Foreword

The formulation of this National Standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) under the project
entitled "Enhancing the Implementation of the AFMA Through Improved Agricultural Engineering Standards" which was funded by the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA).

This Standard was reviewed by the Technical Committee for Study 2 – Development of Standards for Engineering Materials and was circulated to various private and government agencies/organizations concerned for their comments and reactions. These standards were presented to the Philippine Society of Agricultural Engineers (PSAE) and subjected to a public hearing organized by the National Agriculture and Fisheries Council (NAFC). The comments and reactions received during the presentation and public hearing were taken into consideration in the finalization of the standards.

This Standard has technically formulated in accordance with PNS 01:Part 4:1998 – Rules for the Structure and Drafting of Philippine National Standard. It provides specifications and proper application of drives using spur gears and does not cover manufacturing specifications.

In the preparation of this standard, the following references were considered.

Browning power transmission equipment. 1975. Catalog number 8.

Baumeister, Theodore (ed.) 1997. Mark's handbook for mechanical engineers. 10th Edition. Mc Graw Hill Book Company, USA.

Faires, V. M. 1969. Design of Machine Elements. Macmillan Company, New York USA.

Horton, H. L. (Ed.) 1984. Machinery's handbook. 23rd Edition. Industrial press inc, New York.

PNS 374:1991, Spur gears for general engineering – Shapes and dimensions.

Quayle J. P. (Ed.) 1971. Kempe's engineer's yearbook. Volume 1. Morgan-Grampian Book Publishing Co. Ltd, London.

Shigley, Joseph, E. 1977. Mechanical engineering design. 3rd Edition. Mc Graw Hill Book Company, USA.

Engineering Materials – Spur Gears for Agricultural Machines – Specifications and Applications

1 Scope

This standard establishes specifications and provides technical information for the proper application of spur gears for agricultural machinery.

2 Reference

The following normative references contains provisions which, through reference in this text, constitute provisions of this Standard:

PAES 305:2000, Keys and Keyways for Agricultural Machines

3 Application

Spur gears are used to connect parallel shafts and have teeth formed in cylindrical blanks parallel to the shaft axis. They can be used in transmitting motion and power between two shaft in the same or in opposite directions. They can also be used in transmitting linear motion. For the purpose of this standard, only transmission of power between two shafts of opposite directions will be discussed.

4 Definitions

4.1
spur gear
a cylindrical gear whose tooth traces are straight lines parallel to the axis. Generally, it transmits rotational motion and power between two axes

4.2
gear tooth
each of the projecting parts of a gear which are intended to ensure, by contact with the teeth of another gear, that one of the other gear turns the other

4.3
module
the quotient of the pitch, expressed in millimeters, to the number π (or the quotient of the reference diameter, expressed in millimeters, to the number of teeth)

4.4
pitch circle
the line of intersection of the pitch cylinder by a plane perpendicular to the axis of the gear (see Fig. 1)

4.5
addendum
the radial distance between the addendum circle and the pitch circle (see Fig. 1)

