MAGNETIC TAPE TRENDS

AMPEX

APPLICATION ENGINEERING BULLETIN

BULLETIN NO. 11 MARCH, 1966

TAPE REELS FOR INSTRUMENTATION, COMPUTER, VIDEO AND AUDIO RECORDING

The most familiar but least understood component of precision magnetic tape is the reel. Everyone takes the reel for granted and does not realize how significant a contribution a properly designed reel makes to proper system performance. This article will discuss the design philosophy of the reel, industry specifications, and the care and handling of reels. To discuss reels in detail, it is necessary to treat each major product category separately; audio, computer, video, and instrumentation. However, before getting into specific details, it is appropriate to comment on a few basic principles that are common to all reels.

The prime function of a reel is to protect the tape. This protection must be effective under shipping conditions, storage, use and "normal" abuse. A reel is not designed to hold or control the tape pack, in fact, flanges should never contact the tape. The tape pack derives its sole source of support from the contact of the first layer of tape on the hub (see Figure 1). Essentially, all tapes are handled and transported during manufacturing on flangeless hubs. One of the last operations is to rewind tape on flanged reels for shipping. A properly controlled tension pattern will hold 9200' of tape on a hub, and no normal amount of shaking, turning, or vibration will cause it to spill off.

An old wives tale, dearly held by many, is that windage holes are necessary to "let the entrapped air out between layers of tape" during rewind operations. We can let the air out of this tale by simply stating it is not true. The flange design and either presence or absence of windage holes have nothing whatsoever to do with the condition of the tape pack at any speeds. If anything, windage holes will actually "pump air" into the reel during fast modes. All reels are designed with an adequate "free tape path". You will note from Figure 1 that the flange-to-flange dimension (free tape path) is greater than the tape width.

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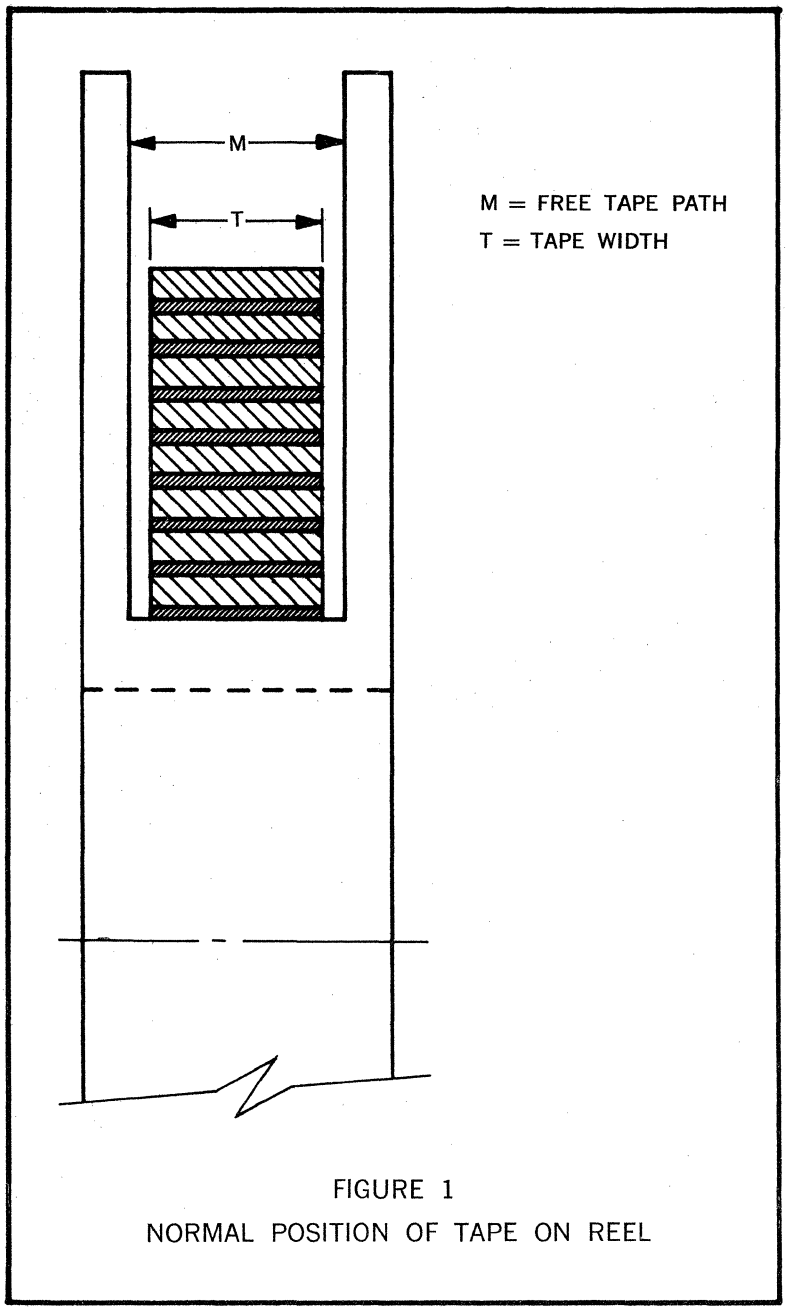

FIGURE 1
NORMAL POSITION OF TAPE ON REEL

A composite listing of the general types of reels used throughout the industry would be as follows:

I. Plastic 5/16" hub - audio

II. NAB metal - non precision (normally referred to as simply "NAB reel") - instrumentation.

III. NAB metal - precision (normally referred to as "precision reel") - instrumentation/video.

IV. IBM plastic - computer

V. Special

This obviously does not include every reel that is available, but it provides a quick look at reels in general, and classifies them in proper perspective. Details of each reel will be discussed as it applies to its specific product application.

Reel and hub specifications were originally standardized through federal specifications used for governmental procurement. These "specs" still govern reel and hub mechanical and performance characteristics. The most complete of these federal "specs" is WR-00175, and this issue of TRENDS will use the basic categories of WR-00175 to present its information.

