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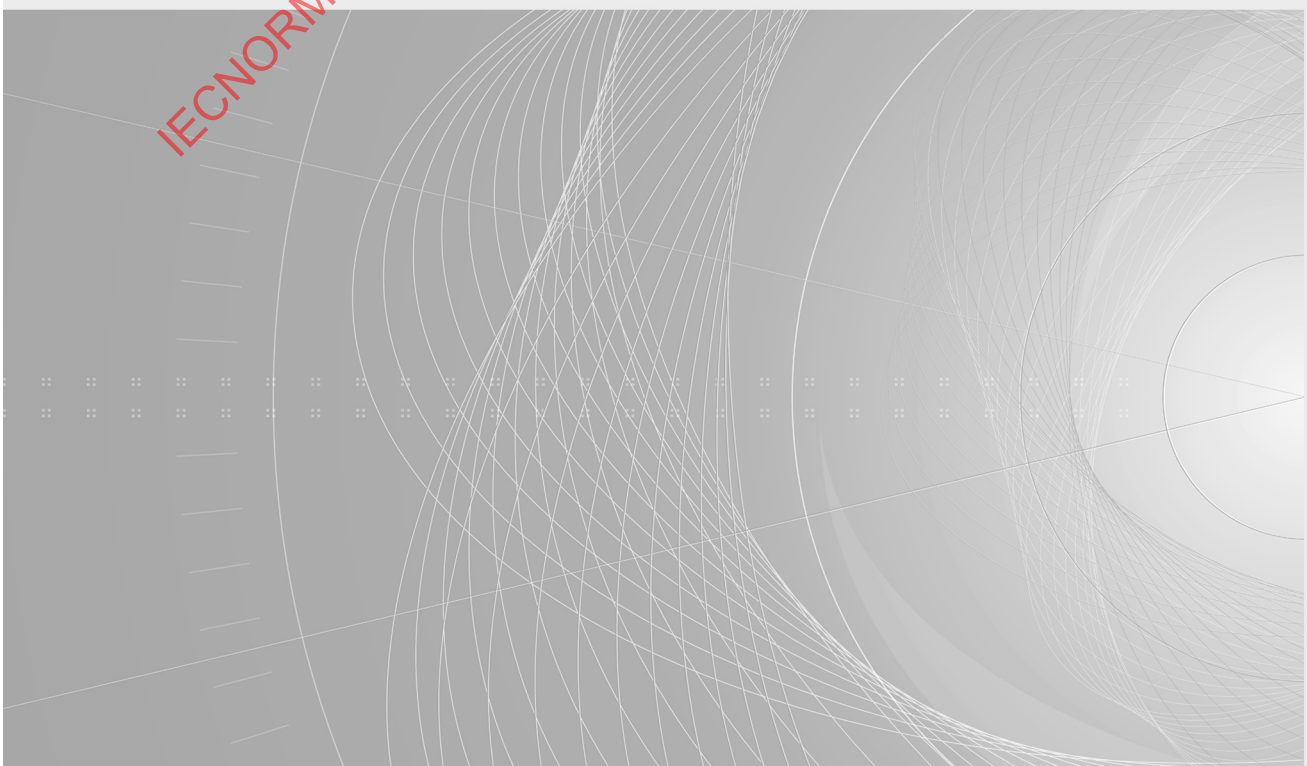
TECHNICAL REPORT

Professional tape-less camera recorder



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TECHNICAL REPORT

Professional tape-less camera recorder

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CONTENTS

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PROFESSIONAL TAPE-LESS CAMERA RECORDER

FOREWORD

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IEC 62712, which is a technical report, has been prepared by technical area 6: Storage media, data structures, equipment and systems, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
100/1781/DTR	100/1839/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

During the last few years, various types of tape-less camera recorders with different formats have emerged to the broadcast and professional video market. It is desirable to ensure interoperability and to establish its operation. The stage 0 project “Professional tape-less camera recorder” was established to meet these requirements and the purpose of this project was to study the possibility of standardization of this type of products in the current market. The initial step of study was to understand the current status of the products in the market. (Performance comparison is out of the scope of this Technical Report.)

