Memo To: Wayne Armstrong, Scott Cutler, Richard Wolf, Ken Steele
Penny Sawyer, Ron Waits, Sam Sawyer, Danny Fergueson
Steve Mottin

Memo From: Frank Durda IV x2865 25-Feb-85 502253

Subject: Format patterns for 5.25 inch diskettes

At the request of Wayne Armstrong, I have done some research into what format patterns are required by the floppy disk controllers used in our various computers and what patterns are produced by the formatting utilities in those operating systems.

This information should allow our duplication facilities to produce diskettes that can be reliably read and written by machines in the field as well as act as a guide for future operating system writers in correct formatting requirements.

In researching this document, I have determined that the following systems are producing format patterns that are out-of-spec:

Color Computer	OS-9
Model III/4/4P/4+	TRSDOS 1.3
	LDOS 5.1.x
	TRSDOS 6.2.x
	CP/M+
Model 100/200	DOS

(All of these systems use the Western Digital FD179x/FD177x controllers.)

I have also determined that our operating systems that use the NEC part all have supplied the recommended Gap IIIa values to the controller, and this is the only part of the format pattern the utility need supply. Of course we should still make sure that any duplication equipment also meets these standards. The operating systems that are correct are:

Model 1000	MS-DOS 02.11.xx
Model 1200	MS-DOS 02.11.xx
Model 2000	Xenix
	MS-DOS 02.11.xx

If you have any questions about the enclosed data, please feel free to call or come by.

Frank Durda IV
390-2865 1300-II Tandy Center

5.25 INCH DISKETTE FORMATTING INFORMATION

Produced 25-Feb-85 Frank Durda IV

1. INTRODUCTION

All of our 5.25" diskettes use format patterns that are derivatives of the IBM System 34 format standard.

Although the size, number of sectors per cylinder and starting sector number vary from operating system to operating system, the standard will always be referred to when discussion various implementations.

The disk controllers that are discussed here are:

Western Digital:
- FD179x-01
- FD179x-02
- FD1770/72/73

NEC
- uPD765A
- uPD7265

Fujitsu
- MB8877a (compatible with FD1793-02)

2. IBM SYSTEM 34 FORMAT

The IBM System 34 standard is shown below:

	Number of Bytes		Value on Media	Description
a.	80	(0/0-80)	4E	Index Gap a
b.	12	(0/0-12)	00	Index Gap b (PLL sync)
c.	3	(0/0-3)	C2*	Index Prefix
d.	1	(0/0-1)	FC (D7 clocking)	Index Mark
e.	50	(32/32-50)	4E	Gap Ia (Post Index)
f.	12	(12)	00	Gap Ib/IIIb (PLL sync)
g.	3	(3)	A1**	Preset CRC
h.	1	(1)	FE	ID Address Mark
i.	1	(1)	nn	Cylinder # (0-76)+
j.	1	(1)	nn	Side Number (0 or 1)
k.	1	(1)	nn	Sector Number (1-26)++
l.	1	(1)	nn	Sector Length +++
m.	2	(2)	nnnn	Two byte CRC (id)
n.	22	(22)	4E	Gap IIa
o.	12	(12)	00	Gap IIb (PLL sync)
p.	3	(3)	A1**	Preset CRC
q.	1	(1)	FB/F8	Data Address Mark
r.	256	(256)	Data	Data Sector+++
s.	2	(2)	nnnn	Two byte CRC (data)
t.	54	(16-24/12)	4E	Gap IIIa (Data gap)
u.	f	(f/f)	4E	Gap IV ++++

Notes:

* C2 is written in MFM with a missing clock transition between bits 3 & 4.

** A1 is written in MFM with a missing clock transition between bits 4 & 5.

\+ Although the IBM standard only envisioned 76 cylinder (8" floppies), the Western Digital FD1793/1773 and the NEC uPD765a/UPD7265 will handle up to 244 cylinders (0 to 243.) Values above 244 are in conflict with format control codes and could cause CRC errors.

++ Sector number was originally envisioned as having the range of 1 to 26. The Western Digital FD1793/1773 and the NEC uPD765a/UPD7265 will allow sector numbers in the range 0 to 243. Sector numbers above 244 are in conflict with format control codes and may render the sectors unusable.

+++ Although the standard was originally for 256 byte sectors, several other sector sizes are available.

