	**International Telecommunication Union** **International Organization for Standardization** **International Electrotechnical Commission**
Source:	**ITU-T Q6/16** ***Visual Coding*** **and** **ISO/IEC JTC1/SC29/WG11** ***Coding of Moving Pictures and Audio***
Title:	**Joint Call for Proposals for Coding of Screen Content**
Status:	**Approved by ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 Q6/16** **(San Jose, 17 January 2014)**

Abstract

This document provides the final call for proposals associated with coding screen content for developing possible future extensions of HEVC.

1 Introduction

The first version of the High Efficiency Video Coding (HEVC) standard [1] targets the coding of 4:2:0 video. This standard is being extended to code 4:2:2 and 4:4:4 content via the HEVC Range Extensions amendment currently under development. Recently, investigation of new coding tools for screen-content material such as text and graphics with motion was requested, and technologies that improve the coding efficiency for screen content have been proposed.

Because there is evidence that significant improvements in coding efficiency can be obtained by exploiting the characteristics of screen content with novel dedicated coding tools, a Call for Proposals (CfP) is being issued with the target of possibly developing future extensions of the High Efficiency Video Coding (HEVC) standard including specific tools for screen content coding. Companies and organizations are invited to submit proposals in response to this Call. The use cases and requirements of this CfP are described in MPEG document N14174 [2].

The proposed technologies will be evaluated based upon objective metrics and through subjective testing. Results of these tests will be made public, taking into account that no direct identification of any of the proponents will be made (unless it is specifically requested or authorized by a proponent to be explicitly identified). Prior to having evaluated the results of the tests, no commitment to any course of action regarding the proposed technology can be made.

Descriptions of proposals shall be registered as input documents to the MPEG and VCEG meetings scheduled for March/April 2014. Proponents need to attend that meeting to present their proposals. Further information about logistical steps to attend the meeting can be obtained from the listed contact persons (see Section 10).

2 Purpose

The purpose of this CfP is to potentially start the work associated with future extensions of HEVC in coding screen content based on the responses received.

3 Timeline

2013/08/02	First Draft Call for Proposals issued
2013/11/01	Availability of test materials
2014/01/17	Final Call for Proposals
2014/01/22	Availability of anchors and end of editing period for Final CfP
2014/02/10	Mandatory registration deadline One of the contact persons (see Section 10) must be notified, and an invoice for the testing fee will be sent after registration. Additional logistic information will also be sent to proponents by this date.
2014/03/05	Coded test material shall be available at the test site[1]. By this date, the payment of the testing fee is expected to be finalized.
2014/03/17	Submission of all documents and requested data associated with the proposal (for details, contact the persons listed in Section 10)
2014/03/27-04/04	Evaluation of proposals at standardization meeting[2]
2015	Final draft standard expected.

4 Test conditions

4.1 Test material

Below is a list of the 4:4:4 screen content sequences to be used. Both the provided RGB and YCbCr formats of each sequence shall be processed. Subjective testing will be performed on only the 1920x1080 and 1280x720 resolutions and using only the RGB format.

Table 1 - Test Sequences

Resolution	Sequence name	Sxx	fps	Frames to be encoded	Copyright conditions (Annex B)
1920x1080	sc_flyingGraphics_1920x1080_60	S01	60	0-599	CC1
	sc_desktop_1920x1080_60	S02	60	0-599	CC1
	sc_console_1920x1080_60	S03	60	0-599	CC1
	sc_socialnetworkMap_1920x1080_60	S04	60	0-599	CC1
	sc_MissionControlClip3_1920x1080_60p	S05	60	0-599	CC2
1280x720	sc_web_browsing_1280x720_30	S06	30	0-299	CC3
	sc_map_1280x720_60	S07	60	0-599	CC4
	sc_programming_1280x720_60	S08	60	0-599	CC1
	sc_SlideShow_1280x720_20	S09	20	0-499	CC5
	sc_robot_1280x720_30	S10	30	0-299	CC6
2560x1440	sc_Basketball_Screen_2560x1440_60p	S11	60	322-621	CC7
	sc_MissionControlClip2_2560x1440_60p	S12	60	120-419	CC8

[1] People who formally registered will receive instructions regarding how to submit the coded materials. If material is received later than the specified deadline, the proposal may be excluded from testing.
[2] Proponents are requested to attend this standardization meeting.