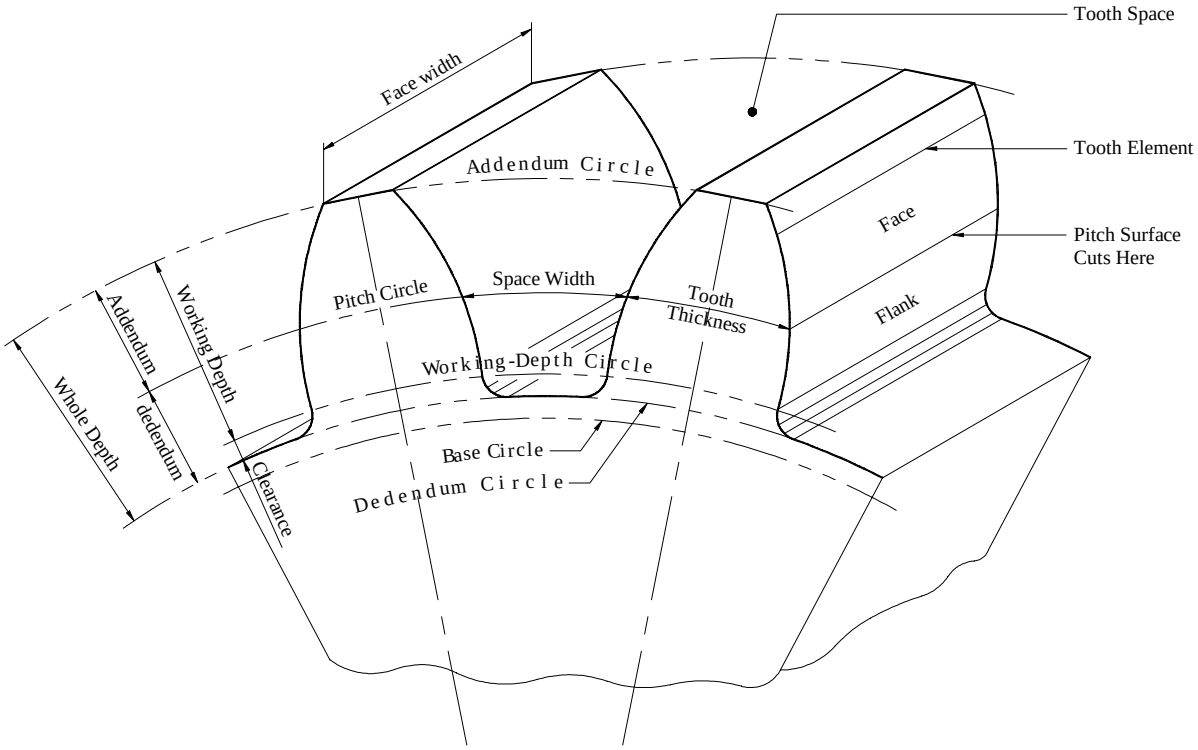

Figure 1 – Nomenclature of spur gears

4.6
addendum circle
the circle that bounds the outer ends of the teeth (Fig. 1)

4.7
dedendum
the radial distance between the dedendum circle and the pitch circle (see Fig. 1)

4.8
dedendum circle
the line of intersection of the dedendum cylinder by a plane perpendicular to the axis of the gear (see Fig.1)

4.9
clearance
the amount by which the dedendum in a given gear exceeds the addendum of its meshing gear (Fig. 1)

4.10
pitch diameter
the diameter of the pitch circle

4.11
addendum diameter
the diameter of the addendum circle

4.12
dedendum diameter
the diameter of the of the dedendum circle

4.13
tooth depth
the radial distance between the addendum circle and the dedendum circle

4.14
circular pitch
the length of the arc of the pitch circle between two consecutive corresponding profiles (see Fig. 1)

4.15
tooth thickness
the width of the tooth measured along the circular pitch (Fig.1)

4.16
tooth space
the space between teeth measured along the pitch circle (Fig.1)

4.17
backlash
the tooth space minus the tooth thickness

4.18
face width
the width over the toothed part of a gear, measured along a straight line generator of the reference cylinder (see Fig. 1)

4.19
tooth flank
the portion of the surface of a tooth lying between the tip surface and the root surface (Fig. 1)

4.20
pressure angle
angle at the point where the profile cuts the pitch circle (see Fig. 2)

4.21
base circle
of an involute cylindrical gear, the "base circle" of the involutes forming the tooth profiles (see Fig. 2)

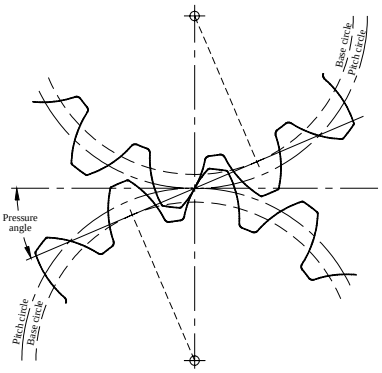

Fig. 2 – Pressure angle and base circle

4.22
tooth profile
the line of intersection of a tooth flank with any defined surface cutting the reference surface

4.23
tooth trace
the line of intersection of a flank with the reference surface

4.24
involute cylindrical gear
a cylindrical gear of which every usable tooth profile is an arc of an involute to a circle (See Fig. 3)

4.25
involute to a circle

a plane curve described by a point on a straight line (the "generating line"), which rolls out without slip on the base circle (Fig 3)

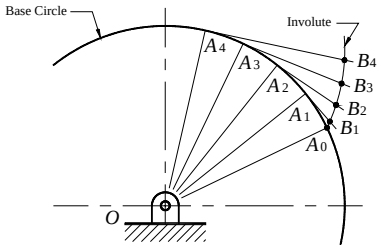

Fig. 3 – Construction of an involute curve

5 Types

Spur gears shall be classified into 6 types according to its shape: A1, B1, C1, A2, B2, and C2 (see Figure 4).