This Technical Report was created as a summary of the project and includes the result of the product survey along with the possibility of standardization. Although the investigation is limited to the products in the market, it does not obstruct or exclude standardization of future products.

PROFESSIONAL TAPE-LESS CAMERA RECORDER

1 Scope

This Technical Report summarizes the results of the study on products and market status of professional tape-less camera recorders. This report also includes the guideline on the possibilities of standardizations for professional tape-less camera recorders, including the following components:

– codec;
– file format;
– metadata;
– recording media;
– interface.

NOTE 1 Each professional tape-less camera recorder used for the product survey is defined as “PRODUCT”.

NOTE 2 Since each PRODUCT is also defined as a “product series” of each manufacturer, PRODUCT may include two or more models with different product specifications.

NOTE 3 Some of the names described in this report represent a trademark or registered trademark of the respective companies. However, symbols such as TM and ® are omitted in this report.

NOTE 4 The interface specifications investigated in this project were limited to a file transfer or compressed bit stream transfer since this report is focusing on a file-based specification.

NOTE 5 The detail specification of each PRODUCT is shown in Annex A.

2 Result of product survey

2.1 General

In this report, eight types of PRODUCTs for investigation are listed, based on the information given by camera recorder manufacturers.

2.2 Codec

2.2.1 Video codec

Each PRODUCT uses efficient video compression formats such as MPEG-2, MPEG-4 AVC/H.264, JPEG2000 and DV. Since these specifications are defined as international standards of ISO/IEC, they can be referred to as a normative reference. The video compression format of PRODUCT-C is defined as SMPTE standard and is also defined as an IEC standard for digital VTR format. It can therefore also be referred to as a normative reference. Since all the compression formats listed in Table 1 are a well-known codec scheme and widely supported in industry, compatibility is ensured with equipment other than camera recorders.

Table 1 – Video codec

	Compression format	Referred standard
PRODUCT-A	MPEG-2 HD	ISO/IEC 13818-2
PRODUCT-B		
PRODUCT-E		
PRODUCT-F		
PRODUCT-G		
PRODUCT-H		
PRODUCT-A	MPEG-2 SD	ISO/IEC 13818-2
PRODUCT-E		
PRODUCT-F		
PRODUCT-C	MPEG-4 AVC / H.264	ISO/IEC 14496-10
PRODUCT-D		
PRODUCT-F	JPEG2000	ISO/IEC 15444-1
PRODUCT-A	DV	IEC 61834-2
PRODUCT-B		
PRODUCT-F		
PRODUCT-G		
PRODUCT-C	DV Based 100Mbps	SMPTE ST 370 (IEC 62447-2)
	DV Based 50Mbps	SMPTE ST 314 (IEC 62071-2)

2.2.2 Audio codec

It is characterized that almost all PRODUCTs listed in Table 2 use uncompressed linear PCM audio for audio codec. Altough a linear PCM specification is not defined in any published standard, linear PCM is also widely supported in many products and compatibility is ensured as well as video codec.

Table 2 – Audio codec

	Compression format	Referred standard
PRODUCT-A	Linear PCM	--
PRODUCT-B		
PRODUCT-C		
PRODUCT-E		
PRODUCT-F		
PRODUCT-G		
PRODUCT-H		

As listed in Table 3, PRODUCT-D uses AC-3 format defined in the ATSC standard which cannot be referred to as a normative reference.

Table 3 – Audio codec for PRODUCT-D

	Compression format	Referred standard
PRODUCT-D	AC-3	ATSC A/52B

2.3 File format

As a file format, MXF (Material eXchange Format) defined as SMPTE standard is adopted in the PRODUCT listed in Table 4. In order to ensure operational compatibility, several kinds of Operational Patterns are defined in the MXF specification. It is characterized that the camera recorders supporting MXF adopt OP-1a (Operational Pattern-1a) or OP-Atom (Operational Pattern-Atom). In case of shooting materials by a camera recorder, since each taken material is wrapped in an individual clip as file, complex operational patterns are not required. OP-1a is used for wrapping video and audio to a single file to facilitate contents exchange. On the other hand, OP-Atom is used for wrapping video and audio in individual files to facilitate contents editing.

