Avid DNxHD Technology

Beauty without the bandwidth. Revolutionary Avid DNxHD® encoding.

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Introduction

Gorgeous quality. Amazing efficiency. Technology that challenges old perceptions and opens up new possibilities. That is the thinking behind Avid DNxHD encoding. It's an industry standardized solution that has put HD within easy reach of postproduction, broadcast television, and sports professionals who stake their reputations on uncompromising quality. A solution engineered to withstand the rigors of multi-generational processing and leverage today's collaborative, networked environments. A solution with over 25 years of industry leadership behind it. A solution that has revolutionized HD production.

The benefits of Avid DNxHD encoding

HD camera compression formats are efficient, but simply aren't engineered to maintain quality during complex postproduction effects processing. Uncompressed HD delivers superior image quality, but data rates and file sizes can stop a workflow dead in its tracks. Avid DNxHD delivers both efficiency and quality without compromise. Avid DNxHD is a revolutionary 10 and 8-bit HD encoding technology that significantly reduces storage and bandwidth requirements while providing mastering-quality HD media.

Key advantages of Avid DNxHD include:

- Optimal mastering picture quality
  Preserves the full raster of the original HD frame and maintains pixel alignment for higher quality downstream encoding and image quality
- Persistent and robust
  Virtually indistinguishable image loss over multiple generations
- Real-time HD sharing and collaboration
  Truly collaborative high quality real-time HD workflow has become practical with Avid DNxHD media over Avid ISIS™ media networks.
- Reduced storage requirements
  Avid DNxHD 145 8-bit media delivers very high HD image quality while requiring approximately 20% less storage capacity than 8-bit uncompressed ITU-R BT.601 standard definition media.
- Industry-wide support
  Over 60 manufacturers currently field products supporting DNxHD, and source code is easily licensable from Avid.
- Recognized standard
  Codified by SMPTE as VC-3 standard, DNxHD is a better long term workflow and archival choice
- Multicam support
  Avid DNxHD encoding supports Avid's Emmy® award-winning real-time multicamera functionality with support for 6 to 36 simultaneous 9-way multicam DNxHD 36 clients on an ISIS 5000 system

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There are five families of Avid DNxHD encoding with different data rates to meet the needs of a wide range of source, production, distribution, and archive requirements applications across broadcast, post production, and sports.

- Avid DNxHD 444: For highest color fidelity and image quality in 1920x1080 progressive projects. Full resolution, 10-bit 4:4:4 RGB video sampling and high bit-rate is excellent for multi-generational finishing and mastering. Absence of subsampling or averaging of chroma information preserves the original color information ensures visually lossless compression.
- Avid DNxHD 220x: For superior quality image in a YCbCr-color space for 10-bit sources. Data rate is dependent on frame rate. For example, 220Mbps is the data rate for 1920 x 1080 30fps interlace sources (60 fields) while progressive sources at 24fps will be 175Mbps
- Avid DNxHD 220: For highest quality image when using 8-bit color sources. Data rates based on frame rates are the same as for Avid DNxHD 220x
- Avid DNxHD 145: For high-quality mastering when using 8-bit lower data rate sources such as HDCAM and DVCPRO. 145Mbps is the data rate for 1920 x 1080 30fps interlaced sources (60 fields). Progressive sources at 24fps will be 115Mbps and at 25fps will be 120Mbps.
- Avid DNxHD 100: For optimal visual impact where workflow speed and storage capacity are important factors. Suitable replacement for DV100 compression and offers lower processing overhead than AVC-Intra 50/100. Sub-samples the video raster from 1920 to 1440 or from 1280 to 960 to reduce compression artifacts, providing a balance of reduced compressed bandwidth and visual quality.
- Avid DNxHD 36: High-quality offline editing of HD progressive sources only. Designed for projects using an offline/online workflow due to large quantities of source media and/or needing more real-time preview streams for craft editorial or multicamera editing.