DEFINITION AND SUB-SECTIONS OF WR-00175

WR00175	Reels and hubs for magnetic recording tape, General Specification for
WR00175/1	Detailed Specification for Reels, Std., Plastic, and Fiberglass, 5/16" center hole.
WR00175/2	Detailed Specification for Hubs, Std., Fiberglass, and Metallic, 3" center hole.
WR00175/3	Detailed Specification for Reels, Std., Fiberglass, and Metallic, 3" center hole (NAB)
WR00175/4	Detailed Specification for Reels, Precision, Aluminum and Magnesium, 3" center hole.

WR00175 supersedes and replaces MIL-R-22842 (BuShips).

INSTRUMENTATION REELS

There are two types of reels prevalent in instrumentation applications: NAB and PRECISION. Detailed specifications for each will first be presented (these are exerpts from WR-00175 and may be used for future reference). Following each detailed specification is a comparison for each of the two types, emphasizing the salient points and advantages of each type. Following are the exerpts from Fed. Spec. WR-00175, Reels and Hubs for Magnetic Recording Tape.

NAB / NON-PRECISION REELS

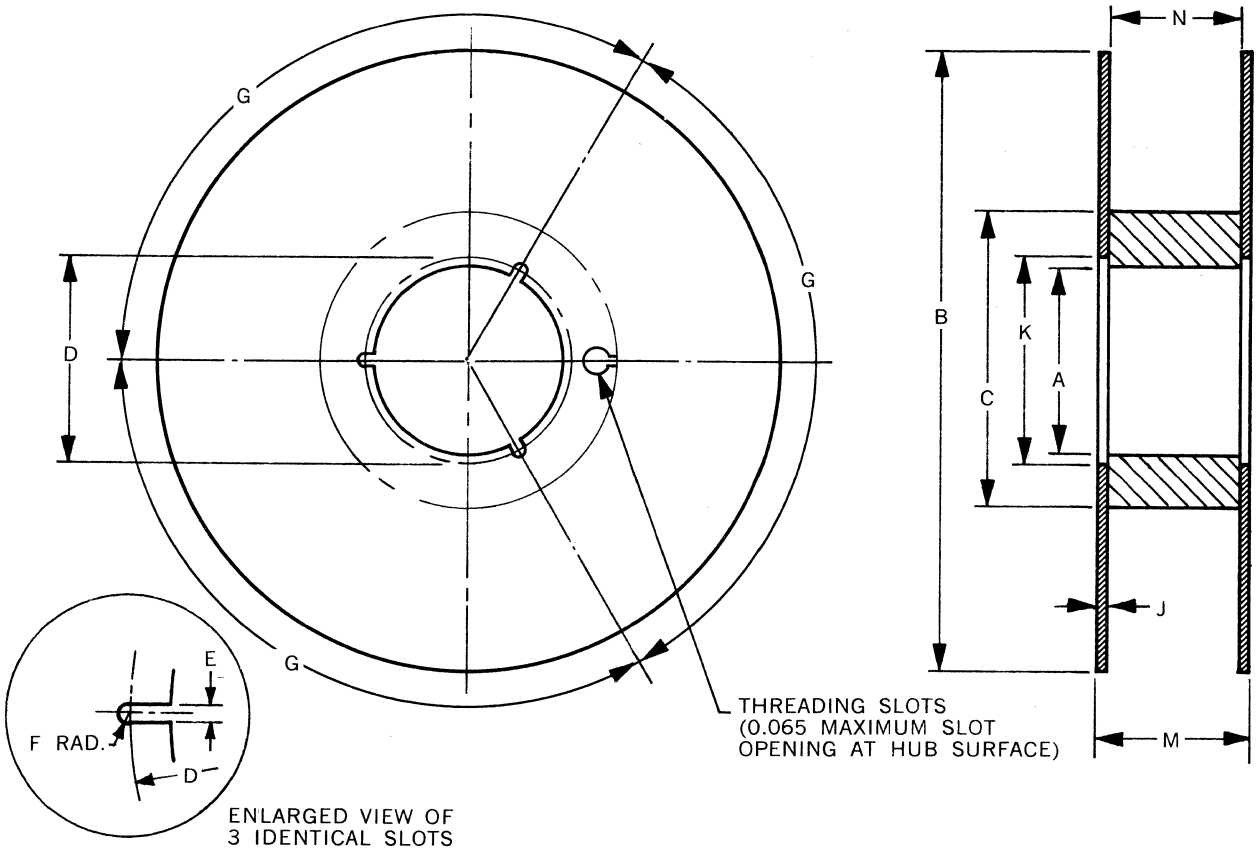

FIGURE 2
STANDARD FIBERGLASS AND ALUMINUM REELS

HUB DIMENSIONS — TABLE 1

Nominal tape width	"M" dimension (tolerance ± 0.010)	"N" dimension (tolerance ± 0.005)
¼	0.462	0.350
½	.712	.600
¾	.962	.850
1	1.212	1.100
1¼	1.462	1.350
1½	1.712	1.600
2	2.212	2.100

NOTES:
1. Unless otherwise specified, all dimensions are in inches.
2. The value "N" for a "PC" and "SC" class reel shall not vary more than ± 0.50 when measured from the hub to the periphery of the flange.

FLANGE DIMENSIONS — TABLE 2

Reel and hub indicator	"B" dimension and tolerance	Flange deflection (maximum)
PC	10.500 ± 0.010	0.17
SC	14.000 ± 0.010	0.21

NOTE: Unless otherwise specified, all dimensions are in inches.