NOTE MXF standards are under revision in SMPTE and, in parallel, also under study for standardization in the IEC TC100/TA6 working group. Since it is confirmed that the MXF specification has been adopted for various types of PRODUCTs, it would be significant to standardize MXF as an IEC standard in order to ensure compatibility among different types of equipment. Therefore, it is desirable to start studying standardization in IEC when primary MXF revision projects in SMPTE finish the revision work.

Table 4 – MXF based PRODUCT list

	File format	Referred standard
PRODUCT-A	MXF OP-1a	SMPTE ST 377-1, SMPTE ST 378, SMPTE ST 379-2, SMPTE ST 380, SMPTE ST 381, etc
PRODUCT-F		
PRODUCT-H		
PRODUCT-C	MXF OP-Atom	SMPTE ST 377-1, SMPTE ST 379-2, SMPTE ST 381, SMPTE ST 382, SMPTE ST 383, SMPTE ST 390, etc
PRODUCT-E		
NOTE SMPTE 377-1/379-2 is a revision of 377M-2004/379-1 that supersedes the previous 377M-2004/379-1. Existing equipment in the market may still reference the older version.		

As listed in Table 5, PRODUCT-B and PRODUCT-G adopt the MP4 file format defined as ISO/IEC standard which can be referred to as a normative reference.

Table 5 – File format of PRODUCT-B and PRODUCT-G

	File format	Referred standard
PRODUCT-B	MP4	ISO/IEC 14496-12 ISO/IEC 14496-14
PRODUCT-G		

The file formats listed in Table 6 are not defined in any standards' bodies. PRODUCT-B and PRODUCT-G adopt AVI Type 2 file format and PRODUCT-G adopts QuickTime file format.

Although both specifications are not standardized, they are generally disclosed and support various types of codec and metadata.

These file formats are widely supported in the IT industry and considered to ensure compatibility with this type of equipment. In addition, it is known that QuickTime file format is the basis for the MP4 file format.

Table 6 – File format of PRODUCT-B and PRODUCT-G

	File format	Referred standard
PRODUCT-B	AVI Type2	not standardized
PRODUCT-G		
PRODUCT-G	QuickTime	not standardized

As listed in Table 7, PRODUCT-D adopts MPEG-2 TS (Transport Stream) as a container of contents. Although MPEG-2 TS specification is defined in ISO/IEC 13818-1, actually MPEG-2 TS is not a file wrapper but a stream definition.

Table 7 – File format of PRODUCT-D

	File format	Referred standard
PRODUCT-D	MPEG-2 TS file	ISO/IEC 13818-1

2.4 Metadata

Metadata is classified as technical metadata and descriptive metadata. The technical metadata is essential data in order to play back video and audio essences. The descriptive metadata provides additional information of the shooting contents. There are two types of encoding of metadata, the determined data specification defined in each supported file format and the proprietary data specification depending on each manufacturer's PRODUCT specification. Table 8 shows metadata specification examples of MXF based camera recorder.

The technical metadata is defined in each file format specification such as MXF or MP4. Since each PRODUCT supports technical information (in case of MXF, defined as the MXF Structural metadata) required to play back video and audio essences, subsequent equipment can determine the essence format and codec type properly and play back each content.

On the other hand, in case of descriptive metadata, PRODUCTs A, F and H implement the descriptive metadata defined in the MXF standard and other PRODUCTs define a proprietary descriptive metadata scheme according to each PRODUCT specification. Each specification on the proprietary descriptive metadata scheme is not disclosed and there is no compatibility.

As for encoding format of metadata, the KLV (Key Length Value) encoding defined as SMPTE ST 336 standard is supported in the MXF specification.