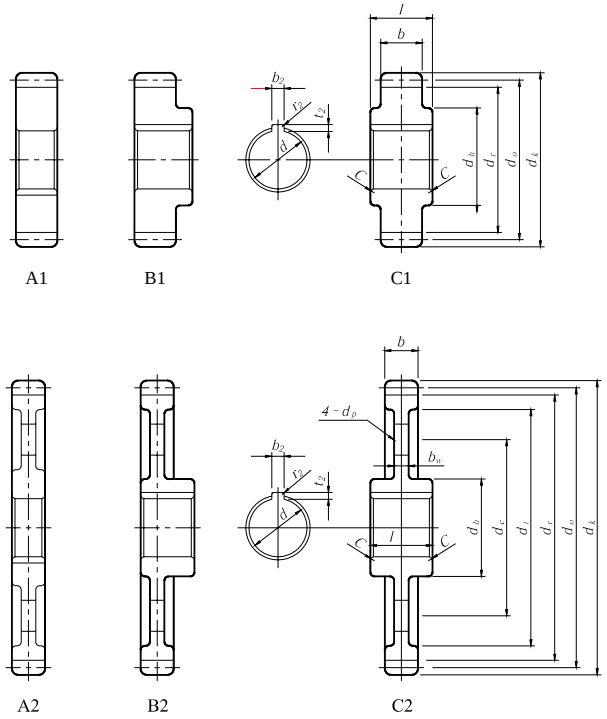

Figure 4 – Spur gear types

6 Materials

Spur gear materials shall be of hot-rolled steel designation 1045 and 3140 with an ultimate tensile strength of 600 MPa and 724 MPa and a Brinell Hardness Number of 215 and 205 respectively.

7 Recommended design practices

7.1 Calculation of gear dimensions

Table 1 specifies the formula for calculating the different dimensions of standard spur gears.

Table 1 – Spur gear calculations

To obtain:	Given:	Formula:
Module	Circular pitch	$\frac{\text{Circular pitch}}{\pi}$
	Number of teeth and pitch diameter	$\frac{\text{Pitch diameter}}{\text{Number of teeth}}$
Pitch diameter	Number of teeth and module	Number of teeth × module
Number of teeth	Pitch diameter and module	$\frac{\text{Pitch diameter}}{\text{Module}}$
Tooth thickness on the pitch line	Module	1.5708 × module
Outside diameter	Pitch diameter and addendum	Add 2 addendums to the pitch diameter
Minimum whole depth	Module	Coarser than 1.0583 module, 2.35 × module
Addendum	Module	addendum = module
Dedendum	Module	dedendum = 1.25x module
Clearance	Whole depth and addendum	Subtract two addendums from the whole depth
Center distance	Number of teeth of driver and driven gear, t_1 and t_2 Module	$\frac{\text{module}(t_1 + t_2)}{2}$

7.2 Power ratings

7.2.1 Power ratings presented in this standard are based on module facewidth, and pressure angle that are shown in Table 2 and a material of hot-rolled steel designation 1045. For power ratings of hot-rolled steel designation 3140, multiply table values by 1.5.

Table 2 - Standard modules and face width

Module, mm/tooth	1.25	1.5	2.0	2.50	3.0	4.0	5.0	6.0	8.0
Face width, mm	16	19	25	32	38	50	63	75	100
Pressure angle, °	20	20	20	20	20	20	20	20	20

7.2.2 Power ratings of spur gears according to the number of teeth and its rpm are shown on Tables 3.-11.

Table 3 – Power ratings* of 1.25 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	**60**	**80**	**100**	**200**	**400**	**600**	**800**	**1,000**	**1,200**	**1,400**	**1,600**	**1,800**	**2,000**	**2,200**	**2,400**	**2,600**	**2,800**
11	27	40	54	67	130	249	358	459	552	638	718	766	861	926	987	1,045	1,099	1,149
12	32	47	62	78	151	289	414	528	633	730	819	870	979	1,051	1,118	1,180	1,239	1,295
13	36	54	72	89	174	331	472	601	718	826	925	978	1,101	1,179	1,252	1,320	1,384	1,444
14	41	62	82	102	197	374	532	675	804	923	1,031	1,086	1,222	1,307	1,385	1,459	1,527	1,591
15	46	69	92	114	221	416	590	747	888	1,016	1,133	1,189	1,337	1,428	1,511	1,589	1,661	1,728
16	50	75	100	124	239	449	636	802	951	1,086	1,208	1,263	1,421	1,515	1,601	1,681	1,755	1,824
17	55	82	108	134	259	485	684	861	1,018	1,160	1,288	1,342	1,510	1,607	1,696	1,778	1,854	1,925
18	59	88	116	145	279	520	731	917	1,083	1,231	1,364	1,416	1,593	1,693	1,785	1,869	1,947	2,019
19	64	95	125	155	299	555	779	974	1,147	1,301	1,439	1,490	1,676	1,779	1,873	1,959	2,038	2,111
20	68	101	134	166	319	592	827	1,032	1,212	1,372	1,515	1,564	1,759	1,864	1,960	2,048	2,129	2,203
21	73	109	144	178	341	630	878	1,093	1,281	1,448	1,596	1,642	1,847	1,955	2,053	2,143	2,225	2,301
22	77	115	152	188	359	661	919	1,141	1,335	1,505	1,656	1,700	1,912	2,021	2,121	2,211	2,294	2,370
24	86	127	168	208	396	724	1,001	1,237	1,441	1,619	1,776	1,812	2,039	2,150	2,251	2,343	2,426	2,502
25	90	134	177	219	417	760	1,048	1,292	1,502	1,685	1,845	1,878	2,113	2,226	2,328	2,421	2,505	2,582
27	100	148	195	241	457	828	1,136	1,394	1,615	1,805	1,972	1,998	2,247	2,363	2,467	2,560	2,646	2,723
28	104	155	204	252	476	860	1,177	1,442	1,667	1,860	2,029	2,051	2,307	2,423	2,528	2,622	2,707	2,784
30	113	168	221	273	515	925	1,258	1,535	1,769	1,968	2,141	2,154	2,424	2,541	2,647	2,741	2,827	2,904
32	123	182	239	296	555	991	1,342	1,630	1,872	2,077	2,254	2,259	2,541	2,660	2,766	2,861	2,947	3,024
33	128	189	249	307	576	1,024	1,383	1,678	1,923	2,131	2,309	2,310	2,599	2,719	2,825	2,920	3,006	3,083
35	138	203	267	330	616	1,090	1,466	1,771	2,023	2,236	2,418	2,410	2,711	2,832	2,939	3,034	3,119	3,197
36	143	211	277	341	637	1,123	1,506	1,816	2,073	2,288	2,471	2,459	2,766	2,887	2,993	3,089	3,174	3,251
40	163	240	315	387	718	1,252	1,665	1,994	2,262	2,484	2,672	2,642	2,972	3,094	3,201	3,296	3,381	3,457