For the Western Digital FD1773/1793 controller, sector sizes are:

00	128 bytes (allowed in MFM)
01	256 bytes
02	512 bytes
03	1024 bytes

The NEC uPD765a/uPD7265 allow these sector sizes:

01	256 bytes
02	512 bytes
03	1024 bytes
04	2048 bytes
05	4096 bytes

128 byte sectors are not available in MFM mode on the NEC parts.

++++ This gap is written until the FDC reaches the leading edge of the index pulse. The amount that is required varies with the number and size of sectors written. Most systems simply supply 4Es as long as the FDC will accept them. See 3 for more information.

3. 5.25 INCH FORMAT VARIATIONS

Since the System 34 used 8 inch diskettes and had a higher transfer rate than standard 5.25 inch disks, the pattern is too large to be used exactly as specified on 5.25 inch media. The number of bytes that can be placed on a 5.25 inch diskette can be calculated by the formula:

1 second divided by 5 revolutions per second equals
.2 seconds per revolution (200 msec.)

Now the fixed transfer rate for double density (MFM recording) is one byte every 32 usec, which gives us:

.2 seconds per revolution divided by
one byte every .000032 seconds (32 usec) equals

6,250 bytes per revolution (track)

If you examine the System 34 standard, you will find the number of bytes required for a track can be expressed as:

Index + Index Gaps + ((Data Gaps + Data Sector) * Number of Sectors)

or, in the case of 18 sectors containing 256 bytes, we find:

4 + 142 + ((116 + 256) * 18) = 6,842 bytes > 6,250 bytes per track

As you can see, we have already exceeded the total number of bytes on a track and Gap IV has not been added yet.

Because of the lower transfer rate on the 5.25 inch drives, the various disk controller manufacturers have made changes in the System 34 format to allow it to be used on these drives. The length of certain gaps has been shortened and some portions of the format have been completely eliminated. Although both Western Digital and NEC have built their controllers to work with these shortened patterns, they will still accept the full System 34 format.

In the System 34 chart in section 2, the numbers in parentheses indicate the values that are recommended by the two controller manufacturers this document covers. The first value is the number as recommended by Western Digital. The number after the slash is the value used by the NEC controller. Note that the NEC controllers generate the format themselves, thus preventing any variation in formats produced by machines using this controller. (Where only one number is listed, the two manufacturers agree on the value.)

Western Digital states that the Index Address Mark portion of the format is not required on the FD179x and FD177x series of parts. Subsequently, Western Digital increases the size of Gap IIIa (t.) The NEC uPD7265 also omits the Index Mark from its format pattern.

Western Digital also allows the following fields to be shortened if desired, but strongly recommends sticking to the values they provide. Here are the allowed variations:

Part of Format that can vary	Minimum Number of Bytes Allowed	Recommended Byte Count
e. (Gap Ia)**	16/32	60
f. (Gap IIIb ONLY)*	8	12
t. (Gap IIIa)**	16/24	24
u. (Gap IV)	16	668

* Line f of the format can be shortened to 8 bytes between sectors only. The Gap Ib must be 12 bytes long. Western Digital has indicated that our Tandon/TPI drives and our systems present too much data jitter and noise to the data separator, particulary in the 1773. Therefore, they advise that Gap IIIb be kept at 12 bytes at all times on these systems.

** The Western Digital FD179x-01 part allowed Gap Ia/IIIa to be shortened to 16 bytes, according to document AO 104. However, the FD179x-02 and FD1770/72/73 parts list 24 bytes as the recommended minimum for Gap IIIa and 32 for Gap Ia. Although this field is not supposed to be critical to PLL lock-up, it has been found that best operation is obtained by using at least 24 bytes for this field. Therefore, we suggest that duplicating machines use 24 bytes for Gap IIIa and at least 32 bytes for Gap Ia.

NEC allows the user to specify the length of Gap IIIa, but recommends the value be no smaller than 12 bytes in length during formatting, and also suggests increasing the value if sector lengths larger than 256 are used. The values suggested by NEC for use with their uPD765A and uPD7265 are:

Sector Size	Gap IIIa Format	Gap IIIa Write Sector
256	12	10
512	50	42
1024	240	128
2048	255	200
4096	255	200

4. MANDATORY FORMAT INFORMATION

Several portions of the two format patterns agree with the System 34 format and must be kept the same. Some of these are used by the controllers to synchronize internal clocks with incoming data during raw reads. Other fields guarantee that a sector can properly be spliced in if written on a system other than the one that formatted the disk.
These fixed fields are described below and refer to the standard in section 2.

I. Gap II, which consists of lines n, o and p of the format. Western Digital states "Gap II cannot be varied from the IBM format." NEC does not allow the size of Gap II to be changed either, and does not provide any way for the programmer to override the mandatory values.

