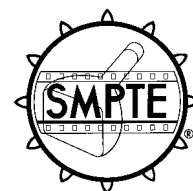


16-mm Sprocket Design



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1 Scope

This practice provides dimensions and specifications for the design of sprockets used with 16-mm motion-picture raw stock or processed film.

2 Dimensions and specifications

2.1 The teeth shall be equally spaced at an index angle of $360/N^\circ$ where N is the number of teeth. A suitable tolerance for the index angle is ± 1 minute of arc for sprockets having 8 to 17 teeth, ± 30 seconds of arc for sprockets having 18 to 34 teeth, and ± 20 seconds of arc for sprockets having 35 to 64 teeth.

2.2 The root diameter is computed from the equation:

$$D = N \times \frac{P}{\pi} - T$$

where N is the number of teeth, P is the sprocket pitch, and T is the film thickness. The different root diameters in tables 1a and 1b were derived using a value for T of 0.15 mm (0.006 in). If optimum working conditions are desired with film materials of different thickness, the root diameter values in tables 1a and 1b should be recomputed.

2.3 Figure 1 shows that either the entering or leaving film path may fall within the limits specified by radii R_1 and R_2 . If the film path is convex with respect to the sprocket surface (curvature away from the sprocket surface), a minimum value of 4.762 mm (0.1875 in) for R_1 is recommended. This is an arbitrary choice, but seems appropriate for 16-mm equipment.

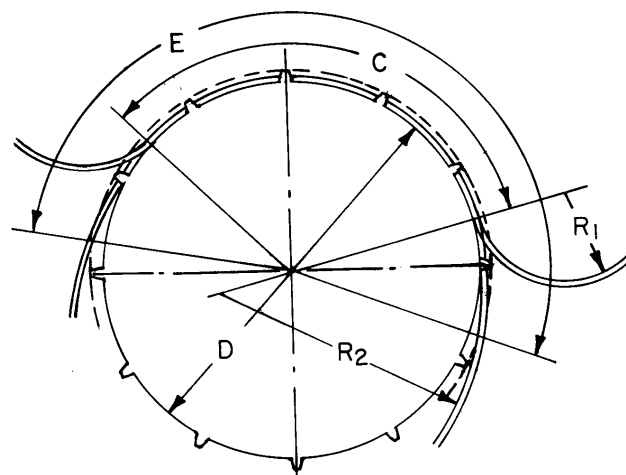


Figure 1 – Sprocket

The shape of the film path as the film leaves the root of the sprocket is determined by film stiffness, curl, set, and tension as well as by the shape and location of rollers or guides.

For the specified tooth shape, the film will be allowed to back-slip over the root circle a maximum distance of 0.066 mm (0.0026 in) for each tooth, measured at the pitch line (film thickness assumed to be 0.15 mm [0.006 in]), by the time the contact point between film and tooth has reached the assumed maximum working height of 0.66 mm (0.026 in), measured radially from the root circle.

2.4 The drive sprocket is most sensitive to tooth shape because the tooth action may take place over the entire working height and is, therefore, used to derive the desired shape. For the usual drive sprocket, the pitch is greater than the film pitch which causes the film to slip backward in

relation to the sprocket travel. The direction of the friction force between the film and the root surface is such as to assist the feed or driving action.

2.4.1 Of the total 0.066-mm (0.0026-in) accommodation provided at each tooth for film slippage, approximately 0.013 mm (0.0005 in) is allocated to the combined tolerance of perforation pitch and sprocket tooth pitch (shorter-than-average perforation pitch combined with longer-than-average tooth pitch). An additional 0.010 mm (0.0004 in) is allocated for distortion of the perforation edge under light load (less than 0.56 N [2 oz-force] between the perforation edge and the tooth for acetate film of 0.15 mm [0.006 in] thickness). The remaining 0.043 mm (0.0017 mm) approximates 0.6% film shrinkage. It should be noted that another combination of greater load and lower shrinkage could fall within the same allowable maximum of 0.053 (0.0021 in). The user is cautioned against high loading because of possible destructive film fatigue and wear, film distortion away from the base circle, and malfunction. The selected values of R_1 , working height and maximum pitch difference, in turn, determine the values of X_T which have been computed and tabulated.

2.4.2 For a concave film path with respect to the sprocket surface (curvature toward the sprocket radius center), the limiting radius, R_2 , has been computed for the same X_T and the same accommodation of 0.066 mm (0.0026 in), assuming a parabolic schedule (displacement function proportionate to the square of time) of reduction versus time (see reference 1). These values of R_2 are set forth in tables 1a and 1b. For those exiting film paths from drive sprockets corresponding to larger values of R_1 and R_2 , including a straight tangent path, the accommodation of 0.066 mm (0.0026 in) for film slippage takes place in less than 0.66 mm (0.026 in) of the working height (or more accommodation results at the same height). Conversely, the slowest accommodation corresponds to the exiting path defined by the minimum values of R_2 . Therefore, the R_2 value is recommended where maximum uniformity of motion is desired.

2.5 The pitch of the usual holdback sprocket should be equal to or less than the pitch of the film. The shortest film pitch is assumed to be

7.536 mm (0.2967 in) corresponding to 0.8% shrinkage of long-pitch film (7.620 mm [0.300 in]). (This value is chosen rather than the 0.6% used for the tooth shape to avoid inadvertent interference at entering teeth.) The user may again exercise control by correct choice of the root diameter if a change is warranted. The friction between the film and the root surface, as well as against guides, assists in film holdback.

