, Ah = 0, Al = 1)
entropy-coded data segment • •
• • (total of 20 scans)
EOI

C.1.14 Compressed test data structure for the full progressive arithmetic decoding process, 12-bit sample precision (Test N)

Compressed test data stream N1

SOI
COM • •
DQT (Pq = 0, 1) quant tables
DRI restart interval (Ri = 10)
SOF$_{10}$ frame parameters (P = 12)
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 1, Ss = Se = 0, Ah = 0, Al = 1)
entropy-coded data segment • •
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 3, Ss = Se = 0, Ah = 0, Al = 1)
entropy-coded data segment • •
• • (total of 20 scans)
EOI

C.1.15 Compressed test data structure for the lossless Huffman decoding process, 2- through 16-bit sample precision (Test O)

Compressed test data stream O1

SOI
COM • •
DRI restart interval (Ri = 85)
SOF_3 frame parameters (P = 8)
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EOI

Compressed test data stream O2

SOI
COM • •
SOF_3 frame parameters (P=16)
DHT (Th = 0 – 3) Huffman tables
DRI restart interval (Ri = 170)
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
DRI restart interval (Ri = 0)
• • (one scan for each component)
EOI

C.1.16 Compressed test data structure for the lossless arithmetic decoding process, 2- through 16-bit sample precision (Test P)

Compressed test data stream P1

SOI
COM • •
DRI restart interval (Ri = 85)
SOF$_{11}$ frame parameters (P = 8)
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EOI

Compressed test data stream P2

SOI
COM • •
SOF$_{11}$ frame parameters (P = 16)
DAC (Tb = 0 – 3) AC cond tables
DRI restart interval (Ri = 170)
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
DRI restart interval (Ri = 0)
• • (one scan for each component)
EOI

C.2 Hierarchical decoder compliance tests

This subclause contains specifications of the structure of the compressed test data streams utilized by hierarchical decoder compliance tests.

C.2.1 Compressed test data structure for hierarchical DCT-based sequential Huffman decoding processes (Test Q)

NOTE – The compressed image test data which has the structure specified by this subclause is not yet available.

Compressed test data stream Q1
SOI
COM • •
DHP hierarchical parameters
DQT quant tables
SOF$_1$ frame parameters
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EXP expand 2:1, 2:1
SOF$_5$ frame parameters
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
• • (repeat for total of 4 differential frames)
EOI

Compressed test data stream Q2
SOI
COM • •
DHP hierarchical parameters
DQT quant tables
SOF$_1$ frame parameters
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
• • (one scan for each component)
EXP expand 2:1, 2:1
SOF$_5$ frame parameters
• • (repeat for total of 4 differential frames)
EOI

C.2.2 Compressed test data structure for hierarchical DCT-based sequential arithmetic decoding processes (Test R)

NOTE – The compressed image test data which has the structure specified by this subclause is not yet available.

Compressed test data stream R1

SOI
COM • •
DHP hierarchical parameters
DQT quant tables
SOF_9 frame parameters
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EXP expand 2:1, 2:1
SOF_{13} frame parameters
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
• • (repeat for total of 4 differential frames)
EOI

Compressed test data stream R2

SOI
COM • •
DHP hierarchical parameters
DQT quant tables
SOF_9 frame parameters
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
• • (one scan for each component)
EXP expand 2:1, 2:1
SOF_{13} frame parameters
• • (repeat for total of 4 differential frames)
EOI

C.2.3 Compressed test data structure for the hierarchical lossless Huffman decoding processes (Test S)

NOTE – The compressed image test data which has the structure specified by this subclause is not yet available.

Compressed test data stream S1

SOI
COM • •
DHP hierarchical parameters
SOF_3 frame parameters (P = 8)
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EXP expand 2:1, 2:1
SOF_7 frame parameters
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
• • (repeat for total of 4 differential frames)
EOI

Compressed test data stream S2

SOI
COM • •
DHP hierarchical parameters
SOF_3 frame parameters (P = 16)
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
• • (one scan for each component)
EXP expand 2:1,2:1
SOF_7 frame parameters
DHT (Th = 0 – 3) Huffman tables
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
• • (one scan for each component)
• • (repeat for total of 4 differential frames)
EOI

C.2.4 Compressed test data structure for the hierarchical lossless arithmetic decoding processes (Test T)

NOTE – The compressed image test data which has the structure specified by this subclause is not yet available.