The other feature clarified in this survey is that each PRODUCT adopts a separate metadata file aiming at operational conveniences. These metadata files are XML (eXtensible Markup Language) encoded in common and XML is standardized in W3C (World Wide Web Consortium). As mentioned above, since a metadata specification of each PRODUCT depends on each PRODUCT specification, there is no compatibility in metadata elements.

In order to ensure compatibility of metadata, it is required to define a common metadata scheme, description format and precise meaning of each element. However, currently only

part of technical metadata defined in each file format as essential elements for decoding is ensured compatibility. Implementation and operation of the descriptive metadata, which is specified as optional, is different in each PRODUCT.

Table 8 – Metadata specification examples of MXF based camera recorder

	Technical metadata	Descriptive metadata
PRODUCT-A	MXF Structural metadata defined in SMPTE ST 377-1 XML clip metadata	MXF Descriptive metadata scheme-1 (DMS-1) defined in SMPTE ST 380 XML clip metadata
PRODUCT-C	MXF Structural metadata defined in SMPTE ST 377-1 XML clip metadata	XML clip metadata
PRODUCT-E	MXF Structural metadata defined in SMPTE ST 377-1 XML clip metadata	XML clip metadata
PRODUCT-F	MXF Structural metadata defined in SMPTE ST 377-1 XML clip metadata	MXF Descriptive metadata scheme-1 (DMS-1) defined in SMPTE ST 380 XML clip metadata
PRODUCT-H	MXF Structural metadata defined in SMPTE ST 377-1 XML clip metadata	MXF Descriptive metadata scheme-1 (DMS-1) defined in SMPTE ST 380 SMPTE ST 385 XML clip metadata

2.5 Recording media

The recording media used in PRODUCT is classified as proprietary media developed by each camera recorder manufacture as listed in Table 9 and non proprietary media defined by a certain licensing association as listed in Table 10. Since all the specifications are not disclosed, they cannot be referred to as a normative reference.

Table 9 – Proprietary recording media

	Media name	Kind	Detail specification
PRODUCT-A	Professional Disc	Optical Disc	Not disclosed
PRODUCT-B	SxS card	Flash memory card	Not disclosed
PRODUCT-C	P2 card	Flash memory card	Not disclosed
PRODUCT-E	GF Pack	Flash memory card	Not disclosed
PRODUCT-F	REV Pro	Hard Disk Drive	Not disclosed

Table 10 – Non proprietary recording media

	Media name	Kind	Detail specification
PRODUCT-D	SD/SDHC card	Flash memory card	SD Association
PRODUCT-G			
PRODUCT-H	CF card	Flash memory card	CF Association

2.6 Interface

Each interface specification between camera recorder and the other equipment is defined in a certain industry association or cooperation.

As listed in Table 11, some of the PRODUCTs adopt specifications defined as IEEE standard. An IEEE standard can be referred to as a normative reference in a IEC standard.

Table 11 – Interface specification-1

	Specification	Referred standard	
PRODUCT-A	RJ-45 10BASE-T	IEEE802.3	IEEE Association
	RJ-45 100BASE-TX	IEEE802.3u	IEEE Association
PRODUCT-F	RJ-45 1000BASE-TX	IEEE802.3ab, 802.3z	IEEE Association
PRODUCT-A	IEEE1394 SBP2	IEEE1394	IEEE Association
PRODUCT-C			
PRODUCT-A	IEEE1394 bit stream	IEEE1394 IEC 61883 (define packet structure of synchronous transmission)	IEEE Association IEC standard
PRODUCT-B			
PRODUCT-C			
PRODUCT-F			
PRODUCT-G			

As listed in Table 12, almost all PRODUCTs adopt Universal Serial Bus (USB) interface and this specification is defined in USB-IF (USB Implementers Forum). Although USB specifications cannot be referred to as a normative reference in an IEC standard at present, a discussion between TC 100 and USB-IF has started in order to standardize Micro USB battery chargers. Since almost all PRODUCTs adopt an USB interface, it is desirable to study the possibility to standardize the USB interface in IEC TC 100.