The tooth shape for a holdback sprocket has little control over the pitch differential accommodation, as the load shifts rather abruptly from the disengaging restraining tooth to the root of the following tooth. The tooth shape specified will ensure clearance at the entering position. If a holdback sprocket is to provide the best possible uniformity of motion, the design must be developed with care (see reference 1).

2.6 The pitch of combination sprockets, 7.600 mm (0.2992 in), should correspond to the pitch of film with 0.3% shrinkage. This value is closer to the feed sprocket pitch than to the holdback sprocket pitch to prevent the film from riding high on the teeth or being damaged by guides at the entering path when used for driving action with the sprocket pitch shorter than the film pitch. Entering guides may be needed for good holdback action when the sprocket pitch is longer than the film pitch.

2.7 The desired tooth shape can be generated by a hob corresponding to the basic rack specified by K_H and B_H in table 2 and figure 4. If the first hob covers the range of N from 8 to 17 inclusively and the second hob 18 to 64 inclusively, no deviations from the ideal tooth shape greater than 0.005 mm (0.0002 in) will occur.

2.8 The tooth width at the base, dimension W , allows ample material for rounding off the tip while preserving the 0.66 mm (0.026 in) or more of working height. The value chosen does not limit the angle of wrap on the sprocket as a wider tooth would. If the wrap length is defined as one-half the sum of the number of pitch lengths in the arc of engagement, E , and the number of pitch lengths in the arc of contact, C (figure 1), then the wrap length may be as high as $6\frac{3}{4}$ pitch lengths without producing interference at the entering teeth of a drive sprocket if the film shrinkage does not exceed 0.8%.

Table 1a – Sprocket dimensions in millimeters

N	RDD	RDC	RDH	K	B	R ₂	X _T
8	19.252	19.201	19.097	1.709	0.111	14.726	0.2478
9	21.678	21.620	21.503	1.750	0.121	15.933	0.2410
10	24.103	24.040	23.909	1.809	0.134	17.137	0.2355
11	26.529	26.459	26.315	1.875	0.149	18.387	0.2309
12	28.954	28.878	28.721	1.939	0.164	19.697	0.2270
13	31.380	31.297	31.127	2.001	0.178	21.037	0.2237
14	33.805	33.716	33.533	2.061	0.192	22.392	0.2209
15	36.231	36.135	35.940	2.120	0.206	23.769	0.2184
16	38.656	38.554	38.346	2.177	0.219	25.157	0.2162
17	41.082	40.974	40.752	2.233	0.233	26.559	0.2142
18	43.507	43.393	43.158	2.288	0.245	27.970	0.2124
19	45.933	45.812	45.564	2.342	0.258	29.374	0.2109
20	48.358	48.231	47.970	2.395	0.271	30.801	0.2094
21	50.784	50.650	50.376	2.446	0.283	32.214	0.2082
22	53.209	53.069	52.782	2.497	0.296	33.646	0.2070
23	55.635	55.489	55.188	2.547	0.308	35.082	0.2059
24	58.061	57.908	57.595	2.597	0.320	36.522	0.2049
26	62.912	62.746	62.407	2.695	0.343	39.420	0.2031
28	67.763	67.584	67.219	2.790	0.367	42.328	0.2016
30	72.614	72.423	72.031	2.883	0.390	45.254	0.2003
32	77.465	77.261	76.843	2.974	0.412	48.206	0.1991
34	82.316	82.099	81.656	3.064	0.434	51.166	0.1981
36	87.167	86.938	86.468	3.153	0.456	54.162	0.1971
38	92.018	91.776	91.280	3.241	0.478	57.158	0.1963
40	96.869	96.614	96.092	3.326	0.499	60.167	0.1956
42	101.720	101.453	100.904	3.412	0.520	63.207	0.1949
44	106.571	106.291	105.717	3.496	0.541	66.258	0.1943
46	111.422	111.129	110.529	3.579	0.562	69.337	0.1937
48	116.273	115.967	115.341	3.661	0.582	72.423	0.1932
50	121.124	120.806	120.153	3.743	0.603	75.537	0.1927
52	125.975	125.644	124.965	3.825	0.623	78.679	0.1922
54	130.826	130.482	129.778	3.904	0.642	81.822	0.1918
56	135.677	135.321	134.590	3.982	0.662	84.964	0.1915
60	145.379	144.997	144.214	4.139	0.702	91.351	0.1908
64	155.081	154.674	153.839	4.292	0.740	97.811	0.1902
N – Number of teeth RDD – Root diameter +0.03 –0.00 of drive sprocket of 7.620 pitch RDC – Root diameter +0.03 –0.00 of combination sprocket of 7.600 pitch RDH – Root diameter +0.00 –0.03 of holdback sprocket of 7.559 pitch K – Circular arc radius for tooth shape, +0.00 –0.05 B – Radial distance of arc center inside root circle, +0.013 –0.000 R₂ – Minimum radius of film path concave to sprocket X_T – Offset of tooth at working height R₁ – Minimum film path radius convex to sprocket, 4.762 Tooth working height – 0.660 Maximum pitch difference – 0.066 Film thickness – 0.152 Other thickness – Root diameter = $N \cdot \text{pitch} / \pi$ – thickness							