Avid DNxHD encoding quality

Avid DNxHD encoding is specifically designed for nonlinear editing and complex multi-generation compositing common in today's collaborative post production and broadcast news environments. It offers a choice of 8 or 10-bit sampling, six user-selectable bit rates, and the ability to maintain high image quality more effectively than native camera codecs. The chart below compares Avid DNxHD encoded media to other popular HD formats:

Format	Avid DNxHD 36	Avid DNxHD 100	Avid DNxHD 145	Avid DNxHD 220	Avid DNxHD 444	DVCPRO HD	HDCAM	HDCAM SR
Bit Depth	8-bit	8-bit	8-bit	8- and 10-bit	10 bit	8-bit	8-bit	10-bit
Sampling	4:2:2	4:2:2	4:2:2	4:2:2	4:4:4	1280 Y samples 4:2:2	1440 Y samples 3:1:1	4:2:2
Bandwidth	36 Mb/sec	100 Mb/sec	145 Mb/sec	220 Mb/sec	440 Mb/sec	100 Mb/sec	135 Mb/sec	440 Mb/sec

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Many popular compressed HD formats do not natively support the full HD raster. Horizontal raster downsampling makes HD images easier to compress, but significantly reduces high frequency detail information in the image. As a result, downsampling makes HD images look softer by degrading horizontal resolution in the process. The camera original HD raster's 1920 pixel horizontal resolution has 33% more resolution than a1440 pixel downsampled image and 50% more than a 1280 pixel downsampled image.

Over multiple generations of postproduction processing, raster downsampling can severely degrade images, increasing unwanted visible artifacts that can render an image unacceptable. Unlike other compressed HD formats such as HDCAM and DVCPRO HD, Avid DNxHD encoding maintains the full original raster of the active video, sampling every available pixel within the image. The table below (Fig. 2) shows the reduction in image size that is a characteristic of raster downsampling used by other HD compression schemes:

FORMAT	RESOLUTION / FRAME RATE	Luminance, Y		Chrominance, CrCb	
		FROM	TO	FROM	TO
HDCAM	1080i/59.94	1920	1440	960	480
DVCPRO HD	1080i/59.94	1920	1280	960	640
DVCPRO HD	1080i/50	1920	1440	960	720
DVCPRO HD	720p/59.94	1280	960	640	480
DVCPRO HD	720p/23.976	1280	960	640	480

Avid DNxHD encoding is open

Avid applications store Avid DNxHD material natively inside industry-standard MXF files, ensuring open accessibility by other MXF-aware applications. In addition, the source code for Avid DNxHD is licensable free of charge, and is available through the Avid website as a download to any end user who wants to compile it on any platform. For QuickTime-aware applications such as Adobe After Effects, Avid distributes QuickTime-wrapped versions of the Avid DNxHD codec family compiled for Windows and Mac OS X. Additionally the DNxHD SDK program provides binary distributions for Windows, Mac OS X and Linux for partners to incorporate into their own applications.

The Avid DNxHD codec has been accepted by SMPTE (Society of Motion Picture and Television Engineers) as the foundation format for the VC-3 standard. After two years of rigid SMPTE Standards efforts, four VC-3-related documents are now publicly available (store.smpte.org/). The Avid DNxHD codec is compliant to SMPTE VC-3. The SMPTE documents are:

- SMPTE 2019-1 VC-3 Picture Compression and Data Stream Format
- SMPTE RP 2019-2 VC-3 Decoder and Bit stream Conformance
- SMPTE 2019-3 VC-3 Type Data Stream Mapping over SDTI
- SMPTE 2019-4 Mapping VC-3 Coding Units into the MXF Generic Container

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This commitment to openness means users can confidently embrace the Avid DNxHD format, safe in the knowledge that their valuable content will always be accessible – with or without Avid equipment.