Table 12 – Interface specification-2

	Specification	Referred standard	
PRODUCT-B	Universal Serial Bus	USB 2.0	USB-IF
PRODUCT-C			
PRODUCT-D			
PRODUCT-E			
PRODUCT-F			
PRODUCT-G			
PRODUCT-H			

3 Guideline for standardization

3.1 Summary of current issues

– Recording media

Since the specifications of recording media used in each PRODUCT are not disclosed, they cannot be referred to as normative reference.

– Specification of PRODUCT-D

The format of PRODUCT-D is widely used for camera recorders but the specification is defined in a certain alliance association and not disclosed in general.

– File format of PRODUCT-B and PRODUCT-G

Since both file formats of PRODUCT-B and PRODUCT-G are not defined in any standard bodies, they cannot be referred to as normative reference.

It is clarified that some specifications cannot be referred to in international standards because they are not publicly available or not defined as a standard. Although it is desirable to standardize such specifications, it depends on the decision of each manufacturer or association whether they wish to disclose the specification or not.

3.2 Proposed guideline for standardization

3.2.1 Product based standardization

In order to define the specification of professional tape-less camera recorders on a product basis, recording media is a fundamental element for the document suite such as a video cassette for a video tape recorder (VTR) standard.

As described in 2.1, however, the fundamental issue is that currently not all the specifications on recording media used for professional tape-less camera recorders are disclosed. The possibility of the product-based standardization therefore depends on whether the specifications of recording media will be publicly available as standards or not.

3.2.2 Essence technology based standardization

Another proposal is based on essence technologies adopted in each professional tape-less camera recorder. File format is one essential element to ensure the interoperability of various types of content between other equipment handling content. For example, since it is confirmed that the MXF file format is widely supported for professional tape-less camera recorders, defining specifications by focusing on the MXF file format is recommended. In this case, the following two possibilities should be considered:

– to standardize the MXF specification in IEC for professional tape-less camera recorders; or

– to develop documents on professional tape-less camera recorders supporting the MXF file format.

A PRODUCT list based on the MXF file format is shown in Table 13. As shown below, since all the specifications adopted in each PRODUCT refer to standardized documents, it is possible to create relevant IEC standards or documents by normatively referencing such source documents.

Table 13 – PRODUCT list based on MXF and other related technologies

PRODUCT	File format		Metadata		Codec	
	Specification	Referred standard	Specification	Referred standard	Specification	Referred standard
A	MXF OP-1a	SMPTE ST 377-1 SMPTE ST 378 SMPTE ST 379-2 SMPTE ST 380 SMPTE ST 381 SMPTE ST 382	MXF MXF DMS-1 Metadata dictionary structure KLV encoding XML	SMPTE ST 377-1 SMPTE ST 380 SMPTE ST 335 SMPTE ST 336 W3C Recommendation 28 October 2004	MPEG-2 HD/SD DV LPCM	ISO/IEC 13818-2 IEC 61834-2 ––
F	MXF OP-1a	SMPTE ST 377-1 SMPTE ST 378 SMPTE ST 379-2 SMPTE ST 381 SMPTE ST 382 SMPTE ST 383 SMPTE ST 405 SMPTE ST 422	MXF MXF DMS-1 Metadata dictionary structure KLV encoding XML	SMPTE ST 377-1 SMPTE ST 380 SMPTE ST 335 SMPTE ST 336 W3C Recommendation 28 October 2004	JPEG2000 MPEG-2 HD/SD DV LPCM	ISO/IEC 15444-1 ISO/IEC 13818-2 IEC 61834-2 ––
H	MXF OP-1a	SMPTE ST 377-1 SMPTE ST 378 SMPTE ST 379-2 SMPTE ST 380 SMPTE ST 381 SMPTE ST 382 SMPTE ST 385	MXF Map SDTI-CP Metadata dictionary structure KLV encoding XML	SMPTE ST 377-1 SMPTE ST 385 SMPTE ST 335 SMPTE ST 336 W3C Recommendation 28 October 2004	MPEG-2 HD/SD LPCM	ISO/IEC 13818-2 ––
C	MXF OP-Atom	SMPTE ST 377-1 SMPTE ST 379-2 SMPTE ST 381 SMPTE ST 382 SMPTE ST 383 SMPTE ST 390 SMPTE RP 2008 SMPTE ST 336	MXF Metadata dictionary structure KLV encoding XML	SMPTE ST 377-1 SMPTE ST 335 SMPTE ST 336 W3C Recommendation 28 October 2004	DV-Based 100Mbps DV-Based 50Mbps MPEG-4 AVC/H.264 LPCM	SMPTE ST 370 (IEC 62447-2) SMPTE ST 314 (IEC 62071-2) ISO/IEC 14496-10 ––
E	MXF OP-Atom	SMPTE ST 377-1 SMPTE ST 379-2 SMPTE ST 381 SMPTE ST 382 SMPTE ST 390 SMPTE ST 336	MXF Metadata dictionary structure KLV encoding XML	SMPTE ST 377-1 SMPTE ST 335 SMPTE ST 336 W3C Recommendation 28 October 2004	MPEG-2 HD/SD LPCM	ISO/IEC 13818-2 ––