II. NEC warns that the Gap IIIa (t.) specified during a write sector command must be shorter than the Gap IIIa that was specified during the format of the track.

5. TRACK INTERLEAVE AND SKEWING INFORMATION

Several of the operating systems that are covered in this document have calculated sector orders that produce the fastest overall disk performance for the given operating system. Because of this, it is important that this interleave be maintained in diskettes produced by duplication equipment. Although most packages have the customer duplicate the master diskette, which will place the correct interleave on any copy the user makes, some packages are distributed on disks that the user cannot duplicate, and so the interleave must be correct or else the performance of the package will be degraded.

I. For convention, all interleave information given in this document will be described in a form compatible with Western Digital documentation.

II. The interleaves for 18 sectors per track are:

	Offset from Index																	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1:1	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
2:1	00	09	01	10	02	11	03	12	04	13	05	14	06	15	07	16	08	17
3:1	00	06	12	01	07	13	02	08	14	03	09	15	04	10	16	05	11	17
4:1	00	09	05	14	01	10	06	15	02	11	07	16	03	12	08	17	04	13
5:1	00	11	04	15	08	01	12	05	16	09	02	13	06	17	10	03	14	07
6:1	00	03	06	09	12	15	01	04	07	10	13	16	02	05	08	11	14	17
7:1	00	13	08	03	16	11	06	01	14	09	04	17	12	07	02	15	10	05
8:1	00	09	07	16	05	14	03	12	01	10	08	17	06	15	04	13	02	11
9:1	00	02	04	06	08	10	12	14	16	01	03	05	07	09	11	13	15	17
10:1	00	09	02	11	04	13	06	15	08	17	01	10	03	12	05	14	07	16
11:1	00	05	10	15	02	07	12	17	04	09	14	01	06	11	16	03	08	13
12:1	00	03	06	09	12	15	02	05	08	11	14	17	01	04	07	10	13	16
13:1	00	07	14	03	10	17	06	13	02	09	16	05	12	01	08	15	04	11
14:1	00	09	04	13	08	17	03	12	07	16	02	11	06	15	01	10	05	14
15:1	00	06	12	05	11	17	04	10	16	03	09	15	02	08	14	01	07	13
16:1	00	09	08	17	07	16	06	15	05	14	04	13	03	12	02	11	01	10
17:1	00	17	16	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01

III. The interleaves for 8 sectors per track are:

	Offset from Index							
	0	1	2	3	4	5	6	7
1:1	00	01	02	03	04	05	06	07
2:1	00	04	01	05	02	06	03	07
3:1	00	03	06	01	04	07	02	05
4:1	00	02	04	06	01	03	05	07
5:1	00	05	02	07	04	01	06	03
6:1	00	04	03	07	02	06	01	05
7:1	00	07	06	05	04	03	02	01

IV. The interleaves for 9 sectors per track are:

	Offset from Index								
	0	1	2	3	4	5	6	7	8
1:1	00	01	02	03	04	05	06	07	08
2:1	00	05	01	06	02	07	03	08	04
3:1	00	03	06	01	04	07	02	05	08
4:1	00	07	05	03	01	08	06	04	02
5:1	00	02	04	06	08	01	03	05	07
6:1	00	03	06	02	05	08	01	04	07
7:1	00	04	08	03	07	02	06	01	05
8:1	00	08	07	06	05	04	03	02	01

For operating systems that number sectors starting with 1, add one to each entry.

V. Track skewing is done by some operating systems as a means of compensating for the track-to-track step and settle time, thus causing the next sequential sector to be approaching the head by the time all head movement has ended.
The skew is how many sector offsets into a track the normal format pattern will start on the next higher numbered track. For example:

```
Track 0                    | Track 1        (2:1 interleave)
...14 06 15 07 16 08 17    | 05 14 06 15 07 16 08 17 00 09 01...
                      0th  |  1  2  3  4  5  6  7  8  9th
```

When these tracks are shown in total:

```
Offset   0  1  2  3  4  5  6  7  8  9  10 11 12 13 14 15 16 17

Track 0 00 09 01 10 02 11 03 12 04 13 05 14 06 15 07 16 08 17
Track 1 05 14 06 15 07 16 08 17 00 09 01 10 02 11 03 12 04 13
                                  ^
         1  2  3  4  5  6  7  8  Start of normal pattern after skewing
```

These examples show a track skew of 9. Some systems also count the beginning sector, which would make this a skew 10, but for compatability with track interleaves, this document will count track skew the same way.
So a track-to-track skew of 1 (which means no skewing) would be written as:

```
Track 0 00 09 01 10 02 11 03 12 04 13 05 14 06 15 07 16 08 17
Track 1 00 09 01 10 02 11 03 12 04 13 05 14 06 15 07 16 08 17
```

VI. Some operating systems that support two-sided diskettes also skew from side to side. The concept is the same as for track skewing. In the track examples, consider track 0 to be on side 1, track 1 to be on side 2, track 2 on cylinder 1, side 1 and so on.