Compressed test data stream T1

SOI
COM • •
DHP hierarchical parameters
SOF_{11} frame parameters (P = 8)
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
EXP expand 2:1, 2:1
SOF_{15} frame parameters
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = Nf)
entropy-coded data segment • •
• • (repeat for total of 4 differential frames)
EOI

Compressed test data stream T2

SOI
COM • •
DHP hierarchical parameters
SOF_{11} frame parameters (P = 16)
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
• • (one scan for each component)
EXP expand 2:1, 2:1
SOF_{15} frame parameters
DAC (Tb = 0 – 3) AC cond tables
SOS scan parameters (Ns = 1)
entropy-coded data segment • •
• • (one scan for each component)
• • (repeat for total of 4 differential frames)
EOI

Annex D

Construction of application-specific compliance tests

(This annex forms an integral part of this Recommendation | International Standard)

Many application-specific encoders and decoders are incapable of operating over the full range of parameter values specified in ITU-T Rec. T.81 | ISO/IEC 10918-1 for a particular process. Also, the requirements on accuracy defined in Annex A in combination with the quantization tables specified in Annex B are not a guarantee of satisfactory image quality for all application environments. Therefore, each application may construct application-specific compliance tests which constrain the range of parameter values or specify different quantization tables.

D.1 Procedure for construction of application-specific compliance tests for DCT-based processes

The parameters which may be constrained for DCT-based processes are as follows:

- Number of samples per line (X);
- Number of lines (Y);
- Number of image components in frame (Nf);
- Horizontal sampling factor (H_i);
- Vertical sampling factor (V_i);
- Number of image components in scan (Ns).

The following parameters may be constrained to the range [0, (maximum number of tables) – 1]:

- Quantization table destination identifier (Tq);
- Huffman table destination identifier (Th);
- AC conditioning table destination identifier (Tb);
- Quantization table destination selector (Tq_i);
- DC entropy coding table destination selector (Td_i);
- AC entropy coding table destination selector (Ta_i).

The values chosen for quantization depend completely on the image quality requirements of the application.

The following procedure shall be followed for construction of application-specific compliance tests for DCT-based processes.

1) Specify desired number of components, dimensions and sampling factors.
2) Create test image from the provided source image test data. Start by filling the first component, proceed from left to right, top to bottom, and end with the last component. If necessary, replicate the provided source image test data.
3) Compute encoder reference test data by applying double precision floating point FDCT and quantize using application-specific quantization tables.
4) Produce compressed test data stream for decoding process by encoding quantized DCT coefficients using the entropy encoder.
5) Compute decoder reference test data by applying double precision floating point IDCT and inverse quantizer to the encoder reference test data. Clip the resulting output data to the range of the sample precision ([0,255] for 8-bit precision and [0,4095] for 12-bit precision). Apply the FDCT and quantizer used in step 2) to the clipped output data to produce the decoder reference test data.

NOTE – The entropy encoder which is needed to generate the compressed test data stream for application-specific compliance tests, shall be developed and validated by the creators of the application-specific compressed test data.

D.2 Procedure for construction of application-specific compliance tests for lossless processes

The parameters which may be constrained for lossless processes are as follows:

- Number of samples per line (X);
- Number of lines (Y);
- Number of image components in frame (Nf);
- Horizontal sampling factor (H_i);
- Vertical sampling factor (V_i);
- Number of image components in scan (Ns).

The following parameters may be constrained to the range [0, (maximum number of tables) – 1]:

- Huffman table destination identifier (Th);
- AC conditioning table destination identifier (Tb);
- DC entropy coding table destination selector (Td_i);
- AC entropy coding table destination selector (Ta_i).

The following procedure shall be followed for construction of application-specific compliance tests for lossless processes.

1) Specify desired number of components, dimensions and sampling factors.
2) Create test image from the provided source image test data. Start by filling the first component, proceed from left to right, top to bottom, and end with the last component. If necessary, replicate the provided source image test data.
3) Compute encoder reference test data by applying the reference lossless encoder. Encoder reference test data is used as the compressed test data stream.
4) Compute decoder reference test data by applying the reference lossless decoder to the compressed test data stream.