4.2 Parameters and conditions

4.2.1 Test conditions, configurations, and colour formats

This section defines the test conditions and related concepts.

The two test conditions are:

- **Lossy**: The decoded compressed content is not necessarily numerically identical to the uncompressed content.
- **Mathematically lossless**: The decoded compressed content is numerically identical to the uncompressed content.

Three coding constraint conditions are defined:

- **C1**: All Intra (AI)
  - All pictures are coded as Intra pictures
- **C2**: Low delay (LD)
  - The first picture is an Intra picture, and there are no backward references for inter prediction (bi-prediction may be applied, but only without picture reordering)
- **C3**: Random Access (RA)
  - Intra picture every 16, 32, and 64 pictures for 20 fps, 30 fps, and 60 fps sequences, respectively

Colour formats:

- Both the provided RGB and YCbCr sequences shall be processed using the above test conditions and coding constraints.

4.2.2 Experimental requirements

4.2.2.1 Lossy test conditions

For each test condition, coding constraint, and colour format, four bitstreams shall be generated for each sequence. The file size (in bytes) for a submitted bitstream shall not exceed the file size of the corresponding anchor bitstream.

4.2.2.2 Mathematically lossless test conditions

For each test condition, coding constraint, and colour format, one bitstream shall be generated for each sequence.

4.2.3 Restrictions

Submissions to the call shall obey the following additional constraints:

1. No use of pre-processing.
2. Only use post-processing if it is part of the decoding process, i.e. any processing that is applied to a picture prior to its use as a reference for inter prediction of other pictures. Such processing can also be applied to non-reference pictures.
3. Quantization settings should be kept static. When change of quantization is used, e.g. as described in item 7 below, it shall be described.

4. Proponents are discouraged from optimizing encoding parameters using non-automatic means.
5. The video coding test set shall not be used as the training set for training large entropy coding tables, VQ codebooks, etc.
6. Usage of multi-pass encoding is limited to the picture level and must be documented.
7. The encoder parameters (QP, lambda, or similar encoder optimizations are allowed to be changed once while coding a sequence, in order to meet the specified file size limits).
8. The file size for a submitted bitstream shall not exceed that of the corresponding anchor bitstream.

4.3 Subjective test procedure

Subjective testing will be performed only on the bitstreams generated using the AI and LD coding constraints, and only for the 1280x720 and 1920x1080 RGB sequences. Table 2 and Table 3 in Section 5.2 show four QP values associated with each anchor sequence. For subjective testing, submitted bitstreams associated with only the three larger of these four QP values will be used. Thus, subjective testing will be performed on the three sequences comprising the lower-rate subset.

- Formal testing using naïve viewers will be performed using A/B side-by-side split-screen viewing, with the viewer voting on a scale of -4 to +4 indicating which half looks better and by how much. A vote of 0 indicates that the viewer can see no difference between the two. The reference used for subjective comparison will be the uncompressed source video. The viewing subjects will be allowed to view the source and the compressed video clips up to three times before voting. Votes will be collected in an electronic way. The scores will be converted in the scale from 1 to 5 and statistical processing of the raw data will be done following common "best practices" (MOS, SD, CI).
- The anchor sequences provide reference points demonstrating the behaviour of well-understood configurations of current technology, obeying the same constraints as imposed on the proposals. The anchors will be included in the encoded bitstreams used in the testing process.

4.3.1 Reporting of results

- Results shall be reported using an Excel spreadsheet template that will be provided by the contact persons. This template will include metrics such as file size, average bit rate, PSNR measurements, BD-Rate metrics compared against anchor(s), bit-rate savings (for lossless), and encode and decode run-times.
- For each bitstream, the number of bits used in coding each frame shall be reported separately.

5 Anchors

Anchors have been generated by encoding the source sequences using the software and configuration files described below from the HM-12.1_RExt-5.1 software.

5.1 Configuration for all anchors

The following files from the HM-12.1_RExt-5.1 software package were used to generate the anchors:

- encoder_intra_main_rext.cfg
- encoder_randomaccess_main_rext.cfg
- encoder_lowdelay_main_rext.cfg

For the lossless case, the anchors were generated using the following settings:

- QP=0
- TransquantBypassEnableFlag=1
- CUTransquantBypassFlagForce=1
- IntraReferenceSmoothing=0

For each sequence, the corresponding "per-sequence" configuration file was used as well.