6. FORMAT PATTERNS OF TANDY OPERATING SYSTEMS

There are several format patterns that are created by the format utilities of our various operating systems.
For each system, the format produced by the operating system is shown with references to the System 34 standard.
Values in parentheses are those considered correct and are recommended for duplication.
Any future release of the operating system should consider incorporating these values.

The details of each system are described below.

7. FORMAT PATTERN FOR TRSDOS 6 and LDOS 5.1.x (Model III,4,4P,4+)

I. The Model III, 4 and 4P use the FD1793 controller and newer Model 4, 4+ and 4Ps use the FD1773, which is compatible with the FD1793.

II. The format (produced by the system formatter) is:

	Number of Bytes	Value on Media	Description
e.	20(32)	4E	Gap Ia (Post Index)**
f.	12	00	Gap Ib/IIIb (PLL sync)
g.	3	A1	Preset CRC
h.	1	FE	ID Address Mark
i.	1	nn	Cylinder # (0-96)
j.	1	nn	Side Number (0 or 1)
k.	1	nn	Sector Number (0-17)
l.	1	nn	Sector Length
m.	2	nnnn	Two byte CRC (id)
n.	22	4E	Gap IIa
o.	12	00	Gap IIb (PLL sync)
p.	3	A1	Preset CRC
q.	1	FB/F8	Data Address Mark
r.	256	Data	Data Sector
s.	2	nnnn	Two byte CRC (data)
x.	1(0)	FF	End of Sector Mark *
t.	17(24)	4E	Gap IIIa (Data gap)***
u.	182	4E	Gap IV

20 + ((256 + 80) * 18) = 6,068 bytes + 182 Gap IV bytes = 6,250 bytes
This pattern is acceptable since 6,068 + 16 bytes is less than 6,250.
(The 16 is the minimum number of bytes allows in Gap IV.
See section 3.)

* TRSDOS 6/LDOS 5.1.x include a 0xFF at the end of each sector. This is required in a single density format (FM recording), but is ignored by the Western Digital parts in double density mode (MFM recording.) This item (x.) can be deleted from the format, but it is suggested that the length of Gap IIIa (t) be increased by one to compensate.*** The presence of the End of Sector mark in the TRSDOS 6/LDOS 5.1.x format is caused by the fact that the format utility can produce either single or double density formats, and some of the code is shared. This byte will be removed (if possible) from any future release of these operating systems.

** TRSDOS 6/LDOS 5.1.x also have a value for Gap Ia that was acceptable with the FD179x-01 part, but Western Digital has increased the minimum value to 32 with the FD179x-02 part.

*** TRSDOS 6/LDOS 5.1.x use a value for Gap IIIa (t.) that is shorter than the recommened value for the FD1773 and the FD179x-02. This format was created when the FD179x-01 was the controller chip and is longer than its minimum of 16 bytes.
Therefore, it is advised that duplicating machines that can increase the size of Gap IIIa to 24 bytes do so. If the machine duplicates the image, then 17/18 bytes* will be acceptable.
Increasing this field to 24 bytes will increase the track length to 6,194 bytes (before Gap IV), so 6,194+16 is less than 6,250 and is considered an acceptable pattern.

If you remove the 0xff byte and increase the size of Gaps Ia and IIIa, the length of the track becomes:

32 + ((256 + 86) * 18) = 6,188 + 16 = 6,204, which is less than 6,250 and allows drive speeds up 302.2 RPM.

The length of these fields should be corrected (if possible) in any future release of these operating systems.

III. TRSDOS 6/LDOS 5.1.x have 18 sectors per track and numbers them starting with 0 (0-17). Each sector contains 256 bytes.

IV. The Data Address marks must be duplicated as they are on the source diskette. In normally formatted disks, they vary on track boundaries (entire track has deleted or undeleted DAM), but this may not be the case on all application packages. (Normally the operating system uses these marks to indicate if the head is over the directory track or not.)
Normal LDOS 5.1.x/TRSDOS 6.2 diskettes have FB on all tracks except the directory track (usually 20 decimal), which is F8. Keep in mind that LDOS 5.1.x/TRSDOS 6.2 allow the directory track to be placed on any track on the disk.