NOTE – The reference lossless encoder and reference lossless decoder which are needed to generate the test data for application-specific compliance tests, shall be developed and validated by the creators of the application-specific test data.

D.3 Procedure for determining compliance of application-specific encoders and decoders

The procedure for application-specific compliance testing follows the procedure defined in Annex A, using the reference test data and the compressed test data stream generated by the procedure defined in D.1 and D.2. The output test data shall satisfy the requirements on accuracy defined in Annex A except the value of absolute differences. The values of all absolute differences shall not exceed a level set by the application.

Annex E

Compliance test data for testing of greater computational accuracy

(This annex does not form an integral part of this Recommendation | International Standard)

Greater computational accuracy of an encoder's FDCT/quantizer, or of a decoder's IDCT, can be tested by first changing the quantization tables shown in Annex B, and then following the Annex A procedures for testing generic DCT-based encoders or decoders. In addition to the compliance test data supplied for compliance testing of generic encoders and decoders, test data which utilizes different quantization tables are provided to assist implementors in measurement of greater computational accuracy. This annex specifies the structure of the compressed image data and quantization tables utilized in this additional test data.

E.1 Quantization table scale factors

The quantization tables used in the test data provided for the measurement of greater computational accuracy are derived by dividing the value of quantization tables in Annex B by a scale factor, F, where F is a power of 2.

Quantization table values for a given value of F are computed from the following formula:

$$E_{ij} = \lceil B_{ij} / F \rceil$$

for i = 0 – 7; for j = 0 – 7.

where

$\lceil\ \rceil$ represents the ceiling function, i.e. rounding up to the next larger integer;

E_{ij} is the quantization table value used in testing for greater accuracy;

B_{ij} is the quantization table value defined in Annex B;

F is the scale factor.

Table E.1 contains the resulting values of the quantization table for Component A (see Annex B) for F = 2.

Table E.1 – Quantization Table for Component A for F = 2

4	3	3	4	6	10	13	15
3	3	4	5	7	15	15	14
4	4	4	6	10	15	18	14
4	5	6	8	13	22	20	16
5	6	10	14	17	28	26	20
6	9	14	16	21	26	29	23
13	16	20	22	26	31	30	26
18	23	24	25	28	25	26	25

E.2 Tests for measurement of greater computational accuracy

Test data is provided for six tests. The test designations and the values of F utilized are shown below:

Test	*F*
A2	2
A3	4
A4	8
A5	16
A6	32
A7	64

E.2.1 Encoder tests

The encoder tests for measurement of greater computational accuracy are performed by following the procedure set forth in A.1.1 and A.1.2. The test is successfully completed if the generated test data satisfies the requirements on accuracy specified in A.1.2.

E.2.2 Decoder tests

The decoder tests for measurement of greater computational accuracy are performed by following the procedure set forth in A.1.3 and A.1.4. The test is successfully completed if the generated test data satisfies the requirements on accuracy specified in A.1.4.

The decoder tests use test data with structure identical to that used by test A. See C.1.1 for a detailed specification of the compressed test data stream structure.

Annex F

Specification of supported parameter ranges

(This annex does not form an integral part of this Recommendation | International Standard)

Many application-specific decoding devices are incapable of processing compressed images over the full range of parameter values specified by the particular decoding process. In addition, the generic compliance tests do not test many of the parameters over their entire allowable range of values.

For these reasons, it is strongly recommended that, for certain parameters, implementors publish the allowable parameter ranges for each decoding process supported. A table similar to Table F.1 should be used for this purpose.

It is recommended that the DCT accuracy level be one for most applications (see A.1.4). For those applications requiring greater precision, lossless coding should be considered. It is recognized that certain applications may have a DCT accuracy level greater than one.

Table F.1 – Parameter ranges supported

Parameter	Size (bits)	Sequential DCT		Progressive DCT	Lossless
		Baseline	Extended		
Sample precision (P)	8				
Number of lines (Y)	16				
Number of samples per line (X)	16				
Number of components in frame (Nf)	8				
Horizontal sampling factors (H_i)	4				
Vertical sampling factors (V_i)	4				
Quantization table selectors (Tq_i)	8				
Number of components in scan (Ns)	8				
Other information					

Annex G

Test data for validation of implementations

(This annex does not form an integral part of this Recommendation | International Standard)

This annex contains a description of image source data, intermediate results of various procedures, compressed data streams, and final reconstructed images which may be used to validate implementations of the various processes specified by this Specification. The tests described in this annex are informative and do not replace or modify the compliance test requirements.