5.1.1 Configuration for all constraint sets

The following settings were used to generate the anchors.

- InternalBitDepth was set to the same value as InputBitDepth (8 for these sequences).

For RGB4:4:4, the decoder was configured using:

- OutputColourSpaceConvert (RGB4:4:4 decoder only) should be set to 'GBRtoRGB' (Template will show GBR instead of YUV in column headings for the RGB sequences).

5.2 Anchor file sizes

The encoder used to generate the anchors did not insert SEI checksum information into the bitstreams. Therefore, the file sizes given in Table 2, Table 3, and Table 4 below do not include any SEI checksum information.

Table 2. QP Values and file sizes for AI

Resolution	Sequence name (shortened)	QP value	Subj. Rate index	File size RGB (bytes)	File size YCbCr (bytes)
1280x720	sc_map	22	R4	92142536	60631109
		27	R3	63087006	40896386
		32	R2	40722859	26318349
		37	R1	25871022	16474858
		lossless		255267766	208352504
	sc_programming	22	R4	92424214	65422706
		27	R3	68587520	45294260
		32	R2	48249060	29896500
		37	R1	31984402	19512303
		lossless		237164404	196083933
	sc_web_browsing	27	R4	24042330	18863728
		32	R3	19216678	13313048
		37	R2	13526650	7404084
		42	R1	9193551	4464390
		lossless		60014920	56015824
	sc_SlideShow	27	R4	16073612	9967909
		32	R3	10579588	6474135
		37	R2	6871897	4136751
		42	R1	4295851	2512257
		lossless		96357524	77383785
	sc_robot	22	R4	86019876	47116406
		27	R3	46044456	22034254

Resolution	Sequence name (shortened)	QP value	Subj. Rate index	File size RGB (bytes)	File size YCbCr (bytes)
		32	R2	21161162	10020610
		37	R1	9777473	4721550
		lossless		344070337	272110040
1920x1080	sc_console	27	R4	71637660	62899695
		32	R3	59708771	49681430
		37	R2	47451071	36969747
		42	R1	35015906	25952622
		lossless		115911401	123985645
	sc_desktop	27	R4	128657623	109585699
		32	R3	108486105	86481350
		37	R2	86926385	63435577
		42	R1	63135032	38392775
		lossless		220244062	223922485
	sc_flyingGraphics	27	R4	156528510	115189980
		32	R3	118553768	80457681
		37	R2	84041897	52118383
		42	R1	54687407	31642245
		lossless		365047853	321618357
	sc_MissionControlClip3	22	R4	171119798	122587012
		27	R3	124179415	87048142
		32	R2	88251062	58745023
		37	R1	60488288	37596391
		lossless		646995494	497499589
	sc_socialnetworkMap	22	R4	620771015	425802844
		27	R3	457084503	296741231
		32	R2	319866730	191682397
		37	R1	208822841	110570029
		lossless		1526995852	1224002107
2560x1440	sc_Basketball_Screen	22	R4	158563513	107509603
		27	R3	109787608	75164647
		32	R2	76979891	50845413
		37	R1	52956780	32673261
		lossless		448088721	368322281
	sc_MissionControlClip2	22	R4	116726423	79787824
		27	R3	78372627	51523968
		32	R2	51021052	31705494
		37	R1	32648167	19222672
		lossless		718611976	522378810

Table 3. QP Values and file sizes for LD

Resolution	Sequence name (shortened)	QP value	Subj. Rate index	File size RGB (bytes)	File size YCbCr (bytes)
1280x720	sc_map	22	R4	3580170	2113695
		27	R3	2269294	1349729
		32	R2	1397951	825221
		37	R1	836136	494097
		lossless		15556382	11238035
	sc_programming	22	R4	13483870	8499379
		27	R3	8508181	4706403
		32	R2	4750075	2230875
		37	R1	2340092	1001585