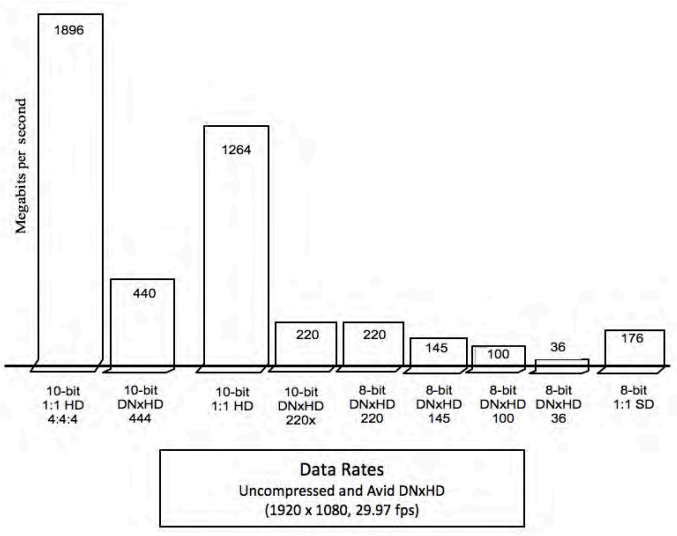
Avid DNxHD encoding: what is "high efficiency?"

Uncompressed high-definition (HD) media can require nearly seven times more bandwidth and storage resources than uncompressed standard-definition (SD) media. Avid® Media Composer®, NewsCutter®, Avid Symphony™, and Avid DS editing systems, especially with Nitris DX or Mojo DX acceleration, have the power to capture uncompressed HD files in standalone HD editing or collaborative HD editorial workgroup environments with Avid ISIS 7000 or ISIS 5000 real-time shared storage systems. However, the breadth of choice, robustness, and quality of DNxHD makes it difficult to justify the storage capacity and cost required to support the high data rates of uncompressed HD media, especially given the extra DNxHD benefits of increased workflow efficiency, easier collaboration, and greater profitability.

Avid DNxHD encoding offers mastering-quality HD media with dramatically reduced file sizes, shattering the barriers to real-time HD productivity, whether using local storage or working in real-time collaborative HD workflows with Avid ISIS. In fact, the efficiency of Avid DNxHD encoding makes it easy to work with mastering-quality HD media directly on notebook systems.

For maximum efficiency, users can pick the Avid DNxHD bit depths and data rates that most closely match those of the source media. Or they can choose to encode 8-bit HD media as 10-bit Avid DNxHD media to maintain pristine image quality over multiple generations of postproduction effects processing. The increased bit depth provides

the additional dynamic range necessary for precise color correction adjustments without introducing signal clipping and rounding-error artifacts. Once postproduction is completed, the media, via HD-SDI, can be output to the same format as the source media, or in other HD formats supported by the HD VTR or encoded directly to the output format such as MPEG for broadcast and DVD delivery.



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Avid DNxHD: what is "mastering quality?"

Unlike Avid DNxHD encoding, a number of camera acquisition formats are only 8-bits deep and reduce the image resolution through horizontal down-sampling – discarding detailed pixel information and high-frequency color information in the process. This results in the image becoming softer during multi-generation postproduction processing:

This example image represents what the camera lens actually sees in the 1920x1080 full high definition raster.

This is the same image after its raster has been horizontally sub-sampled down to 1440 pixels and recorded to videotape.

The same image returned to its normal raster. Sharpness deteriorates after multiple generations of sub- sampling in post production.

This is an A and -B mix of the original image and a negative of the subsampled image. The horizontal sub-sampling losses quickly become obvious.

This is an A and -B mix of the original image and a negative of the Avid DNxHD image. The image details are maintained with very high accuracy.

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You can perform the A and B mix test on any NLE or switcher to test for quality losses through any digital process. When you establish a 50/50 mix of any original digital signal with a negative image of the same signal after passing though the encoding process to be tested, the resulting visual differences are the errors generated by the encoding. A blank image with no notable visual differences indicates a very high degree of quality and accuracy in the process.

Avid DNxHD encoding solves the deterioration problems associated with multigenerational sub-sampling, while preserving the option to sub-sample (DNxHD 100) when desired. When used to post HDCAM or DVCPRO HD source material, the Avid DNxHD full raster encoding options offer significant advantages:

- Preserves the full raster of the original HD frame with no reduction in the horizontal luminance and chroma samples.
- Pixels are properly aligned so that downstream processes such as MPEG2 encoding can be better optimized resulting in a higher quality image for broadcast.