* Based on steel designation 1045, 20° pressure angle and 16 mm average face width.

Table 4 – Power ratings* of 1.5 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	**60**	**80**	**100**	**200**	**400**	**600**	**800**	**1,000**	**1,200**	**1,400**	**1,600**	**1,800**	**2,000**	**2,200**	**2,400**	**2,600**	**2,800**
11	46	69	91	113	221	419	598	761	909	1,044	1,169	1,236	1,390	1,489	1,580	1,666	1,746	1,821
12	54	80	106	132	256	485	689	873	1,040	1,191	1,330	1,399	1,574	1,682	1,782	1,875	1,962	2,043
13	62	92	122	152	294	554	785	991	1,177	1,345	1,497	1,568	1,764	1,881	1,990	2,090	2,183	2,270
14	71	105	139	173	334	625	882	1,111	1,315	1,498	1,664	1,735	1,952	2,078	2,194	2,301	2,400	2,492
15	79	118	156	193	373	695	978	1,226	1,448	1,645	1,823	1,894	2,131	2,264	2,386	2,499	2,603	2,699
16	86	128	169	210	404	750	1,051	1,315	1,547	1,754	1,940	2,007	2,258	2,395	2,521	2,636	2,742	2,840
17	93	139	184	228	437	809	1,129	1,408	1,653	1,870	2,063	2,127	2,392	2,534	2,663	2,781	2,889	2,989
18	101	150	198	245	470	866	1,205	1,498	1,754	1,979	2,179	2,238	2,518	2,663	2,795	2,915	3,025	3,127
19	108	161	213	263	503	924	1,281	1,588	1,854	2,088	2,294	2,349	2,643	2,791	2,926	3,048	3,160	3,262
20	116	172	228	282	537	983	1,358	1,679	1,955	2,197	2,410	2,460	2,767	2,918	3,055	3,179	3,293	3,396
21	124	185	244	302	574	1,045	1,440	1,775	2,063	2,313	2,533	2,577	2,899	3,054	3,193	3,320	3,434	3,539
22	131	195	257	318	604	1,096	1,505	1,850	2,145	2,401	2,624	2,662	2,995	3,151	3,291	3,418	3,533	3,638
24	146	216	285	352	665	1,197	1,634	1,998	2,307	2,572	2,802	2,827	3,180	3,338	3,480	3,607	3,722	3,827
25	154	228	300	371	699	1,255	1,708	2,084	2,401	2,671	2,905	2,924	3,290	3,450	3,592	3,721	3,837	3,942
27	170	251	331	408	766	1,365	1,847	2,242	2,573	2,853	3,094	3,099	3,487	3,649	3,793	3,922	4,038	4,144
28	177	262	345	426	798	1,417	1,911	2,315	2,651	2,935	3,178	3,176	3,573	3,736	3,880	4,009	4,126	4,231
30	193	285	375	462	861	1,519	2,038	2,458	2,805	3,096	3,343	3,327	3,743	3,906	4,051	4,180	4,295	4,400
32	209	309	405	499	927	1,624	2,168	2,603	2,960	3,257	3,509	3,478	3,913	4,077	4,222	4,351	4,466	4,570
33	217	321	421	518	960	1,677	2,232	2,675	3,037	3,337	3,591	3,553	3,997	4,161	4,306	4,435	4,550	4,653
35	234	345	452	556	1,027	1,782	2,360	2,816	3,187	3,493	3,750	3,696	4,158	4,323	4,468	4,596	4,711	4,814
36	242	357	468	575	1,060	1,833	2,422	2,886	3,260	3,568	3,827	3,766	4,237	4,402	4,546	4,674	4,789	4,891
40	276	406	531	652	1,192	2,036	2,665	3,152	3,540	3,857	4,120	4,029	4,532	4,697	4,841	4,967	5,080	5,180

* Based on steel designation 1045, 20° pressure angle and 19 mm average face width.