NAB / NON-PRECISION REELS

REEL DIMENSIONS AND TOLERANCES

Characteristic	Reel and hub indicator	
	PB	PC and SC
A	3.000 $^{+0.020}_{-0.000}$	3.000 $^{+0.004}_{-0.000}$
B	10.500 ± .020	(See table 2)
C	4.500 ± .015	4.500 ± 0.010
D	3.250 $^{+.020}_{-.000}$	3.250 ± .002
E	0.219 $^{\pm .013}_{-.000}$	(See notes 4 and 5)
F	.109 $^{+.007}_{-.000}$	(See notes 4 and 5)
G	120 degrees ± 0.5 degree	120 degrees ± 6 minutes
J	0.120 maximum	0.055 maximum
K	Not applicable	3.031 $^{+0.004}_{-.000}$
M	0.495 ± 0.020	(See table 1)
N (See note 6)	.285 $^{+.020}_{-.010}$	(See table 1)
Mounting surface parallelism (see 4.3)	.001 inch per inch of diameter max.	0.002 inch per inch of diameter max.
Outside hub surface parallelism (see note 7)	.001 TIR	0.001 inch per inch of width – max.
Inside hub surface taper and perpendicularity (see note 8)	Not applicable	0.002 inch per inch of width – max.
Outside hub surface taper and perpendicularity (see note 8)	0.002 TIR	.003 inch per inch of width – max.
Outside hub surface concentricity	.010 TIR	0.010 TIR
Flange rim concentricity	.050 TIR	.050 TIR
Lateral runout	.060 TIR	.050 TIR
Flange wobble	---	---
Moment of inertia	Not applicable	Not applicable
Roughness of inside flange surface	125μ in. maximum	80μ in. maximum
Roughness of outside hub surface	125μ in. maximum	80μ in. maximum
Flange deflection	0.17 maximum	(See table 2)
Percentage of open flange area	50 percent maximum	50 percent maximum
Threading method (number optional)	Threading slots	Threading slots
Number of fasteners per flange	Not applicable	3 minimum (See note 9)

NOTES:

1. Unless otherwise specified, all dimensions are in inches.
2. Lateral mounting surfaces extend out to "C" diameter.
3. All sharp edges shall be rounded 0.004 radius.
4. The key slot dimensions on the hub for types I and II reels shall be:
   "E" = 0.219 $^{+0.006}_{-.000}$ "F" = 0.109R $^{+0.003}_{-0.000}$
5. The key slot dimensions on the flanges for type I shall be:
   "E" = 0.250 $^{+0.000}_{-.010}$ "F" = 0.125R $^{+0.000}_{-.005}$
6. The value "N" for a "PB" class reel shall not vary more than ± 0.050 when meansured from the hub to periphery of the flange.
7. The outside hub surface parallelism for a "PC" and "SC" class reel of a nominal ¼ inch width and ½ inch width shall not exceed 0.002 TIR and 0.003 TIR, respectively.
8. The taper and perpendicularity on the inside hub surface and on the outside hub surface for a "PC" and "SC" class reel of a nominal ¼ inch width and ½ inch width shall not exceed 0.002 TIR and 0.003 TIR, respectively.
9. Not applicable for type II reels. The minimum metal to adhesive contact area for type III reels shall be 2.25 square inches.