Avid DNxHD full raster encoding delivers more precise color correction, graphics, effects, and compositing over multiple generations of postproduction processing. The result is image quality that is virtually indistinguishable from the original image, even compared to uncompressed HD in postproduction – regardless of source material. Quality is consistently higher than is possible when working within an 8-bit space, or when beginning with a sub-sampled, poorly encoded, or resized image.

A controlled test was performed to compare uncompressed HD to DNxHD 220 for a film out. To get uncompressed HD; film was scanned at 2K then rendered as uncompressed HD, and then DNxHD 220. The two HD elements were edited together with a diagonal wipe between the two formats. The resulting sequence was exported as DPX files for a film out. The 35mm film was projected, as well as the digital files. In a calibrated screening room, experienced engineers were unable to pick where the split was done, nor which part of the image was Avid DNxHD.

-PostWorks, New York

Avid DNxHD in a workgroup environment

Efficiency has even more meaning in a workgroup, where benefits like mastering quality HD and low storage requirements are magnified by the power of teamwork. Better quality results, faster turnaround times, and improved productivity are all benefits of simultaneous editing processes within a workgroup. With Avid DNxHD all this HD value is possible on networks built for SD.

For instance, for 1080p/29.97 projects, an ISIS 7000 system will support 10 DNxHD 145 dual stream Gbit Ethernet-connected clients, with the ability to expand to 260 clients, and an ISIS 5000 system will similarly support from 8 to 48 dual stream clients, all with effortless real-time media access. Of course, ISIS workgroups can also support mixed resolutions based on user's needs and configurations.

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Avid DNxHD family of mastering resolutions

Avid DNxHD is available in multiple HD encoding choices per resolution/frame rate combination, each identified by bandwidth (megabits/second) and bit depth, as shown below.