Resolution	Sequence name (shortened)	QP value	Subj. Rate index	File size RGB (bytes)	File size YCbCr (bytes)
		lossless		78897207	64009811
	sc_web_browsing	27	R4	731141	548257
		32	R3	584399	380031
		37	R2	421550	230533
		42	R1	272537	146395
		lossless		1735413	1600091
	sc_SlideShow	27	R4	2077788	1161746
		32	R3	1220110	684546
		37	R2	743270	418290
		42	R1	451212	248582
		lossless		23638943	17000124
	sc_robot	22	R4	15324321	6759983
		27	R3	5624411	2210437
		32	R2	1939874	767218
		37	R1	729349	305472
		lossless		222482527	164087109
1920x1080	sc_console	27	R4	10042844	8048197
		32	R3	8178164	6224817
		37	R2	6281133	4534981
		42	R1	4798830	2981828
		lossless		19649617	19674846
	sc_desktop	27	R4	3033207	2632886
		32	R3	2587756	2183183
		37	R2	2189938	1776766
		42	R1	1820751	1231980
		lossless		5408002	4348487
	sc_flyingGraphics	27	R4	53421802	32938128
		32	R3	30852154	18525514
		37	R2	18430257	10225575
		42	R1	10299769	5123634
		lossless		298625843	240181298
	sc_MissionControlClip3	22	R4	5851448	3240467
		27	R3	3313443	1847948
		32	R2	1873184	1072693
		37	R1	1097435	637035
		lossless		81759661	55531702
	sc_socialnetworkMap	22	R4	282016409	152924867
		27	R3	153419691	76309725
		32	R2	77790603	34114122
		37	R1	36871564	13705447
		lossless		129996901	988033085
2560x1440	sc_Basketball_Screen	22	R4	8044050	3404979
		27	R3	3477661	1647730
		32	R2	1699846	868802
		37	R1	914245	495052
		lossless		82712725	61282533
	sc_MissionControlClip2	22	R4	8333490	4707501
		27	R3	4815701	2593677
		32	R2	2622407	1375804
		37	R1	1407341	729123
		lossless		76460674	52984853

Table 4. QP Values and file sizes for RA

Resolution	Sequence name (shortened)	QP value	Subj. Rate index	File size RGB (bytes)	File size YCbCr (bytes)
1280x720	sc_map	22	R4	4501612	2840475
		27	R3	2887568	1831433
		32	R2	1823125	1140735
		37	R1	1120100	693982
		lossless		18174517	13639491
	sc_programming	22	R4	13102518	8213841
		27	R3	8030025	4474633
		32	R2	4407113	2204345
		37	R1	2317418	1110838
		lossless		82803765	67075797
	sc_web_browsing	27	R4	1290778	1022496
		32	R3	1038530	736472
		37	R2	749593	427095
		42	R1	523900	270424
		lossless		3080936	2876018
	sc_SlideShow	27	R4	2404731	1448344
		32	R3	1480810	901666
		37	R2	947351	577079
		42	R1	607024	353519
		lossless		26025993	19488012
	sc_robot	22	R4	13647023	6459781
		27	R3	5547595	2360637
		32	R2	2110351	908920
		37	R1	881611	398555
		lossless		222365735	166760700
1920x1080	sc_console	27	R4	10503018	8530286
		32	R3	8432849	6463863
		37	R2	6533184	4682673
		42	R1	4669591	2969466
		lossless		21226442	21282865
	sc_desktop	27	R4	4966344	4418817
		32	R3	4265219	3554065
		37	R2	3524449	2785623
		42	R1	2654808	1750340
		lossless		8839189	7858355
	sc_flyingGraphics	27	R4	48729745	30750698
		32	R3	28432373	17251149
		37	R2	17058695	9635504
		42	R1	9643868	4927179
		lossless		298345959	245727167
	sc_MissionControlClip3	22	R4	8087851	5072478
		27	R3	4989539	3197544
		32	R2	3161023	2015823
		37	R1	2067819	1267636
		lossless		92329952	64106756
	sc_socialnetworkMap	22	R4	236392855	128455364
		27	R3	124986899	63021987
		32	R2	63176101	28542789
		37	R1	30479593	12319840
		lossless		1302260234	988256887
2560x1440	sc_Basketball_Screen	22	R4	9130151	4530155
		27	R3	4542547	2556761
		32	R2	2596157	1539342

		37	R1	1604909	938033
		lossless		94218091	70088060
	sc_MissionControlClip2	22	R4	9216099	5559372
		27	R3	5329404	3156638
		32	R2	3035038	1755127
		37	R1	1774447	1006952
		lossless		85619170	60117415

Anchor bitstreams are available in the "CfP-Anchor" directory of the FTP site at ftp://hevc@ftp.tnt.uni-hannover.de/testsequences/FrExt-candidate-sequences/screen_content. Further details of access to the FTP site can be obtained from the listed contact persons (see Section 10).