4 Conclusion

This Technical Report provides the results of the survey on existing professional tape-less camera recorder products and also includes a guideline on the possibilities of standardizations for professional tape-less camera recorders.

As a result of investigating the current situation, it is confirmed that developing IEC documents relevant to professional tape-less camera recorders would be possible by specifying the scope of the standardization. For example, it is possible to standardize essential technologies adopted in professional tape-less camera recorders such as file format and related elements such as codec and metadata. It is desirable to specify essential technologies of professional tape-less camera recorders to ensure compatibility with other equipment on a file basis. In addition, in order to standardize on a product basis, it is necessary that the specification of recording media adopted in professional tape-less camera recorders will be publicly available as standard.

Annex A

PRODUCT list

A.1 List-1: PRODUCT-A, -B

		PRODUCT-A	PRODUCT-B
Recording Media		Optical Disc	Solid Memory
		Professional Disc 23,3GB / 50GB	SxS memory card 8GB/16GB/32GB
Video Codec	Specification	MPEG-2 HD Long GOP 422P@HL	MPEG-2 HD Long GOP MP@HL
	Bit rate	50Mbps	35Mbps
	Resolution Frame rate	1920 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94p/50p	1920 x 1080 59,94i/50i/29,97p/25p/23,98p 1440 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94p/50p/29,97p/25p/23,98p
	Standard	ISO/IEC 13818-2	ISO/IEC 13818-2
Audio Codec	Specification	LPCM 48kHz/16bit, 4ch (Format 8ch)	LPCM 48kHz/16bit, 2ch (Format 4ch)
	Standard	—	—
Video Codec	Specification	MPEG-2 HD Long GOP MP@HL,H14	MPEG-2 HD Long GOP MP@H14
	Bit rate	35Mbps/25Mbps/18Mbps	25Mbps
	Resolution Frame rate	1440 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94p/50p/23,98p(pull-down)	1440 x 1080 59,94i/50i/23,98p(pull-down)
	Standard	ISO/IEC 13818-2	ISO/IEC 13818-2
Audio Codec	Specification	LPCM 48kHz/16bit, 4ch	LPCM 48kHz/16bit, 2ch (Format 4ch)
	Standard	—	—
Video Codec	Specification	MPEG-2 422P@ML	
	Bit rate	50Mbps/40Mbps/30Mbps	
	Resolution Frame rate	720 x 480 59,94i 720 x 576 50i	
	Standard	ISO/IEC 13818-2	
Audio Codec	Specification	LPCM 48kHz/16, 24bit, 4ch	
	Standard	—	