V. The Interleave for TRSDOS 6.2 is 2:1. (See Section 5 for the resulting sector ordering.)
LDOS 5.1.4 has an interleave of 3:1.

VI. The Track Skew value for TRSDOS 6.2 is 9. (See Section 5 for the resulting offset in the format pattern by track.)
LDOS 5.1.4 has a Track Skew of 6.

VII. TRSDOS 6.2/LDOS 5.1.x allow 1 or 2 sided formatting with single sided being the default. These systems also allow 35 to 96 cylinders, with 40 cylinders* being the default.

Tandy does not currently support double sided operation, and if we ever did, packages would likely not be released on double sided media.
(In double sided operation, TRSDOS 6.2 has a side to side skew of 2 and a cylinder to cylinder skew of 7. In double sided operation, LDOS 5.1.4 has a side to side skew of 2 and a cylinder to cylinder skew of 4.)

* (The above information does not apply to the Model I version of LDOS 5.1.x.)

8. FORMAT PATTERN FOR TRSDOS 1.3 (Model III,4,4P,4+)

I. The Model III, 4 and 4P use the FD1793 controller and newer Model 4, 4+ and 4Ps use the FD1773, which is compatible with the FD1793.

II. The format (produced by the system formatter) is:

	Number of Bytes	Value on Media	Description
e.	64(32)	4E	Gap Ia (Post Index)*
f.	8(12)	00	Gap Ib/IIIb(PLL sync)*
g.	3	A1	Preset CRC
h.	1	FE	ID Address Mark
i.	1	nn	Cylinder # (0-39)
j.	1	nn	Side Number (0)
k.	1	nn	Sector Number (1-18)
l.	1	nn	Sector Length
m.	2	nnnn	Two byte CRC (id)
n.	22	4E	Gap IIa
o.	12	00	Gap IIb (PLL sync)
p.	3	A1	Preset CRC
q.	1	FB/F8	Data Address Mark
r.	256	Data	Data Sector
s.	2	nnnn	Two byte CRC (data)
t.	24	4E	Gap IIIa (Data gap)
u.	898	4E	Gap IV

64 + ((256 + 82) * 18) = 6,148 bytes + 16 Gap IV bytes = 6,164 bytes
This pattern is acceptable since 6,164 is less than 6,250.
(The 16 is the minimum number of bytes allows in Gap IV.
See section 3.)

* Although 8 bytes is the documented minimum for Gap IIIb, TRSDOS 1.3 uses 8 bytes for Gap Ib, which is incorrect. Gap Ib should be 12 bytes (in front of first sector after Index).
Western Digital advises that both Gaps Ib and IIIb be kept at 12 bytes due to our hardware. See Section 3 for more information.

If both Gap Ib and IIIb are set to 12 bytes, the total track length becomes 64 + ((256 + 86) * 18) = 6,220 bytes. After adding a minimum of 16 bytes for Gap IV, 6,220+16 = 6,236, which is below 6,250. However, this value is close to 6,250, and requires that drives not be running at more than 300.67 RPM. It is suggested that Gap I be shortened to 32 bytes, which would allow the drive to be running at up to 302.2 RPM.
The next release of TRSDOS 1.x should correct these values.

III. TRSDOS 1.3 has 18 sectors per track and numbers them starting with 1 (1-18). Each sector contains 256 bytes.

IV. The Data Address Mark varies from track to track. (On a normal disk, they vary on track boundaries and indicate if the head is over the directory.) Standard diskettes have F8 on all tracks except 17 (decimal), which has FB. A duplicator must duplicate these exactly as they appear on the master.