Project Format	Resolution	Frame Size	Color Space	Bits	FPS	Mbps	Min/GB
1080p/60	Avid DNxHD 440x	1920 x 1080	4:2:2	10	60	440	0.325
1080p/60	Avid DNxHD 440	1920 x 1080	4:2:2	8	60	440	0.325
1080p/60	Avid DNxHD 290	1920 x 1080	4:2:2	8	60	291	0.492
1080p/60	Avid DNxHD 90	1920 x 1080	4:2:2	8	60	90	1.585
1080p/59.94	Avid DNxHD 440x	1920 x 1080	4:2:2	10	59.94	440	0.325
1080p/59.94	Avid DNxHD 440	1920 x 1080	4:2:2	8	59.94	440	0.325
1080p/59.94	Avid DNxHD 290	1920 x 1080	4:2:2	8	59.94	291	0.493
1080p/59.94	Avid DNxHD 90	1920 x 1080	4:2:2	8	59.94	90	1.585
1080p/50	Avid DNxHD 365x	1920 x 1080	4:2:2	10	50	367	0.390
1080p/50	Avid DNxHD 365	1920 x 1080	4:2:2	8	50	367	0.390
1080p/50	Avid DNxHD 240	1920 x 1080	4:2:2	8	50	242	0.590
1080p/50	Avid DNxHD 75	1920 x 1080	4:2:2	8	50	75	1.900
1080i/59.94	Avid DNxHD 220x	1920 x 1080	4:2:2	10	29.97	220	0.651
1080i/59.94	Avid DNxHD 220	1920 x 1080	4:2:2	8	29.97	220	0.651
1080i/59.94	Avid DNxHD 145	1920 x 1080	4:2:2	8	29.97	145	0.985
1080i/59.94	Avid DNxHD 100	1920 x 1080*	4:2:2	8	29.97	100	1.429
1080i/50	Avid DNxHD 185x	1920 x 1080	4:2:2	10	25	184	0.78
1080i/50	Avid DNxHD 185	1920 x 1080	4:2:2	8	25	184	0.78
1080i/50	Avid DNxHD 120	1920 x 1080	4:2:2	8	25	121	1.181
1080i/50	Avid DNxHD 85	1920 x 1080*	4:2:2	8	25	84	1.713
1080p/25	Avid DNxHD 365x	1920 x 1080	4:4:4	10	25	367	0.39
1080p/25	Avid DNxHD 185x	1920 x 1080	4:2:2	10	25	184	0.78
1080p/25	Avid DNxHD 185	1920 x 1080	4:2:2	8	25	184	0.78
1080p/25	Avid DNxHD 120	1920 x 1080	4:2:2	8	25	121	1.181
1080p/25	Avid DNxHD 85	1920 x 1080*	4:2:2	8	25	84	1.713
1080p/25	Avid DNxHD 36	1920 x 1080	4:2:2	8	25	36	3.98
1080p/24	Avid DNxHD 350x	1920 x 1080	4:4:4	10	24	352	0.406
1080p/24	Avid DNxHD 175x	1920 x 1080	4:2:2	10	24	176	0.814
1080p/24	Avid DNxHD 175	1920 x 1080	4:2:2	8	24	176	0.814
1080p/24	Avid DNxHD 115	1920 x 1080	4:2:2	8	24	116	1.231
1080p/24	Avid DNxHD 80	1920 x 1080*	4:2:2	8	24	80	1.785
1080p/24	Avid DNxHD 36	1920 x 1080	4:2:2	8	24	36	3.98
1080p/23.976	Avid DNxHD 350x	1920 x 1080	4:4:4	10	23.976	352	0.407
1080p/23.976	Avid DNxHD 175x	1920 x 1080	4:2:2	10	23.976	176	0.814
1080p/23.976	Avid DNxHD 175	1920 x 1080	4:2:2	8	23.976	176	0.814
1080p/23.976	Avid DNxHD 115	1920 x 1080	4:2:2	8	23.976	116	1.231
1080p/23.976	Avid DNxHD 80	1920 x 1080*	4:2:2	8	23.976	80	1.787
1080p/23.976	Avid DNxHD 36	1920 x 1080	4:2:2	8	23.976	36	3.98
1080p/29.97	Avid DNxHD 440x	1920 x 1080	4:4:4	10	29.97	440	0.325
1080p/29.97	Avid DNxHD 220x	1920 x 1080	4:2:2	10	29.97	220	0.651
1080p/29.97	Avid DNxHD 220	1920 x 1080	4:2:2	8	29.97	220	0.651
1080p/29.97	Avid DNxHD 145	1920 x 1080	4:2:2	8	29.97	145	0.985
1080p/29.97	Avid DNxHD 100	1920 x 1080*	4:2:2	8	29.97	100	1.429
1080p/29.97	Avid DNxHD 45	1920 x 1080	4:2:2	8	29.97	45	3.18
720p/59.94	Avid DNxHD 220x	1280 x 720	4:2:2	10	59.94	220	0.651
720p/59.94	Avid DNxHD 220	1280 x 720	4:2:2	8	59.94	220	0.651
720p/59.94	Avid DNxHD 145	1280 x 720	4:2:2	8	59.94	145	0.985
720p/59.94	Avid DNxHD 100	1280 x 720^	4:2:2	8	59.94	100	1.402
720p/50	Avid DNxHD 175x	1280 x 720	4:2:2	10	50	175	0.818
720p/50	Avid DNxHD 175	1280 x 720	4:2:2	8	50	175	0.818
720p/50	Avid DNxHD 115	1280 x 720	4:2:2	8	50	115	1.244
720p/50	Avid DNxHD 85	1280 x 720^	4:2:2	8	50	85	1.68

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Project Format	Resolution	Frame Size	Color-Space	Bits	FPS	Mbps	Min/GB
720p/29.97	Avid DNxHD 110x	1280 x 720	4:2:2	10	29.97	110	1.3
720p/29.97	Avid DNxHD 110	1280 x 720	4:2:2	8	29.97	110	1.3
720p/29.97	Avid DNxHD 75	1280 x 720	4:2:2	8	29.97	72	2.05
720p/29.97	Avid DNxHD 50	1280 x 720^	4:2:2	8	29.97	51	2.8
720p/25	Avid DNxHD 90x	1280 x 720	4:2:2	10	25	92	1.59
720p/25	Avid DNxHD 90	1280 x 720	4:2:2	8	25	92	1.59
720p/25	Avid DNxHD 60	1280 x 720	4:2:2	8	25	60	2.39
720p/25	Avid DNxHD 45	1280 x 720^	4:2:2	8	25	43	3.361
720p/23.976	Avid DNxHD 90x	1280 x 720	4:2:2	10	23.976	88	1.566
720p/23.976	Avid DNxHD 90	1280 x 720	4:2:2	8	23.976	88	1.566
720p/23.976	Avid DNxHD 60	1280 x 720	4:2:2	8	23.976	58	2.381
720p/23.976	Avid DNxHD 50	1280 x 720 ^	4:2:2	8	23.976	41	3.504