PRECISION REELS

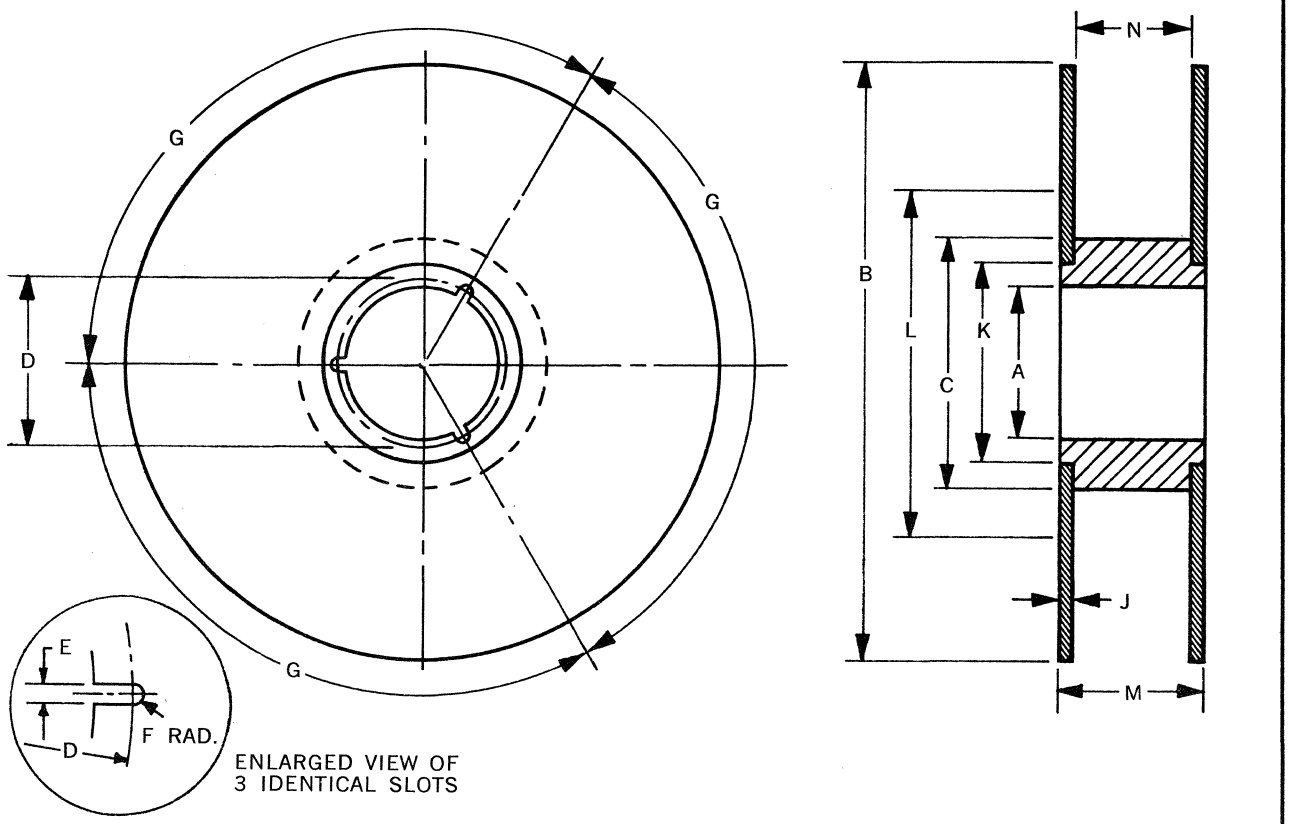

FIGURE 3
PRECISION ALUMINUM AND MAGNESIUM REELS

HUB DIMENSIONS AND MOMENT OF INERTIA — TABLE 1

Nominal tape width	"M" dimension and tolerance	"N" dimension and tolerance	Moment of inertia (Maximum)					
			Types I and IV			Types II and III		
			PCP	QCP	SCP	PCP	QCP	SCP
¼	0.462 ± 0.003	0.270 ± 0.002	0.12	0.22	0.31	0.16	0.33	0.45
½	.712 ± 0.003	.520 ± 0.002	.12	.22	.31	.16	.33	.45
¾	.962 ± 0.003	.770 ± 0.002	.13	.23	.32	.17	.34	.46
1	1.212 ± 0.003	1.020 ± 0.002	.13	.23	.32	.17	.34	.46
1¼	1.462 ± 0.003	1.270 ± 0.002	.14	.24	.33	.18	.35	.47
1½	1.712 ± 0.003	1.520 ± 0.002	.14	.24	.33	.18	.35	.47
2	2.212 ± 0.003	2.020 ± 0.002	.15	.25	.34	.19	.36	.48

NOTES:
1. All dimensions are in inches except moment of inertia values which have units of pound-feet^2.
2. The value "N" shall not vary more than the following for a given reel class when measured from the hub to the periphery of the flange:
   "PCP" class reel $^{+\ 0.015}_{-\ 0.010}$ "QCP" class reel $^{+\ 0.020}_{-\ 0.010}$ "SCP" class reel $^{+\ 0.025}_{-\ 0.010}$

FLANGE DIMENSIONS — TABLE 2

Reel and hub indicator	"B" dimension and tolerance	Flange rim concentricity	Flange deflection (maximum)		
			Type I	Type II, III	Type IV
PCP	10.500 ± 0.010	0.010 TIR	0.020	0.015	0.012
QCP	12.500 ± .010	.012 TIR	.028	.021	.023
SCP	14.000 ± .010	.015 TIR	.030	.024	.030

NOTE: Unless otherwise specified, all dimensions are in inches.

PRECISION REELS

REEL DIMENSIONS AND TOLERANCES

Characteristic	Type indicator	
	Types I, II and III.	Type IV
A	3.000 + 0.003 − 0.000	3.000 + 0.004 − .000
B	(See table 2)	
C (see note 10)	4.500 ± 0.010	4.500 ± .010
D	3.250 ± .002	3.250 ± .002
E	0.219 + .006 − .000	0.219 + .006 − .000
F	.109 + .003 − .000	.109 + .003 − .000
G	120 degrees ± 6 min.	120 degrees ± 6 min.
J	0.098 maximum	0.098 max.
K (see note 6)	3.700 max. 3.600 min.	3.700 max. 3.600 min.
L	6.000 min.	6.000 min.
M	(See table 1)	
N	(See table 1)	
Mounting surface parallelism	0.0004 inch per inch of diameter—max.	0.0008 inch per inch of diameter—max.
Outside hub surface parallelism (see note 7)	.0004 inch per inch of width—max.	.0008 inch per inch of width—max.
Inside hub surface taper and perpendicularity (see note 8)	.0006 inch per inch of width—max.	.002 inch per inch of width—max.
Outside hub surface taper and perpendicularity (see note 8)	.0006 inch per inch of width—max.	.002 inch per inch of width—max.
Outside hub surface concentricity	.002 TIR	.003 TIR
Flange rim concentricity	(See table 2)	
Lateral runout	.020 TIR	.020 TIR
Flange wobble	----------	----------
Moment of inertia	(See table 1)	
Roughness of inside flange surface	50 μ in. max.	50 μ in. max.
Roughness of outside hub surface	50 μ in. max.	50 μ in. max.
Flange deflection	(See table 2)	
Percentage of open flange area	25% max.	25% max.
Threading method	Multiple wrap	Multiple wrap
Number of fasteners per flange	6 min. (see note 9)	6 min.

NOTES:

1. Unless otherwise specified, all dimensions are in inches.
2. Lateral mounting surfaces extend out to "C" diameter.
3. Outside surfaces of the flanges between "K" and "L" diameters shall not extend beyond the mounting surfaces.
4. All sharp edges shall be rounded 0.004 radius.
5. Any solid metal section for a type IV reel shall be of a minimum thickness of at least 0.080 inch.
6. The "K" diameter for the flange shall be 3.700 maximum and the "K" diameter for the hub shall be 3.600 minimum.
7. The outside hub surface parallelism for types I, II, and III reels of a nominal ¼-inch width and ½-inch width shall not exceed 0.0002 TIR, and for a type IV reel of a nominal ¼-inch width and ½-inch width shall not exceed 0.0004 TIR.
8. The taper and perpendicularity on the inside hub surface and on the outside hub surface for types I, II, and III reels for a nominal ¼-inch width and ½-inch width shall not exceed 0.0006 TIR, and for a type IV reel of a nominal ¼-inch width and ½-inch width shall not exceed 0.002 TIR.
9. Not applicable for type III reels. The minimum metal to adhesive contact area for type III reels shall be 2.25 square inches.
10. This dimension is exclusive of any friction rings used on the reel (see 6.1). If friction ring is used, it shall meet the following requirements:
    (a) The material shall be neoprene of a durometer hardness of 60 ± 10.
    (b) Inside and outside diameters shall be concentric to 0.020 inch TIR.
    (c) The inside and outside surfaces shall be parallel to 0.010 inch per inch of width.
    (d) The sides of the friction ring shall be at right angles (90 degrees) within ± 1 degree.
    (e) Friction ring shall meet the temperature and humidity cycling.
    (f) The width of the ring shall be 0.010 $^{+\ 0.000}_{-\ .010}$ less than "N" dimension.
    (g) The ring shall be centered so that there is a visible clearance between the flanges and the edge of the ring. This clearance on each side shall be visibly equal.