V. The Interleave for TRSDOS 1.3 is 6:1. (See Section 5 for the resulting sector ordering.)

VI. The Track Skew value for TRSDOS 1.3 is 1 (none.)

VII. TRSDOS 1.x only allows 40 tracks and does not support two sided operation. (It ignores the presence of side 2.)

9. FORMAT PATTERN FOR MSDOS 02.11.00 (Model 1000/1200/2000)

I. The Model 1000, 1200 and 2000 use the NEC uPD765A controller.

II. The format (produced by the system formatter with default parameters) is:

	Number of Bytes	Value on Media	Description
a.	80	4E	Index Gap a
b.	12	00	Index Gap b (PLL sync)
c.	3	C2	Index Prefix
d.	1	FC	Index Mark
e.	50	4E	Gap Ia (Post Index)
f.	12	00	Gap Ib/IIIb (PLL sync)
g.	3	Al	Preset CRC
h.	1	FE	ID Address Mark
i.	1	nn	Cylinder # (0-39)
j.	1	nn	Side Number (0-1)
k.	1	nn	Sector Number (1-9)
l.	1	nn	Sector Length
m.	2	nnnn	Two byte CRC (id)
n.	22	4E	Gap IIa
o.	12	00	Gap IIb (PLL sync)
p.	3	Al	Preset CRC
q.	1	FB	Data Address Mark
r.	512	Data	Data Sector
s.	2	nnnn	Two byte CRC (data)
t.	80	4E	Gap IIIa (Data gap)
u.	218 (minimum)	4E	Gap IV

146 + ((512 + 142) * 9) = 6,032 bytes + 16 Gap IV bytes = 6,048 bytes
This pattern is acceptable since 6,048 is less than 6,250.
**** (The 16 is the minimum number of bytes allows in Gap IV.
See section 3.)

III. The default format has 9 sectors per track and numbers them starting with 1 (1-9). Each sector contains 512 bytes. The format utility in its default mode formats both sides of the disk with the same format and sector count. Disks can be formatted with 8 sectors per track to be compatible with early IBM MS-DOS systems.

IV. The Data Address Mark is FB on all sectors.

V. The Interleave for Model 1000/1200/2000 MSDOS 02.11.00 is 1:1.

VI. The Track Skew value for Model 1000/1200/2000 MSDOS 02.11.00 is 1.

VII. The Model 1000 and 1200 normally formats disks as 2-sided, 40-track, with 9 sectors per track.

The Model 2000 normally formats disks as 2-sided, 80-track, with 9 sectors per track. (96 TPI drives.)

The side to side skew for the 1000/1200/2000 is 1 (none.)

10. FORMAT PATTERN FOR OS-9 (Color Computer)

I. The Color Computer disk cartridge uses a FD1793 in older versions, and the FD1773 in the newer units.

II. The format (produced by the system formatter) is:

	Number of Bytes	Value on Media	Description
e.	32	4E	Gap Ia (Post Index)*
f.	8(12)	00	Gap Ib/IIIb(PLL sync)*
g.	3	A1	Preset CRC
h.	1	FE	ID Address Mark
i.	1	nn	Cylinder # (0-34)
j.	1	nn	Side Number (0)
k.	1	nn	Sector Number (1-18)
l.	1	nn	Sector Length
m.	2	nnnn	Two byte CRC (id)
n.	22	4E	Gap IIa
o.	12	00	Gap IIb (PLL sync)
p.	3	A1	Preset CRC
q.	1	FB	Data Address Mark
r.	256	Data	Data Sector
s.	2	nnnn	Two byte CRC (data)
t.	24	4E	Gap IIIa (Data gap)
u.	158	4E	Gap IV

32 + ((256 + 82) * 18) = 6,116 bytes + 16 Gap IV bytes = 6,132 bytes
This pattern is acceptable for length.

* Although 8 bytes is the acceptable minimum for Gap IIIb, OS-9 uses 8 bytes for Gap Ib, which is incorrect. Gap Ib should be 12 bytes (in front of first sector after Index).
Western Digital advises that both Gaps Ib and IIIb be kept at 12 bytes due to our hardware. See Section 3 for more information.

If both Gap Ib and IIIb are set to 12 bytes, the total track length becomes 32 + ((256 + 86) * 18) = 6,188 bytes. After adding a minimum of 16 bytes for Gap IV, 6,188 + 16 = 6,204 bytes, which is acceptable.

III. OS-9 has 18 sectors per track and numbers them starting with 1 (1-18). Each sector contains 256 bytes.

IV. The Data Address Mark is FB on all sectors.

V. The Interleave for OS-9 is 2:1. (See Section 5 for the resulting sector ordering.)

VI. The Track Skew value for OS-9 is 1 (none.)

VII. OS-9 normally formats 35 tracks, but can produce 40 track, single sided diskettes.

11. FORMAT PATTERN FOR MODEL 100/200 DOS

I. The Model 100 and 200 disk box use a MB8877a, which is documented as being 100% compatible with the Western Digital FD1793-02. Therefore, this discussion will proceed assuming it has the same requirements.