Table 5 – Power ratings* of 2.0 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	**60**	**80**	**100**	**200**	**400**	**600**	**800**	**1,000**	**1,200**	**1,400**	**1,600**	**1,800**	**2,000**	**2,200**	**2,400**	**2,600**	**2,800**
11	108	160	212	263	507	948	1,334	1,676	1,980	2,252	2,498	2,598	2,923	3,108	3,277	3,433	3,578	3,711
12	125	186	247	306	588	1,093	1,532	1,916	2,255	2,556	2,826	2,924	3,290	3,490	3,673	3,841	3,996	4,138
13	144	215	284	352	675	1,247	1,739	2,166	2,540	2,871	3,165	3,259	3,667	3,882	4,078	4,257	4,421	4,572
14	164	244	322	399	764	1,404	1,949	2,418	2,826	3,184	3,501	3,589	4,037	4,266	4,473	4,662	4,835	4,993
15	184	273	361	446	851	1,557	2,152	2,659	3,098	3,481	3,818	3,897	4,384	4,624	4,841	5,037	5,217	5,381
16	200	297	392	485	921	1,676	2,306	2,840	3,299	3,696	4,044	4,111	4,625	4,870	5,090	5,290	5,471	5,637
17	217	322	425	525	996	1,803	2,470	3,032	3,510	3,923	4,283	4,337	4,879	5,129	5,354	5,556	5,740	5,908
18	234	347	458	565	1,069	1,925	2,628	3,214	3,710	4,136	4,505	4,546	5,115	5,369	5,596	5,801	5,986	6,155
19	252	373	491	607	1,143	2,049	2,786	3,396	3,909	4,348	4,726	4,753	5,347	5,605	5,835	6,042	6,228	6,398
20	270	399	526	649	1,219	2,175	2,945	3,578	4,108	4,559	4,946	4,958	5,578	5,839	6,071	6,280	6,467	6,638
21	289	428	563	694	1,300	2,309	3,114	3,772	4,320	4,783	5,180	5,177	5,824	6,089	6,324	6,534	6,724	6,895
22	305	451	593	731	1,366	2,415	3,246	3,920	4,478	4,948	5,348	5,330	5,996	6,261	6,496	6,706	6,894	7,065
24	338	499	655	807	1,499	2,627	3,506	4,210	4,787	5,268	5,675	5,625	6,328	6,594	6,828	7,036	7,223	7,391
25	357	527	691	850	1,576	2,749	3,656	4,378	4,967	5,456	5,869	5,802	6,527	6,794	7,029	7,238	7,425	7,592
27	394	580	760	934	1,722	2,977	3,934	4,686	5,294	5,795	6,216	6,116	6,881	7,148	7,384	7,592	7,777	7,943
28	411	606	793	974	1,790	3,083	4,061	4,826	5,441	5,946	6,368	6,252	7,034	7,301	7,536	7,743	7,927	8,092
30	447	657	860	1,054	1,929	3,294	4,312	5,100	5,728	6,240	6,666	6,518	7,333	7,599	7,832	8,036	8,218	8,381
32	484	711	929	1,138	2,071	3,510	4,567	5,377	6,017	6,536	6,965	6,785	7,633	7,898	8,129	8,332	8,512	8,673
33	503	738	964	1,181	2,143	3,617	4,693	5,514	6,160	6,682	7,112	6,916	7,780	8,045	8,275	8,477	8,656	8,816
35	541	793	1,035	1,266	2,286	3,829	4,941	5,781	6,437	6,964	7,396	7,168	8,064	8,327	8,556	8,756	8,933	9,090
36	560	821	1,070	1,308	2,357	3,934	5,062	5,911	6,571	7,100	7,534	7,289	8,201	8,463	8,690	8,890	9,065	9,221
40	638	932	1,212	1,479	2,638	4,341	5,530	6,408	7,083	7,618	8,052	7,746	8,714	8,973	9,196	9,390	9,561	9,713

* Based on steel designation 1045, 20° pressure angle and 25 mm average face width.