G.1 Test data description

Referring to Figure 4 of ITU-T Rec. T.81 | ISO/IEC 10918-1, test data for validation of encoder processes have the following elements:

1) source image data;
2) unquantized FDCT coefficients;
3) quantized DCT coefficients;
4) compressed data streams.

Referring to Figure 6 of ITU-T Rec. T.81 | ISO/IEC 10918-1, test data for validation of decoder processes includes items 3) and 4) above, and also:

5) dequantized DCT coefficients;
6) reconstructed image data.

For hierarchical encoder and decoder validation tests, additional intermediate reconstructed image data before and after upsampling are included. In addition, down sampling source image data are given. For lossless processes DCT-related data is not required.

G.2 Source image data

Six test image data sets are provided. For three precisions, 8-bit, 12-bit, and 16-bit, test sets X and Y are provided.

Test set X is a three component image with 8 bits per sample which was extracted from a CCIR Recommendation 601-1 resolution image. For higher precisions, the low order bits are random. This image is 128×128 samples with three components having horizontal sampling factors of 2:1:1. This test set has both smooth areas and high detail areas.

Test set Y is a four component image, and is the same test data as used for compliance testing. Test set Y uses a wider range of sampling factors and image dimensions which are not multiples of eight.

G.3 Compressed data streams

Validation tests are defined for representative examples of all of the modes of operation described in ITU-T Rec. T.81 | ISO/IEC 10918-1. These tests are listed in Table G.1. Note that two compressed data streams are supplied for each validation test, corresponding to the two test image data sets. The quantization tables used in the DCT-based modes are the example tables given in Annex K of ITU-T Rec. T.81 | ISO/IEC 10918-1. The modes of operation listed in Table G.1 are:

S(B) Baseline sequential DCT.

S(E) Extended sequential DCT.

P(SS) Progressive DCT with spectral selection.

P(SA) Progressive DCT with successive approximation.

P(FULL) Progressive DCT with both spectral selection and successive approximation.

LL Lossless.

H-S Hierarchical using the sequential DCT mode. This test does not include a final lossless correction.

H-L Hierarchical using lossless mode. The final output is Lossless. The first differential frame uses a point transform.

The sample Huffman tables referred to in the baseline sequential validation tests (tests 1a and 1b) are given in Annex K of ITU-T Rec. T.81 | ISO/IEC 10918-1.

In tests 2a and 2b default conditioning is used. However, this default conditioning is explicitly specified in the compressed data stream by means of a DAC marker segment.

Table G.1 – Validation compressed data streams

Validation Test	JPEG Mode	P (bits)	Entropy Coding	Coding Tables	Nf	Interleave	DRI
V1	S(B)	8	Huffman	Sample	Max	No	No
V2	S(B)	8	Huffman	Sample	Max	Yes	No
V3	S(B)	8	Huffman	Custom	Max	No	Yes
V4	S(B)	8	Huffman	Custom	Max	Yes	Yes
V5	S(E)	8	Arithmetic	Default	Max	No	Yes
V6	S(E)	8	Arithmetic	Default	Max	Yes	Yes
V7	P(SS)	8	Huffman	Custom	Max	No	Yes
V8	P(SS)	8	Huffman	Custom	Max	Yes (DC)	Yes
V9	P(SA)	8	Huffman	Custom	Max	Yes (DC)	Yes
V10	P(Full)	8	Huffman	Custom	Max	Yes (DC)	Yes
V11	P(SS)	8	Arithmetic	Custom	Max	No	Yes
V12	P(SS)	8	Arithmetic	Custom	Max	Yes (DC)	Yes
V13	P(SA)	8	Arithmetic	Custom	Max	Yes (DC)	Yes
V14	P(Full)	8	Arithmetic	Custom	Max	Yes (DC)	Yes
V15	LL	8	Huffman	Custom	1	--------	Yes
V16	LL	8	Huffman	Custom	Max	Yes	Yes
V17	LL	12	Huffman	Custom	1	--------	Yes
V18	LL	12	Huffman	Custom	Max	Yes	Yes
V19	LL	16	Huffman	Custom	1	--------	Yes
V20	LL	16	Huffman	Custom	Max	Yes	Yes
V21	LL	8	Arithmetic	Custom	1	--------	Yes
V22	LL	8	Arithmetic	Custom	Max	Yes	Yes
V23	LL	12	Arithmetic	Custom	1	--------	Yes
V24	LL	12	Arithmetic	Custom	Max	Yes	Yes
V25	LL	16	Arithmetic	Custom	1	--------	Yes
V26	LL	16	Arithmetic	Custom	Max	Yes	Yes
V27	S(E)	12	Huffman	Custom	1	--------	Yes
V28	S(E)	12	Arithmetic	Custom	1	--------	Yes
V29	H-S	8	Huffman	Custom	Max	Yes	Yes
V30	H-S	8	Arithmetic	Custom	Max	Yes	Yes
V31	H-L	8	Huffman	Custom	Max	Yes	Yes
V32	H-L	8	Arithmetic	Custom	Max	Yes	Yes