II. The format (produced by the system formatter) is:

	Number of Bytes	Value on Media	Description
e.	64(32)	4E	Gap Ia (Post Index)*
f.	8(12)	00	Gap Ib/IIIb(PLL sync)*
g.	3	A1	Preset CRC
h.	1	FE	ID Address Mark
i.	1	nn	Cylinder # (0-39)
j.	1	nn	Side Number (0)
k.	1	nn	Sector Number (1-18)
l.	1	nn	Sector Length
m.	2	nnnn	Two byte CRC (id)
n.	22	4E	Gap IIa
o.	12	00	Gap IIb (PLL sync)
p.	3	A1	Preset CRC
q.	1	FB	Data Address Mark
r.	256	Data	Data Sector
.	2	nnnn	Two byte CRC (data)
t.	24	4E	Gap IIIa (Data gap)
u.	128	4E	Gap IV

64 + ((256 + 82) * 18) = 6,148 bytes + 16 Gap IV bytes = 6,164 bytes
This pattern is acceptable since 6,164 is less than 6,250.
(The 16 is the minimum number of bytes allows in Gap IV.
See section 3.)

* Although 8 bytes is the documented minimum for Gap IIIb, TRSDOS 1.3 uses 8 bytes for Gap Ib, which is incorrect. Gap Ib should be 12 bytes (in front of first sector after Index).
Western Digital advises that both Gaps Ib and IIIb be kept at 12 bytes due to our hardware. Since these units do not actually use the Western Digital part, they may have more noise immunity.
See section 3 for more information on the Western Digital part.

If both Gap Ib and IIIb are set to 12 bytes, the total track length becomes 64 + ((256 + 86) * 18) = 6,220 bytes. After adding a minimum of 16 bytes for Gap IV, 6,220+16 = 6,236, which is below 6,250. However, this value is close to 6,250, and requires that drives not be running at more than 300.67 RPM. It is suggested that Gap I be shortened to 32 bytes, which would allow the drive to be running at up to 302.2 RPM.
The next release of Model 100/200 formatters should correct this problem.

III. The Model 100/200 has 18 sectors per track and numbers them starting with 1 (1-18). Each sector contains 256 bytes.

IV. The Data Address Mark is FB on all sectors.

V. The Interleave for the Model 100/200 is 6:1.

VI. The Track Skew value for Model 100/200 is 1 (none.)

VII. The Model 100/200 only allows 40 tracks and does not support two sided operation. (It ignores the presence of side 2.)

12. FORMAT PATTERN FOR MODEL 2000 XENIX

I. The Model 2000 uses the NEC uPD765A controller.

II. The format (produced by the system formatter with default parameters) is:

	Number of Bytes	Value on Media	Description
a.	80	4E	Index Gap a
b.	12	00	Index Gap b (PLL sync)
c.	3	C2	Index Prefix
d.	1	FC	Index Mark
e.	50	4E	Gap Ia (Post Index)
f.	12	00	Gap Ib/IIIb (PLL sync)
g.	3	Al	Preset CRC
h.	1	FE	ID Address Mark
i.	1	nn	Cylinder # (0-39)
j.	1	nn	Side Number (0-1)
k.	1	nn	Sector Number (1-9)
l.	1	nn	Sector Length
m.	2	nnnn	Two byte CRC (id)
n.	22	4E	Gap IIa
o.	12	00	Gap IIb (PLL sync)
p.	3	Al	Preset CRC
q.	1	FB	Data Address Mark
.	512	Data	Data Sector
s.	2	nnnn	Two byte CRC (data)
t.	80	4E	Gap IIIa (Data gap)
u.	218 (minimum)	4E	Gap IV

146 + ((512 + 142) * 9) = 6,032 bytes + 16 Gap IV bytes = 6,048 bytes
This pattern is acceptable since 6,048 is less than 6,250.

III. The default format has 9 sectors per track and numbers them starting with 1 (1-9). Each sector contains 512 bytes. The format utility in its default mode formats both sides of the disk with the same format and sector count.

IV. The Data Address Mark is FB on all sectors.

V. The Interleave 2000 Xenix is 1:1.

VI. The Track Skew value for 2000 Xenix is 1 (none.)

VII. The Model 2000 normally formats disks as 2-sided, 80-track, with 9 sectors per track. (96 TPI drives.) (It does allow disks to be formatted with only 40 tracks.)

The side to side skew for 2000 Xenix is 1 (none.)

13. FORMAT PATTERN FOR CP/M+ (Model 4,4P,4+)

I. The Model 4 and 4P use the FD1793 controller and newer Model 4, 4+ and 4Ps use the FD1773, which is compatible with the FD1793.