6 Requirements on Submissions

6.1 Submission categories and details

Proponents shall provide the following; incomplete proposals will not be considered:

A) Coded test material submission to be received by 5th March 2014:

1. Bitstreams for the 1280x720 and 1920x1080 RGB lossy test cases with the larger three QP values (associated with subjective rate indexes R1, R2, and R3) as specified in Table 2 and Table 3 (Total of 60 bitstreams)
2. Decoded sequences (RGB) for the 1280x720 and 1920x1080 RGB lossy test cases with the larger three QP values specified in Table 2 and Table 3
3. Binary decoder executable.
4. MD5 Checksum files for 1.–3.

B) Coded test material to be brought for the meeting of the ITU-T/ISO/IEC Joint Collaborative Team on Video Coding (JCT-VC) beginning on 27 March 2014:

1. Bitstreams for all test cases as specified in Table 2, Table 3, and Table 4 (total of 360 bitstreams), using the naming convention given in Section 8
2. Decoded sequences (YUV and AVI files) for all test cases as specified in Table 2, Table 3, and Table 4
3. Binary decoder executable.
4. MD5 Checksum files for 1.-3.

C) Document to be submitted by 17 March 2014 shall contain:

1. A technical description of the proposal sufficient for full conceptual understanding and generation of equivalent performance results by experts and for conveying the degree of optimization required to replicate the performance. This description should include all data processing paths and individual data processing components used to generate the bitstreams. It does not need to include complete bitstream format or implementation details, although as much detail as possible is desired.
2. A completed Excel spreadsheet, using the template that will be supplied to Proponents after registration.
3. The technical description shall also contain a statement about the programming language in which the software is written, e.g. C/C++ and platforms on which the

binaries were compiled. Note that low-level programming optimizations such as assembly code/intrinsics and external video libraries are discouraged.

4. The technical description shall state how the proposed technology behaves in terms of random access to any frame within the sequence. For example, a description of the GOP structure and the maximum number of frames that must be decoded to access any frame could be given.
5. The technical description shall specify the expected encoding and decoding delay characteristics of the technology, including structural delay e.g. due to the amount of frame reordering and buffering, the degree of frame-level multi-pass decisions and the degree by which the delay can be minimized by parallel processing.
6. The technical description shall contain information suitable to assess the complexity of the implementation of the technology, including the following:
    - Encoding time[3] for each submitted bitstream of the software implementation. Proponents shall provide a description of the platform and methodology used to determine the time. To help interpretation, a description of software and algorithm optimizations undertaken, if any, is welcome.
    - Decoding time[3] for each bitstream running the software implementation of the proposal, and for the corresponding constraint case anchor bitstream(s)[4] run on the same platform. Proponents shall provide a description of the platform and methodology used to determine the time. To help interpretation, a description of software optimizations undertaken, if any, is encouraged.
    - Expected memory usage of encoder and decoder.
    - Complexity of encoder and decoder, in terms of number of operations, dependencies that may affect throughput, etc.
    - Complexity characteristics of Motion Estimation (ME) / Motion Compensation (MC): e.g. number of reference pictures, sizes of frame memories (and associated decoder data), sample value wordlength, block size, and motion compensation interpolation filter(s), if that information differs from what is already being used in the HM-12.1_RExt-5.1 anchors.
    - Description of transform(s): use of integer/floating point precision, transform characteristics (such as length of the filter/block size), if that information differs from what is already being used in HM-12.1_RExt-5.1 anchors.
    - Degree of capability for parallel processing.

D) Optional information

Proponents are encouraged (but not required) to allow other committee participants to have access, on a temporary or permanent basis, to their encoded bitstreams and binary executables or source code.

6.2 Source Code

Proponents are advised that, upon acceptance for further evaluation, it will be required that certain parts of any technology proposed be made available in source code format to participants

[3] For example, using ntimer for Windows systems.

[4] The decoder source code to be used to process the anchor bit-streams will be provided to proponents and must be compiled as-is, without modification of source code, compiler flags, or settings.

in the core experiments process and for potential inclusion in the prospective standard as reference software. When a particular technology is a candidate for further evaluation, commitment to provide such software is a condition of participation. The software shall produce identical results to those submitted to the test. Additionally, submission of further improvements (bug fixes, etc.) is certainly encouraged.