Table 6 – Power ratings* of 2.5 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	60	80	100	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800
11	214	318	421	521	997	1,836	2,551	3,168	3,706	4,179	4,598	4,718	5,308	5,611	5,886	6,137	6,367	6,577
12	250	371	489	606	1,155	2,112	2,919	3,607	4,202	4,722	5,179	5,286	5,947	6,272	6,566	6,833	7,076	7,299
13	288	427	563	696	1,322	2,403	3,303	4,064	4,716	5,281	5,775	5,865	6,598	6,945	7,256	7,538	7,794	8,028
14	327	485	639	790	1,494	2,699	3,690	4,521	5,227	5,834	6,362	6,431	7,235	7,600	7,927	8,222	8,490	8,733
15	366	542	714	882	1,664	2,986	4,063	4,957	5,711	6,355	6,912	6,957	7,827	8,207	8,546	8,851	9,127	9,377
16	398	589	775	957	1,798	3,208	4,344	5,278	6,060	6,724	7,295	7,313	8,227	8,612	8,955	9,262	9,539	9,790
17	432	639	841	1,036	1,941	3,443	4,640	5,616	6,428	7,113	7,699	7,689	8,650	9,041	9,387	9,697	9,976	10,228
18	466	689	905	1,115	2,080	3,669	4,922	5,936	6,773	7,476	8,074	8,034	9,039	9,433	9,782	10,094	10,373	10,626
19	501	739	970	1,195	2,222	3,897	5,205	6,255	7,116	7,835	8,445	8,375	9,422	9,820	10,171	10,484	10,764	11,016
20	536	791	1,038	1,277	2,366	4,127	5,489	6,573	7,457	8,192	8,812	8,712	9,801	10,201	10,554	10,868	11,148	11,400
21	574	847	1,110	1,364	2,520	4,372	5,791	6,912	7,821	8,572	9,204	9,072	10,206	10,610	10,966	11,281	11,562	11,814
22	606	893	1,170	1,437	2,645	4,565	6,022	7,165	8,086	8,844	9,478	9,317	10,481	10,884	11,238	11,550	11,829	12,078
24	671	987	1,291	1,584	2,896	4,947	6,476	7,659	8,602	9,371	10,010	9,788	11,012	11,411	11,760	12,068	12,341	12,586
25	708	1,041	1,360	1,668	3,040	5,167	6,739	7,947	8,905	9,683	10,328	10,075	11,334	11,734	12,083	12,390	12,663	12,906
27	780	1,145	1,494	1,829	3,314	5,577	7,222	8,471	9,451	10,242	10,893	10,578	11,901	12,299	12,645	12,949	13,218	13,458
28	815	1,195	1,558	1,906	3,442	5,766	7,441	8,705	9,693	10,487	11,138	10,794	12,143	12,540	12,884	13,185	13,451	13,688
30	885	1,296	1,687	2,061	3,699	6,141	7,872	9,165	10,166	10,965	11,616	11,214	12,616	13,008	13,347	13,644	13,905	14,137
32	958	1,400	1,821	2,221	3,964	6,521	8,308	9,627	10,641	11,445	12,097	11,637	13,092	13,480	13,815	14,107	14,364	14,592
33	995	1,454	1,889	2,302	4,096	6,711	8,524	9,856	10,875	11,680	12,333	11,844	13,325	13,711	14,044	14,334	14,589	14,815
35	1,070	1,560	2,025	2,465	4,360	7,083	8,945	10,299	11,327	12,135	12,787	12,243	13,773	14,155	14,484	14,769	15,020	15,242
36	1,107	1,614	2,093	2,546	4,491	7,266	9,150	10,514	11,546	12,355	13,006	12,434	13,988	14,368	14,694	14,978	15,227	15,447
40	1,259	1,830	2,366	2,870	5,007	7,974	9,938	11,333	12,376	13,184	13,829	13,151	14,795	15,165	15,483	15,758	15,998	16,210

* Based on steel designation 1045, 20° pressure angle and 32 mm average face width.