PRECISION REELS - WR-00175/4

WR-00175 SPECIFIES FOUR TYPES OF PRECISION REELS:

TYPE I	Tapered Flange Aluminum, with flanges fastened to hubs with screws, nuts, or bolts.
TYPE II	Flat Flange Aluminum, with flanges fastened to hubs with screws, nuts, or bolts.
TYPE III	Same as Type II, except flanges fastened by adhesives.
TYPE IV	Flat Flange Magnesium, flanges fastened to hub with screws, nuts, or bolts.

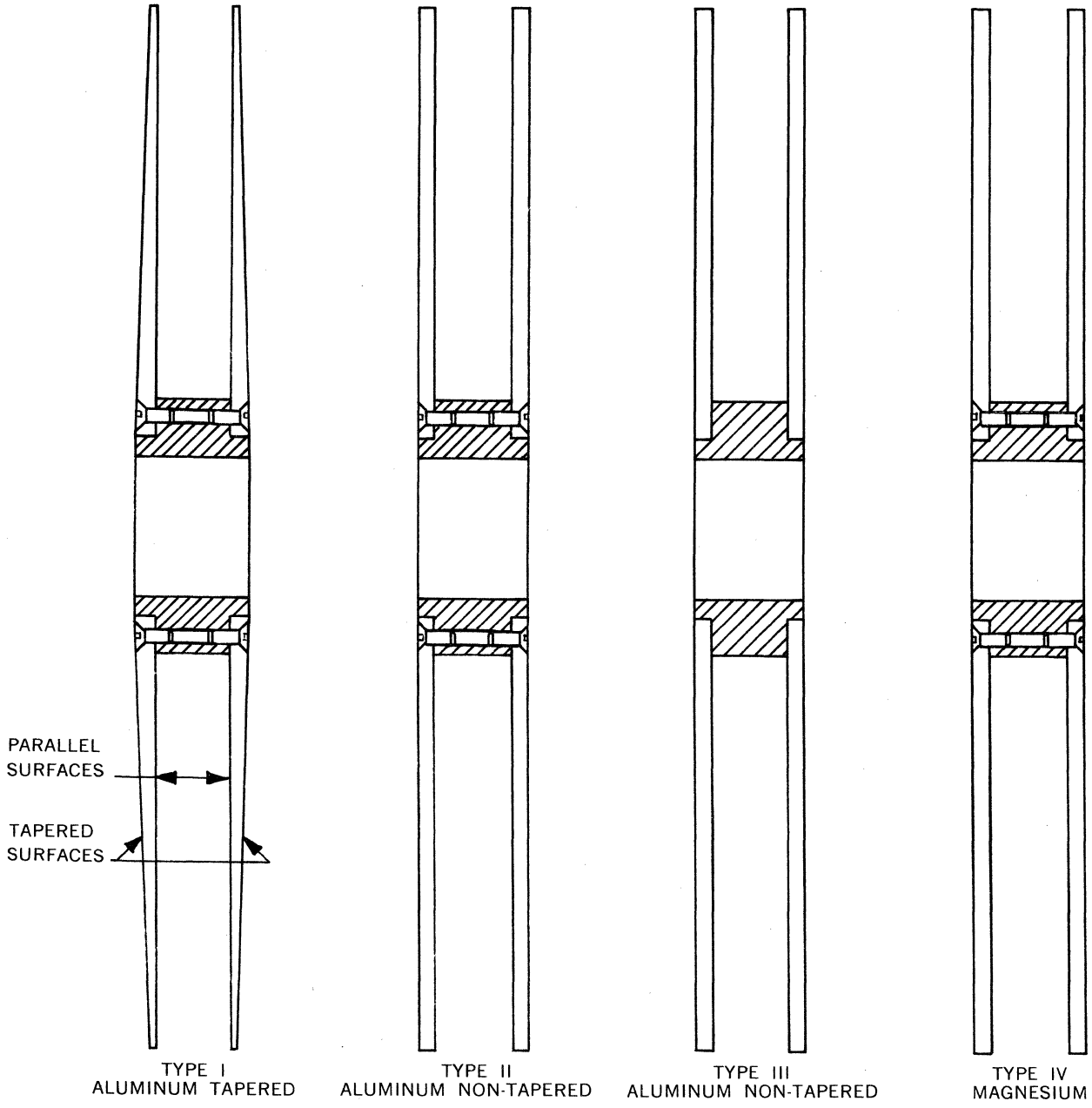

FIGURE 4
TYPES OF PRECISION INSTRUMENTATION REELS

NAB - NON PRECISION REELS

Fed. Spec. WR-00175/3 contains the detailed specs for NAB reels. NAB reels are available with fiberglass (10-1/2" only) or aluminum flanges and are identified by

Reel Indicator	Flange O. D.	Description
PB	10-1/2 "	Reel, fiberglass, 4-1/2" hub, 3" center hole, and 10-1/2" flanges
PC	10-1/2 "	Reel, metallic, assembled, includes 4-1/2" hub and 10-1/2" flanges
SC	14"	Reel, metallic, assembled, includes 4-1/2" hub and 14" flanges

"What is the difference between NAB and Precision reels", and "when should I use precision reels instead of NAB"? are the most frequent questions asked about instrumentation reels. The two most important considerations are moment of inertia and dimensional tolerances. Precision reels have stringent requirements on moment of inertia which enable transports to achieve designed flutter specs. All manufacturers use precision reels to check out equipment, and guarantee performance specifications only when precision reels are used. Flange tolerances, free tape path, hub tolerances, etc. are held to tighter tolerances on precision reels. The following chart tabulates the major differences between NAB and Precision reels.