7 IPR

Proponents are advised that this call is being made subject to the common patent policy of ITU-T/ITU-R/ISO/IEC and other established policies of these standardization organizations. The persons named as contacts in Section 10 below can assist potential submitters in identifying the relevant policy information.

8 Test Sites and Delivery of Test Material

At the time of registration, the Proponents will receive instruction on the following points:

- Proponent code (to be used in the file names)
- FTP site with username and password to up-load the video files
- Name of the Test Laboratory to which to pay the test fee

The Test Coordinator will identify two or more Test Laboratories in relation to the number of received submission(s).

The test video files will be named with a name formed using the following fields:

- Pnn: uses two digits to identify the Proponent, as communicated to the Proponents by the Test Coordinator); The Anchor test sequences will be identified by the code P10;
- Sxx: uses two digits to identify one of the ten Source video sequences (see codes in "Table 1 - Test Sequences");
- Ry: uses one digit to identify one of the three encoding rates: R1 identifies the lowest rate, R2 the middle rate, and R3 the highest rate used for subjective testing (see codes in Table 2 and Table 3). Note that rate R4 is not used for the testing described in this section;
- Cz: uses one digit to identify the coding constraint set (C1 identifies AI; C2 identifies LD; C3 identifies RA – C3 not to be submitted for subjective testing)

As an example of the filename convention, the file named P10S01R1C2 will be produced using the Anchor encoder, the "*sc_flyingGraphics_1920x1080_60*" sequence, at the lowest rate (associated with QP=42 in this case) and according to the coding constraint "LD".

9 Testing Fee

Proponents will be charged a fee per submitted proposal. Such fee will be a flat charge for each proposal to cover the logistics costs of the subjective testing (without any profit). The fee is EUR 3000 and is non-refundable.

The testing fee will mainly cover costs for test labs, incentives for the test subjects, and the creation of the side by side video files, including the selection of the active windows for the S01, S02, S03, S04 and S05. The precise selection of the active windows for these video clips will not be revealed to the Proponents until the MPEG and VCEG meetings scheduled for March/April 2014. This task will be done under the responsibility and the coordination of the Test

Coordinator, who will provide the 4:4:4 <.rgb> files (to be used to run the test) to the Test Laboratories.

10 Contacts

Contact persons:

Prof. Dr. Jens-Rainer Ohm
RWTH Aachen University, Institute of Communication Engineering
Melatener Str. 23, 52074 Aachen, Germany
Tel. +49-241-8027671, Fax. +49-241-8022196, email ohm@ient.rwth-aachen.de

Dr. Gary Sullivan
Microsoft Corporation
One Microsoft Way, Redmond, WA 98052
Tel. +1-425-703-5308, Fax. +1-425-936-7329, email garysull@microsoft.com

Test Coordinator:

Dr. Vittorio Baroncini
Senior Researcher, Audio Video Signal Processing Area
Fondazione Ugo Bordoni
Viale del Policlinico, 141 - 00161 - Rome - Italy
Tel. +39-06-54802134, Mobile +39-333-5474643, email vittorio@fub.it

11 References

[1] D. Bross, W.-J. Han, J.-S. Ohm, G. J. Sullivan, Y.-K. Wang, T. Wiegand, “High Efficiency Video Coding (HEVC) text specification draft 10 (for FDIS & Last Call),” Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-M1005, Geneva, CH, Jan 2013.

[2] ISO/IEC JTC 1/SC 29/WG 11 document N14174, “Requirements for an extension of HEVC for coding of screen content”, Jan. 2014, San Jose, USA.

ANNEX A: Spreadsheet containing data for anchors

A spreadsheet specifying the file sizes and objective performance of the anchors is available in Excel files that can be obtained from the listed contact persons.

Contents:

A) Anchor performance measurement spreadsheet
    a. HM-12.1_RExt-5.1_SCC_CFP_Anchor-lossy.xlsm
    b. HM-12.1_RExt-5.1_SCC_CFP_Anchor-lossless.xlsm

B) Anchor bitstream description spreadsheet with information on file size and MD5 checksum
    a. SCC_CFP_Anchor-BitstreamDescription.xlsx

ANNEX B: Copyright conditions statements for test sequences

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