Table 7 – Power ratings* of 3.0 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	**60**	**80**	**100**	**200**	**400**	**600**	**800**	**1,000**	**1,200**	**1,400**	**1,600**	**1,800**	**2,000**	**2,200**	**2,400**	**2,600**	**2,800**
11	365	541	714	883	1,676	3,042	4,177	5,135	5,955	6,663	7,283	7,389	8,312	8,745	9,135	9,486	9,806	10,097
12	425	630	830	1,026	1,938	3,492	4,766	5,828	6,729	7,501	8,171	8,245	9,276	9,737	10,149	10,521	10,857	11,162
13	490	725	954	1,178	2,217	3,965	5,379	6,546	7,526	8,360	9,079	9,116	10,255	10,742	11,176	11,566	11,917	12,236
14	556	823	1,082	1,335	2,501	4,443	5,993	7,260	8,314	9,205	9,968	9,962	11,207	11,717	12,170	12,575	12,939	13,269
15	623	921	1,210	1,490	2,781	4,906	6,581	7,937	9,056	9,996	10,796	10,743	12,086	12,613	13,080	13,496	13,870	14,207
16	677	1,000	1,312	1,615	3,002	5,259	7,018	8,427	9,582	10,545	11,361	11,260	12,668	13,199	13,668	14,085	14,458	14,794
17	735	1,084	1,422	1,748	3,236	5,633	7,479	8,944	10,136	11,124	11,957	11,807	13,283	13,819	14,291	14,710	15,084	15,420
18	792	1,167	1,529	1,879	3,464	5,991	7,915	9,430	10,653	11,661	12,507	12,307	13,845	14,384	14,857	15,275	15,649	15,983
19	851	1,252	1,639	2,013	3,696	6,351	8,352	9,913	11,165	12,192	13,049	12,799	14,399	14,939	15,413	15,831	16,203	16,536
20	911	1,339	1,752	2,149	3,931	6,714	8,788	10,394	11,673	12,717	13,585	13,284	14,944	15,487	15,961	16,378	16,749	17,081
21	975	1,433	1,873	2,295	4,182	7,100	9,253	10,906	12,215	13,278	14,158	13,805	15,530	16,075	16,551	16,969	17,340	17,671
22	1,029	1,511	1,972	2,415	4,384	7,400	9,602	11,281	12,602	13,670	14,551	14,149	15,918	16,459	16,930	17,344	17,710	18,036
24	1,138	1,668	2,174	2,658	4,789	7,993	10,287	12,011	13,353	14,428	15,308	14,813	16,664	17,197	17,659	18,064	18,421	18,738
25	1,201	1,759	2,290	2,797	5,021	8,335	10,686	12,440	13,799	14,882	15,767	15,222	17,124	17,656	18,117	18,519	18,874	19,189
27	1,322	1,933	2,513	3,064	5,461	8,969	11,413	13,213	14,595	15,688	16,575	15,934	17,926	18,453	18,907	19,303	19,652	19,960
28	1,381	2,016	2,618	3,190	5,666	9,259	11,740	13,556	14,943	16,037	16,922	16,237	18,266	18,789	19,239	19,631	19,975	20,280
30	1,499	2,184	2,832	3,445	6,077	9,832	12,382	14,227	15,624	16,719	17,599	16,825	18,929	19,443	19,884	20,268	20,605	20,902
32	1,621	2,359	3,053	3,709	6,498	10,413	13,030	14,902	16,308	17,403	18,280	17,419	19,596	20,103	20,537	20,914	21,243	21,534
33	1,684	2,447	3,165	3,842	6,708	10,701	13,349	15,234	16,644	17,739	18,613	17,709	19,923	20,426	20,857	21,230	21,556	21,844
35	1,809	2,625	3,390	4,108	7,126	11,266	13,971	15,877	17,293	18,386	19,255	18,267	20,551	21,046	21,470	21,836	22,156	22,438
36	1,872	2,714	3,502	4,240	7,333	11,542	14,273	16,189	17,606	18,698	19,564	18,535	20,852	21,344	21,764	22,127	22,443	22,722
40	2,125	3,071	3,950	4,769	8,145	12,609	15,428	17,369	18,787	19,869	20,721	19,536	21,978	22,455	22,860	23,210	23,514	23,781

* Based on steel designation 1045, 20° pressure angle and 38 mm average face width.