		PRODUCT-A	PRODUCT-B
Video Codec	Specification	DV	DV
	Bit rate	25Mbps	25Mbps
	Resolution Frame rate	720 x 480 59,94i 720 x 576 50i	720 x 480 59,94i 720 x 576 50i
	Standard	IEC 61834-2	IEC 61834-2
Audio Codec	Specification	LPCM 48kHz/16bit, 4ch	LPCM 48kHz/16bit, 4ch
	Standard	––	––
File Format	Specification	MXF OP-1a	MP4
	Standard	SMPTE ST 377-1, SMPTE ST 378, SMPTE ST 379-2, SMPTE ST 380, SMPTE ST 381 SMPTE ST 382	ISO/IEC 14496-12 ISO/IEC 14496-14
	Specification		AVI Type2 (for DV recording only)
	Standard		––
Metadata	Specification	Structural metadata Descriptive metadata (Time/Date, Comments and other additional information including A/V proxy data) DMS-1 XML Clip metadata	Technical metadata Descriptive metadata XML Clip metadata
	Standard	MXF metadata: SMPTE ST 377-1, SMPTE ST 380 XML Schema: W3C Recommendation 28 October 2004	MP4 metadata: ISO/IEC 14496-12 XML Schema: W3C Recommendation 28 October 2004
Interface	Specification	RJ-45 100BASE-TX	Universal Serial Bus
	Standard	IEEE802.3u	USB 2.0
	Specification	RJ-45 10BASE-T	HDV/DV stream
	Standard	IEEE802.3	IEEE 1394
	Specification	Serial Bus Protocol 2	
	Standard	IEEE 1394	

A.2 List-2: PRODUCT-C, -D

		PRODUCT-C	PRODUCT-D
Recording Media		Solid Memory	Solid Memory
		P2 memory card 8GB/16GB/32GB/64GB	SDHC memory card 4GB/8GB/16GB/32GB
Video Codec	Specification	D-12 DV-Based 100Mbps	AVC (MPEG-4 Part10 | H.264)
	Bit rate	100Mbps	21Mbps/17Mbps/13Mbps/6Mbps
	Resolution Frame rate	1280 x 1080 59,94i/29,97p/23,98p 1440 x 1080 50i/25p 960 x 720 59,94p/50p/29,97p/25p/23,98p	1920 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94p/50p/29,97p/25p/23,98p
	Standard	SMPTE ST 370 IEC 62447-2	ISO/IEC 14496-10
Audio Codec	Specification	LPCM 48kHz/16bit, up to 4ch	AC3 48kHz/16bit, 2ch
	Standard	—	ATSC A/52B
Video Codec	Specification	AVC-Intra MPEG-4 AVC/H.264 High 4:2:2 Intra Profile	
	Bit rate	100Mbps	
	Resolution Frame rate	1920 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94i/50i/29,97p/25p/23,98p	
	Specification	AVC-Intra MPEG-4 AVC/H.264 High 10 Intra profile	
	Bit rate	50Mbps	
	Resolution Frame rate	1440 x 1080 59,94i/50i/29,97p/25p/23,98p 960 x 720 59,94i/50i/29,97p/25p/23,98p	
	Standard	ISO/IEC 14496-10	
Audio Codec	Specification	LPCM 48kHz/16bit, 24bit, up to 4ch	
	Standard	—	
Video Codec	Specification	DV-Based 50Mbps	
	Bit rate	50Mbps	
	Resolution Frame rate	720 x 480 59,94i 720 x 576 50i	
	Standard	SMPTE ST 314 IEC 62071-2	

		PRODUCT-C	PRODUCT-D
Audio Codec	Specification	LPCM 48kHz/16bit, up to 4ch	
	Standard	––	
File Format	Specification	MXF OP-Atom	MPEG-2 TS (file)
	Standard	SMPTE ST 377-1, SMPTE ST 379-2, SMPTE ST 381, SMPTE ST 382, SMPTE ST 383, SMPTE ST 390, SMPTE RP 2008, SMPTE ST 336	ISO/IEC 13818-1
Metadata	Specification	XML Clip Metadata	XML Clip metadata
	Standard	XML Schema: W3C Recommendation 28 October 2004	XML Schema: W3C Recommendation 28 October 2004
Interface	Specification	Universal Serial Bus	Universal Serial Bus
	Standard	USB 2.0	USB 2.0
	Specification	Serial Bus Protocol 2	
	Standard	IEEE 1394	