COMPARISON OF NAB AND PRECISION REELS

	NAB	PRECISION
Number of fasteners per flange	3 minimum	6 minimum
Threading method	Threading slots	Multiple Wrap
Percentage of open flange area (windage holes)	50% maximum	25% maximum
Moment of Inertia	Not applicable	Specified per table IV WR-00175/4
Free tape path tolerance	for 1/2" reel 0.600±0.005	For 1/2" reel 0.520±0.002
Flange Thickness	0.055 max.	0.098 max.

COMPUTER REELS

Computer reels may be categorized into two broad classifications, IBM (industry) compatible, and non-IBM. Standard IBM reel is 1/2" x 10-1/2" plastic, but smaller sizes are available, such as the 1/2" x 8-1/2" for 1200', and the data mailer size of 1/2" x 6" for 200'. Non-IBM may take the form of 1/2", 3/4", or 1" aluminum precision or special flange configuration with a hub design to fit a reel hold down that is neither IBM compatible nor NAB.

■ IBM REELS. The IBM reel design has undergone extensive modifications and improvements since its inception. Most current reel specifications are shown in Figure 5.

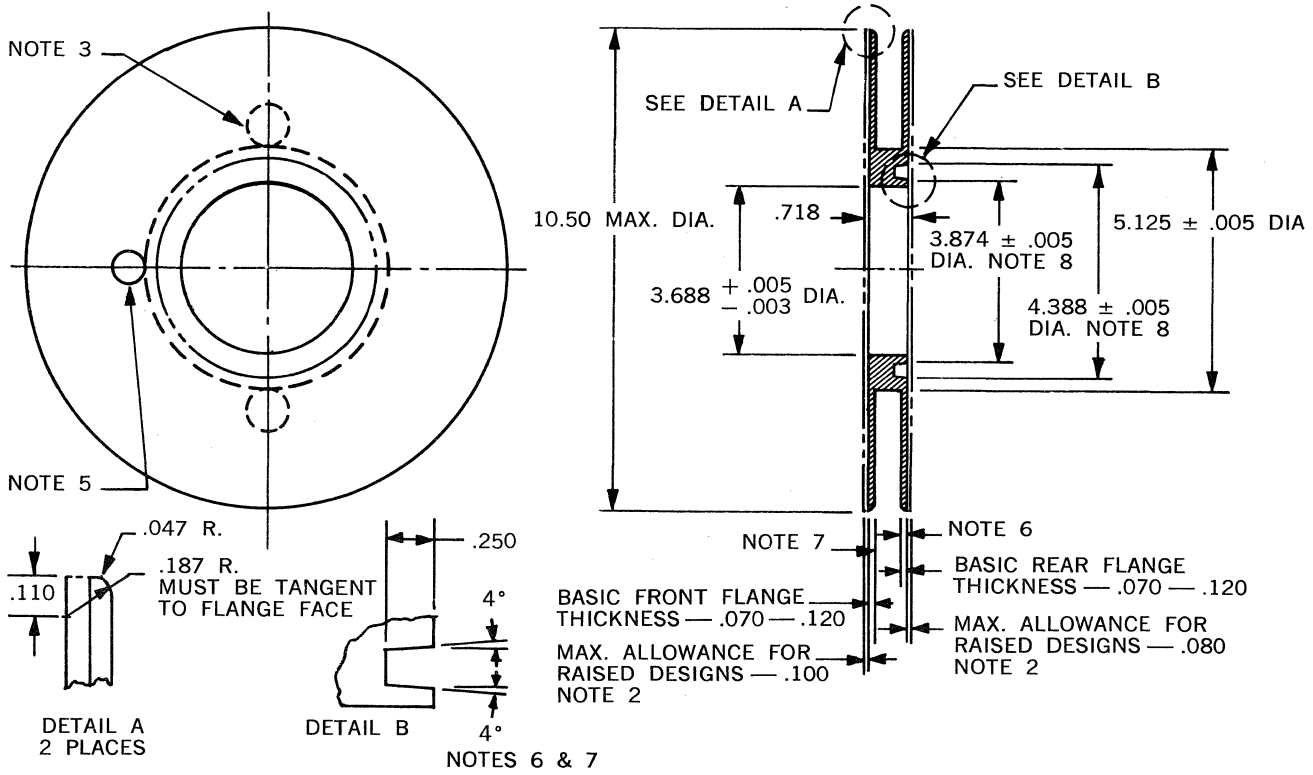

FIGURE 5
IBM COMPATABLE REELS

NOTES:

1. The outside cylinder surface of the hub shall be concentric with the center bore within .010".
2. Bosses, ribs, or raised designs are permitted on outside surfaces of the flanges.
3. Flange holes are optional. When provided, actual number, size and shape are optional.
4. Combined moment of inertia of the reel and tape may not exceed .0910"/pound/second^2.
5. A finger guide is necessary, but size, shape and location are optional. (Recommended minimum distance from centerline, 2.75".)
6. Rear edge of hub to rear flange distance shall have at least one point within:
   (a) .097" (+ .005, − .015) measured at .50" ± .12" from hub O.D. The remainder of the flange shall be within .097" (+ .005, − .015).
   (b) .097" (+ .005, − .015) measured at 2.22" ± .12" from hub O.D. The remainder of the flange shall be within .097" (+ .005, − .020).
7. Rear edge of hub to front flange distance shall have at least one point within:
   (a) .622" (+ .010, − .005) measured at .50" ± .12" from hub O.D. The remainder of the flange shall be within .622" (+ .015, − .005).
   (b) .622" (+.015, −.005) measured at 2.22" ± .12" from hub O.D. The remainder of the flange shall be within .622" (+ .020, − .005).
8. Diameters taken to top of groove.