Annex H

Examples and guidelines

(This annex does not form an integral part of this Recommendation | International Standard)

This annex provides examples of test data and other guidelines.

H.1 Summary of tests described in this Specification

Table H.1 gives a summary of the tests described in this Specification.

Table H.1 – Summary of tests described in this Specification

Test		Purpose or Object of test	Supplied information	Test for compliance
Compliance tests (normative)	Compressed data compliance tests	• Interchange compressed image data format syntax compliance tests – Non-hierarchical coding processes syntax compliance tests – Hierarchical coding processes syntax compliance tests • Abbreviated compressed data format syntax requirements – Abbreviated format non-hierachical coding processes syntax compliance tests – Abbreviated format for table specification data syntax compliance – tests	Check list (Tables 1 to 4)	Consistency
	Encoder compliance tests	• Compliance tests for DCT-based encoders • Compliance tests for lossless encoders	Source image test data and encoder reference test data	DCT accuracy No tests
	Decoder compliance tests	• Compliance tests for DCT-based encoders • Compliance tests for lossless encoders	Compressed image test data and decoder reference test data	DCT accuracy No tests
Validation tests (informative)	Encoder validation tests	• Source image data • Unquantized FDCT coefficients • Quantized DCT coefficients • Compressed data streams	(For hierarchical encoder and decoder validation tests, additional intermediate reconstructed image data before and after upsampling are included. In addition, downsampling source image data are given)	No tests – For information
	Decoder validation tests	• Dequantized DCT coefficients • Reconstructed image data		No tests – For information
	Lossless validation tests	• Source image data • Compressed data streams		No tests – For information

H.2 Examples of application-specific compliance tests

This subclause contains two examples of application-specific compliance tests which utilize constrained parameter sets.

The first example utilizes a test image with three components, having samples per line and number of lines which are a multiple of 8, simplified sampling ratios and compressed image data encoded using the baseline process.

The second example utilizes a test image with one component, having samples per line and number of lines which are a multiple of 8, simplified sampling ratios and compressed image data encoded using the baseline process.

The parameter values used in these examples are shown in Tables H.2 and H.3.

Table H.2 – Parameter values used in example 1

Parameter	Size (bits)	Sequential DCT baseline process constrained to:
Sample precision (P)	8	8
Number of lines (Y)	16	256
Number of samples per line (X)	16	256
Number of components in frame (Nf)	8	3
Horizontal sampling factors (H_i)	4	2, 1, 1
Vertical sampling factors (V_i)	4	2, 1, 1
Quantization table selectors (Tq_i)	8	0, 1, 1
Number of components in scan (Ns)	8	3

Table H.3 – Parameter values used in example 2

Parameter	Size (bits)	Sequential DCT baseline process constrained to:
Sample precision (P)	8	8
Number of lines (Y)	16	256
Number of samples per line (X)	16	256
Number of components in frame (Nf)	8	1
Horizontal sampling factors (H_i)	4	1
Vertical sampling factors (V_i)	4	1
Quantization table selectors (Tq_i)	8	0
Number of components in scan (Ns)	8	1