A.3 List-3: PRODUCT-E, -F

		PRODUCT-E	PRODUCT-F
Recording Media		Solid Memory	Removable HDD Solid Memory
		GF PACK memory pack 16GB/32GB/64GB	REV PRO Compact Flash memory card 4GB/8GB/16GB/32GB/64GB
Video Codec	Specification	MPEG-2 HD Intra Frame 422P@HL	JPEG2000
	Bit rate	100Mbps	100Mbps/75Mbps/50Mbps
	Resolution Frame rate	1920 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94p/50p	1920 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94p/50p
	Specification	MPEG-2 HD Long GOP 422P@HL	
	Bit rate	50Mbps	
	Resolution Frame rate	1920 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94p/50p	
	Specification	MPEG-2 422P@ML	JPEG2000
	Bit rate	50Mbps/40Mbps/30Mbps	50Mbps/40Mbps/30Mbps
	Resolution Frame rate	720 x 480 59,94i 720 x 576 50i	720 x 512 59,94i 720 x 608 50i
	Standard	ISO/IEC 13818-2	ISO/IEC 15444-1
Audio Codec	Specification	LPCM 48kHz/16bit or 24bit, 4ch	LPCM 48kHz/24bit, 4ch
	Standard	––	––
Video Codec	Specification		MPEG-2 HD Intra Frame MP@HL/MP@H-14L
	Bit rate		80Mbps/60Mbps
	Resolution Frame rate		1920 x 1080 / 1440 x 1080 59,94i/50i/29,97p/25p/23,98p 1280 x 720 59,94p/50p
	Specification		MPEG-2 HD Long GOP MP@HL
	Bit rate		50Mbps
	Resolution Frame rate		1920 x 1080 59,94i/50i/29,97p/25p/23,98p

		PRODUCT-E	PRODUCT-F
	Specification		MPEG-2 HD Long GOP MP@H14
	Bit rate		35Mbps/25Mbps
	Resolution Frame rate		1440 x 1080 59,94i/50i/29,97p/25p/23,98p
	Specification		MPEG-2 HD Long GOP MP@HL/MP@H-14L
	Bit rate		50Mbps/35Mbps/18Mbps
	Resolution Frame rate		1280 x 720 59,94p/50p
	Specification		MPEG-2 Intra Frame 422P@ML
	Bit rate		50Mbps/40Mbps/30Mbps
	Resolution Frame rate		720 x 480 / 720 x 512 59,94i 720 x 576 / 720 x 608 50i
	Standard		ISO/IEC 13818-2
Audio Codec	Specification		LPCM 48kHz/24bit, 4ch
	Standard		—
Video Codec	Specification		DV
	Bit rate		25Mbps
	Resolution Frame rate		720 x 480 59,94i 720 x 576 50i
	Standard		IEC 61834-2
Audio Codec	Specification		LPCM 48kHz/16bit, 4ch
	Standard		—
File Format	Specification	MXF OP-Atom	MXF OP-1a
	Standard	SMPTE ST 377-1, SMPTE ST 379-2, SMPTE ST 336, SMPTE ST 381, SMPTE ST 382, SMPTE ST 390	SMPTE ST 377-1, SMPTE ST 378, SMPTE ST 379-2, SMPTE ST 381, SMPTE ST 382, SMPTE ST 383, SMPTE ST 405, SMPTE ST 422
Metadata	Specification	XML Clip metadata	Subset of SMPTE ST 380 XML Clip metadata
	Standard	XML Schema: W3C Recommendation 28 October 2004	MXF metadata: SMPTE ST 380 XML Schema: W3C Recommendation 28 October 2004
Interface	Specification	Universal Serial Bus	Universal Serial Bus