When the first IBM reel was designed, everyone was convinced that windage holes were required to relieve entrapped air between tape layers during rewind. It has since been proven that windage holes are not necessary to achieve a good pack, and in fact, windage holes actually "pump" air into the pack. Today's solid flange reel design has great functional significance, and the design has evolved through various stages to achieve its present status. It is a well established fact, that today's computer tape does not wear out, but is retired due to accumulation of excessive dropouts which are the result of physical deformation to the tape edges and surface contamination. The intent of the solid flange reel is to protect the tape from fingers and airborne foreign contaminants. The first attempt towards a solid flange reel was to reduce the size of the 3 windage holes. The next step was to have one small threading hole, and the final change was to a completely solid flange. During this transition, the front flange was changed from opaque to transparent to permit unobstructed view of the tape pack. Color coding is accomplished by using different colored opaque rear flanges.

IBM introduced a new 360 system which incorporated a different style hold down. This hold down was retrofitted on many of the existing 729 drives. This new hold down offered the advantage of a positive seating action by increasing the radial force applied to the hub. Such concentrated stress made hub breakage of all plastic (polystyrene) reels more common. To cope with this, a metal hub reel was developed. The aluminum insert was added solely for structural rigidity, and not to change thermal transfer characteristics, nor moment of inertia.

Some reels are designed such that the aluminum hub provides the winding surface for the tape. This can cause dropouts in normal use, for in the case of precision tape, experience has shown that the aluminum winding surface could conceivably cause minute surface discontinuities to "reflect" through many layers of tape and cause dropouts. For this reason, Federal Spec. WT-0070 for instrumentation tape discounts the first and last 1% of the tape for dropout tests. This is also readily apparent in video tape wound on an aluminum surface.

Plastic computer reel design provides an optimum design that is a compromise between cost and durability. The average data processing center requires thousands of tapes for efficient operation and proper size of supporting libraries. The reel must be economically designed so that cost is not a prime consideration, yet the reel must be durable enough to withstand the rigorous handling of day-to-day computer operation.

■ NON-IBM. This category is not as simple to define as IBM because it incorporates many specialized designs. Historically, IBM compatible systems comprised roughly 75% of the total computer market. The present trend in computer system design philosophy is to go IBM compatible for new systems.

The majority of non-IBM compatible transports use an NAB type hold-down and precision reels. Precision reels are available with either aluminum or magnesium flanges. For computer applications it is definitely

advisable to use magnesium reels because the heavier aluminum flanges have a greater moment of inertia which will cause servo problems under the fast stop-start shuttling demands of the computer program. Another point is that precision hubs should have neoprene rings for the tape winding surface to minimize the occurrence of dropouts near the hub end.

■ REEL BANDS. A recent innovation in computer tape packaging has appeared on the scene in the form of wrap-around reel bands. With the acceptance of solid flange reels, it was a natural follow up to design a wrap-around band to completely enclose the tape. Such an approach has definite advantages, but there are certain limitations associated with the use of reel bands. It must be clearly pointed out that there is no wrap-around band design that will provide complete protection to the tape during handling, storage and shipment. The best recommended functional computer package is that employing a separate plastic canister. A reel band is not a functional substitute for a canister. The reason behind this is simple. Computer tape edges are most fragile, and must be protected at all times. Good handling practice dictates that reels should always be handled by the hub and never by the flanges, which would squeeze the flanges into the tape pack. The normal shuttling operation of a computer will invariably leave the tape pack in an uneven state, with tape edges protruding slightly (Figure 6). Further, plastic computer flanges are not rigid enough to withstand flexing if exposed to rough handling. With a wrap-around band, the flanges are still free to move in and out causing edge damage to the tape.

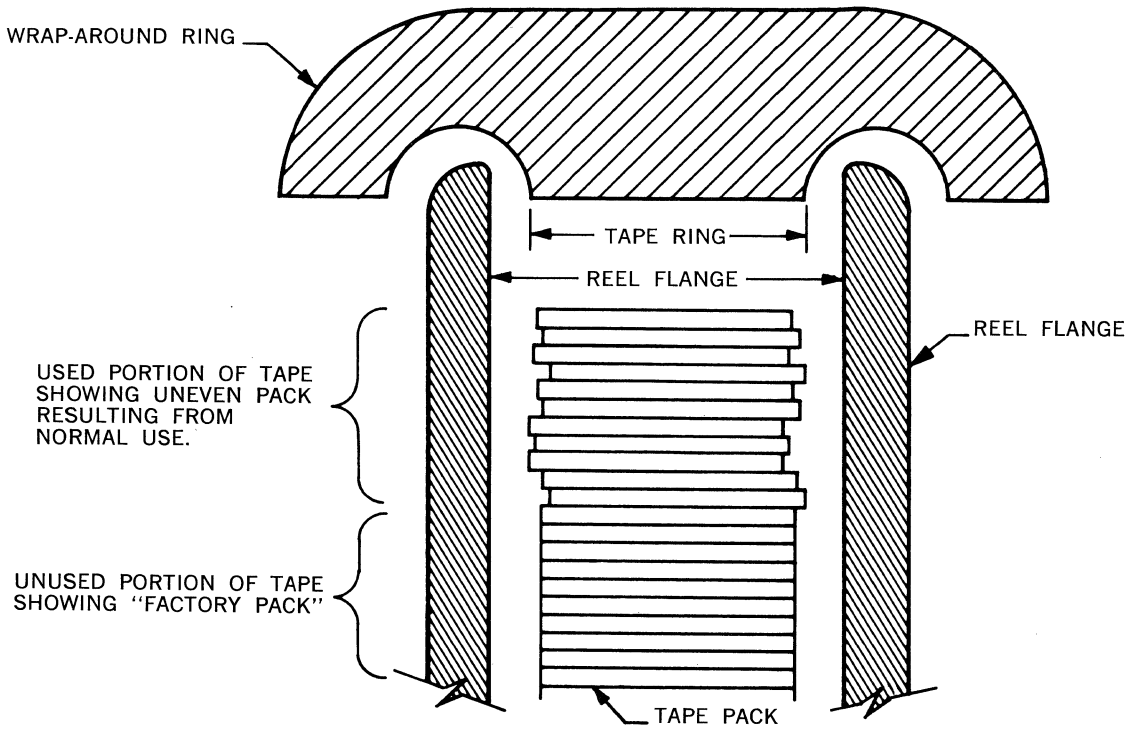

FIGURE 6
CROSS-SECTION OF COMPUTER REEL WITH WRAP-AROUND RING

Video tape is supplied on 2" precision, heavy-duty (non-tapered) aluminum reels. A rugged precision reel is absolutely necessary for video tape to provide proper support and protection to the heavy tape. Reel dimensions are just as critical with the 2" video tape as the most stringent instrumentation applications. The following reel specifications have been approved by American Standards Association.