* = Sub-sampled to 1440x1080 ^ = Sub-sampled to 960 x 720

Avid DNxHD mixed in the timeline

Avid editing systems are designed for flexibility. They can handle HD, HDV, SD, and DV media at mixed frame rates in the same timeline, all playable in real time. Just drop the media right in the same timeline, even add effects and compositing. All elements can be automatically be converted in real-time or output to any desired target resolution. Avid DNxHD can be combined with lower resolution HD formats including HD or SD proxies for the best in fast, efficient, and low-cost HD production, combining high file efficiency with the quality of Avid DNxHD for graphics, compositing and effects.

Offline to Online HD

The Avid DNxHD 36 resolution is targeted specifically at the creative editorial workflow. Avid DNxHD 36 is a high-quality offline resolution supporting full 16x9 aspect ratio and is available for 1080p/23.976, 1080p/24, 1080p/25, and 1080p/29.97 projects. Native HD offline editing adds several benefits to the overall workflow, such as: perfect conform of all effects (compared to working with standard definition 16:9 anamorphic), removes timecode conversions between standard definition frames rates of 30fs and 25fps, tracking of pulldown cadence when in NTSC, single pass capture of picture and sound, and high enough quality to screen directly without the additional cost and time of a conform step.

The Avid DNxHD 36 data rate is only 50% more than standard definition DV25 allowing for massive amounts of dailies to be captured. For example, 100,000 feet of 35mm, 4-perf film (~18.5 hours) when captured at Avid DNxHD 36 will only require 279GB of storage.

DNxHD 444 is the latest addition to the DNxHD line of codecs, and offers full raster 1920 x 1080 frame sizes while preserving the original color information. This means that there is no subsampling or averaging of the chroma information, and is an excellent choice for finishing and mastering applications.

Avid DNxHD and future potential

Avid DNxHD encoding is a scaleable solution that will allow Avid to add different formats, resolutions, and data rates as required by the marketplace. As the demands move to higher and lower bit rates, there will be an Avid DNxHD solution to meet those needs.

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Avid High-Definition Products that support Avid DNxHD

No matter what HD format you shoot, Avid's got you covered: all the way from native HDV to uncompressed HD. And with breakthrough Avid DNxHD encoding technology revolutionizing HD postproduction, Avid HD solutions give you everything you need to deliver "Beauty without the Bandwidth":

Avid Media Composer

Real-time Avid DNxHD editing delivers unsurpassed creative editorial

Avid DS Nitris

Industry-leading uncompressed HD, HD-RGB, Avid DNxHD, and 2K/4K perfaormance

Avid Symphony

An HD conform and finishing powerhouse for uncompressed HD and Avid DNxHD

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Avid NewsCutter®

Designed for high-efficiency HD broadcast workflows

Nitris DX

High-performance HD/SD/ stereoscopic 3D film/ video editing and finishing with analog/digital I/O

Mojo DX

High-performance HD/SD editing with digital I/O and monitoring

Avid ISIS

Engineered for effortless support for Avid DNxHD workgroups, with high availability and scalability from a few editing seats to hundred

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Avid Interplay™ Production

Workgroup acceleration, wide-area connectivity, and complete real-time media production management, with support for all DNxHD resolutions

Avid AirSpeed 5000

Workgroup-connected video production server supports DNXHD ingest, encoding, and playback for seamless high-quality end-to-end HD workflows

Register now to receive more information on Avid DNxHD encoding. You can also access our downloadable codec source code anytime for free just by visiting our website at: http://www.avid.com/us/request-info/dnxhd

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