II. CP/M+ uses one format on track 0 and another on the remaining tracks. (The reason for this switch in format is not known, as the Model 4 and 4P ROM will read a 512 byte boot sector.)
Both track formats are shown below.

CP/M+ TRACK 0 FORMAT

	Number of Bytes	Value on Media	Description
e.	32	4E	Gap Ia (Post Index)
f.	12	00	Gap Ib/IIIb(PLL sync)
g.	3	A1	Preset CRC
h.	1	FE	ID Address Mark
i.	1	nn	Cylinder # (0-39)
j.	1	nn	Side Number (0)
k.	1	nn	Sector Number (1-18)
l.	1	nn	Sector Length
m.	2	nnnn	Two byte CRC (id)
n.	22	4E	Gap IIa
	12	00	Gap IIb (PLL sync)
p.	3	A1	Preset CRC
q.	1	FB/F8	Data Address Mark
r.	256	Data	Data Sector
s.	2	nnnn	Two byte CRC (data)
x.	1(0)	FF	End of Sector Mark **
t.	17(24)	4E	Gap IIIa (Data gap)*
u.	150	FF(4E)	Gap IV ***

32 + ((256 + 75) * 18) = 5,990 bytes + 16 Gap IV bytes = 6,006 bytes
This pattern is acceptable since 6,164 is less than 6,250.
(The 16 is the minimum number of bytes allows in Gap IV.
See section 3.)

* TRSDOS 6/LDOS 5.1.x use a value for Gap IIIa (t.) that is shorter than the recommened value for the FD1773 and the FD179x-02.
Therefore, it is advised that duplicating machines that can increase the size of Gap IIIa to 24 bytes do so.
The size of this field should be corrected in the next release.

** The byte in this field (x.) is not required and is ignored by the FD179x/FD177x controllers in MFM operation. This byte should be removed at the next release.

*** The Gap IV value is incorrect. The remainder of the track should be filled with 4Es instead of FFs. This should be corrected in the next release.

If you remove the 0xff byte and increase the size of Gap IIIa, the length of the track becomes:

32 + ((256 + 86) * 18) = 6,188 bytes + 16 Gap IV bytes = 6,204 bytes
This pattern is acceptable since 6,204 is less than 6,250.

CP/M+ TRACK 1 TO 39 FORMAT

	Number of Bytes	Value on Media	Description
a.	80	4E	Index Gap a
b.	12	00	Index Gap b (PLL sync)
c.	3	C2	Index Prefix
d.	1	FC	Index Mark
e.	50	4E	Gap Ia (Post Index)
f.	12	00	Gap Ib/IIIb (PLL sync)
g.	3	Al	Preset CRC
h.	1	FE	ID Address Mark
i.	1	nn	Cylinder # (0-39)
j.	1	nn	Side Number (0-1)
k.	1	nn	Sector Number (1-9)
l.	1	nn	Sector Length
m.	2	nnnn	Two byte CRC (id)
n.	22	4E	Gap IIa
.	12	00	Gap IIb (PLL sync)
p.	3	Al	Preset CRC
q.	1	FB	Data Address Mark
r.	512	Data	Data Sector
s.	2	nnnn	Two byte CRC (data)
t.	76	4E	Gap IIIa (Data gap)
u.	904 (minimum)	FF(4E)	Gap IV *

146 + ((512 + 138) * 8) = 5,346 bytes + 16 bytes = 5,362
This format is acceptable.

* The wrong fill character is used for Gap IV. Western Digital and the System 34 standard specify that the track be back-filled with 4Es. This should be corrected in the next release.

III. CP/M+ has 18 sectors per track on track 0 and numbers them starting with 1 (1-18). Each sector contains 256 bytes. All other tracks contain 8 sectors, 512 bytes per sector, and sector numbers start with 1.

IV. The Data Address Mark is FB on all sectors.

IV. The Data Address Mark is FB on all sectors.

V. The Interleave for CP/M+ on track 0 is 3:1. (See Section 5 for the resulting sector ordering.)
The Interleave on the other remaining tracks does not match any standard sector ordering. The order used is:

Offset from Index

00 01 02 03 04 05 06 07
01 07 05 03 02 08 06 04

It is possible that this is meant to be 4:1, since sector 1 and 2 are three apart. If so, the correct order would be:

01,03,05,07,02,04,06,08

VI. The Track Skew value for CP/M+ is 1 (none.)

VII. CP/M+ only allows 40 tracks and does not support two sided operation. (It ignores the presence of side 2.)