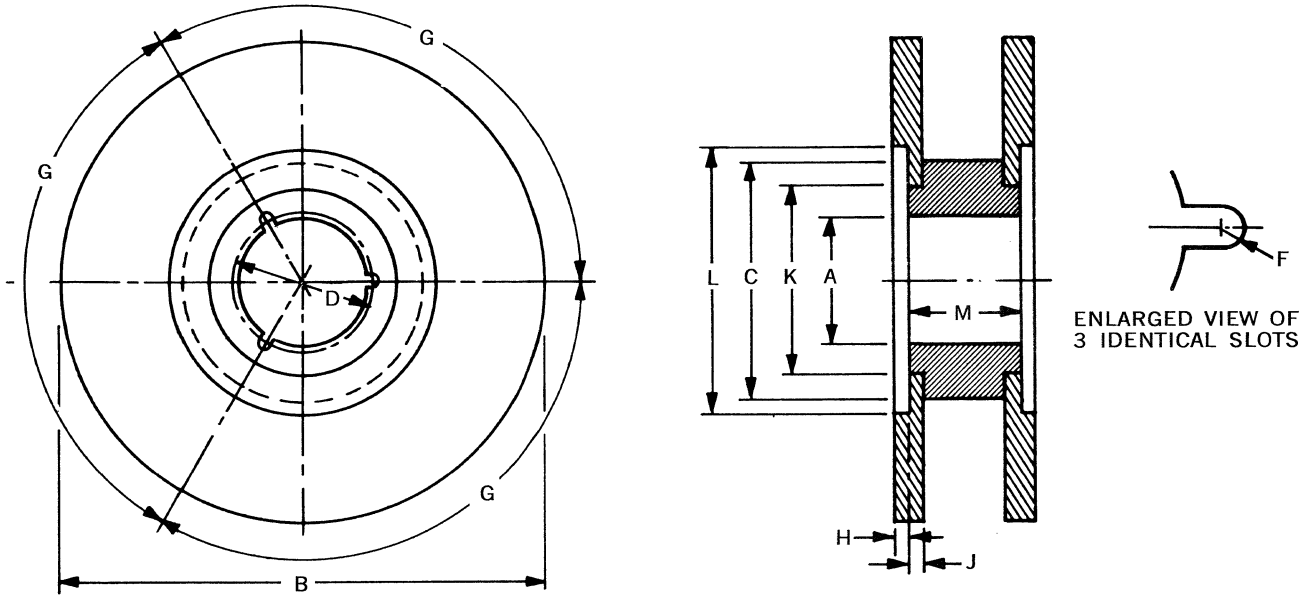

FIGURE 7
STANDING VIDEO TAPE REEL DIMENSIONS

REEL DIMENSIONS

Dimensions	Inches	Millimeters	Degrees
A	3.000 + 0.004	76.20 + 0.10	
B	See Table 2	See Table 2	
C	4.500 ± 0.100	114.30 ± 2.54	
D	3.250 ± 0.002	82.55 ± 0.05	
F	0.109 $^{+0.003}_{-0.000}$	2.77 $^{+0.08}_{-0.00}$	
G			120 ± 0.1
H	0.025 max†	0.64 max†	
J	0.099 max†	2.51 max†	
K	3.600 min‡	91.44 min‡	
L	6.000 min‡	152.40 min‡	
M*	2.212 ± 0.003	56.18 ± 0.08	

* The hub surfaces defined by M shall be parallel within 0.0002 in. (0.005mm) per inch and square with the hub outside diameter C within 0.001 in. (0.03mm) at maximum diameter.

† The surface of the flanges from B to L shall lie between the planes defined by H and J.

‡ Outside surfaces of reel flanges between diameters K and L shall not extend beyond the surfaces defined by Dimension M.

REEL CAPACITIES

Maximum Capacity,*		Maximum Playing Time in Min at		Dimension B	
		7.5 In. (19.05 cm)	15 In. (38.1 cm)		
Feet	Meters	Per Second		Inches	Millimeters
750	228	20	10	6.50 ± 0.010	165.1 ± 0.25
1650	503	44	22	8.00 ± 0.010	203.2 ± 0.25
3600	1097	96	48	10.50 ± 0.010	266.7 ± 0.25
5540	1689	148	74	12.50 ± 0.010	317.5 ± 0.25
7230	2203	192	96	14.00 ± 0.010	355.6 ± 0.25

* Maximum capacity is based on a minimum distance of 0.2 in. (5mm) from the reel periphery to the tape stack, utilizing maximum thickness tape.

In addition to meeting the ASA reel specifications, most manufacturers provide a reel with a neoprene ring to facilitate tape threading. Such a ring protects the tape and minimizes dropouts resulting from surface irregularities of the aluminum hub.

Extra precaution should be taken in handling video reels, and they should never be picked up by the flange. The extra weight of the tape will bend the flange out of specifications if it is handled in this manner. Reels should never be stored on edge unless they are enclosed in a suitable container.

AUDIO REELS

Detailed specifications for audio reels are contained in Federal Spec. WR-00175/1. Since most audio reels are used in less critical applications, dimensions are not held to precision tolerances. Economy is the keynote in audio reel design, and many variations are available that afford basic protection to the tape at the least possible cost.