Table 8 – Power ratings* of 4.0 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	60	80	100	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800
11	847	1,253	1,646	2,029	3,792	6,703	9,009	10,881	12,430	13,734	14,846	14,793	16,643	17,379	18,032	18,614	19,137	19,610
12	986	1,456	1,912	2,353	4,373	7,662	10,225	12,279	13,961	15,365	16,553	16,406	18,457	19,231	19,915	20,522	21,066	21,556
13	1,135	1,674	2,195	2,699	4,988	8,664	11,484	13,716	15,527	17,026	18,287	18,036	20,291	21,100	21,811	22,442	23,005	23,510
14	1,290	1,899	2,487	3,054	5,615	9,670	12,736	15,135	17,064	18,648	19,972	19,610	22,061	22,899	23,634	24,284	24,862	25,379
15	1,443	2,122	2,776	3,405	6,228	10,638	13,925	16,468	18,496	20,150	21,524	21,047	23,678	24,537	25,288	25,950	26,538	27,063
16	1,567	2,302	3,007	3,684	6,705	11,362	14,785	17,407	19,479	21,159	22,548	21,965	24,711	25,569	26,317	26,974	27,557	28,077
17	1,700	2,494	3,254	3,983	7,212	12,127	15,692	18,395	20,516	22,225	23,630	22,939	25,806	26,666	27,413	28,068	28,647	29,163
18	1,831	2,683	3,497	4,275	7,702	12,854	16,544	19,316	21,474	23,203	24,619	23,821	26,799	27,656	28,399	29,050	29,624	30,135
19	1,965	2,876	3,744	4,572	8,198	13,583	17,391	20,227	22,420	24,167	25,592	24,688	27,774	28,629	29,368	30,014	30,583	31,089
20	2,102	3,074	3,997	4,875	8,699	14,313	18,235	21,130	23,355	25,118	26,550	25,541	28,734	29,585	30,321	30,962	31,526	32,027
21	2,250	3,285	4,267	5,199	9,234	15,089	19,133	22,093	24,354	26,138	27,580	26,463	29,770	30,622	31,355	31,994	32,555	33,052
22	2,373	3,460	4,489	5,464	9,660	15,680	19,791	22,777	25,044	26,824	28,258	27,047	30,428	31,268	31,991	32,620	33,171	33,659
24	2,622	3,815	4,938	5,998	10,508	16,839	21,071	24,100	26,374	28,145	29,563	28,170	31,691	32,510	33,213	33,822	34,355	34,825
25	2,765	4,018	5,195	6,303	10,995	17,512	21,824	24,888	27,177	28,952	30,370	28,880	32,490	33,304	34,001	34,604	35,132	35,597
27	3,040	4,408	5,687	6,887	11,910	18,746	23,181	26,292	28,594	30,366	31,773	30,102	33,865	34,664	35,346	35,936	36,450	36,902
28	3,172	4,593	5,920	7,162	12,333	19,303	23,783	26,905	29,205	30,970	32,368	30,613	34,440	35,229	35,902	36,483	36,990	37,435
30	3,439	4,969	6,390	7,715	13,178	20,400	24,960	28,101	30,396	32,146	33,525	31,607	35,558	36,329	36,986	37,551	38,043	38,475
32	3,716	5,357	6,875	8,284	14,038	21,507	26,144	29,303	31,593	33,329	34,691	32,614	36,690	37,446	38,087	38,639	39,118	39,539
33	3,856	5,553	7,120	8,571	14,468	22,055	26,726	29,892	32,179	33,909	35,263	33,107	37,245	37,993	38,627	39,172	39,646	40,061
35	4,138	5,947	7,609	9,143	15,316	23,122	27,855	31,030	33,309	35,023	36,360	34,052	38,309	39,042	39,662	40,195	40,656	41,061
36	4,280	6,144	7,853	9,427	15,734	23,643	28,401	31,579	33,852	35,558	36,886	34,505	38,819	39,544	40,158	40,684	41,140	41,539
40	4,849	6,930	8,823	10,553	17,363	25,634	30,472	33,647	35,891	37,561	38,852	36,194	40,719	41,415	42,003	42,505	42,940	43,320

* Based on steel designation 1045, steel designation 1045, 20° pressure angle and 50 mm average face width.

Table 9 – Power ratings* of 5.0 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	60	80	100	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800
11	1,656	2,440	3,196	3,926	7,228	12,473	16,454	19,577	22,094	24,165	25,899	25,457	28,639	29,740	30,706	31,560	32,321	33,003
12	1,927	2,834	3,706	4,546	8,316	14,204	18,592	21,989	24,696	26,904	28,739	28,102	31,615	32,763	33,765	34,649	35,434	36,135
13	2,216	3,255	4,250	5,206	9,462	16,003	20,795	24,456	27,344	29,682	31,612	30,766	34,612	35,802	36,838	37,748	38,553	39,272
14	2,515	3,689	4,810	5,884	10,627	17,802	22,972	26,875	29,926	32,376	34,387	33,326	37,491	38,715	39,777	40,707	41,529	42,261
15	2,813	4,118	5,363	6,551	11,759	19,519	25,023	29,131	32,313	34,852	36,923	35,646	40,102	41,348	42,426	43,369	44,199	44,937
16	3,053	4,463	5,803	7,079	12,631	20,781	26,476	30,680	33,910	36,471	38,549	37,085	41,720	42,957	44,024	44,956	45,775	46,501
17	3,310	4,831	6,273	7,642	13,556	22,114	28,007	32,313	35,597	38,184	40,274	38,618	43,446	44,677	45,738	46,661	47,472	48,189
18	3,562	5,192	6,733	8,191	14,447	23,373	29,436	33,822	37,143	39,745	41,838	39,998	44,998	46,220	47,270	48,182	48,982	49,689
19	3,821	5,561	7,201	8,749	15,345	24,629	30,851	35,312	38,666	41,280	43,374	41,353	46,522	47,734	48,774	49,676	50,465	51,162
20	4,086	5,938	7,678	9,317	16,251	25,883	32,256	36,784	40,168	42,792	44,886	42,685	48,020	49,223	50,253	51,145	51,925	52,612
21	4,370	6,342	8,189	9,924	17,216	27,217	33,753	38,358	41,778	44,419	46,519	44,132	49,649	50,846	51,869	52,754	53,527	54,207
22	4,605	6,674	8,606	10,416	17,975	28,212	34,823	39,444	42,857	45,480	47,559	45,019	50,646	51,824	52,829	53,696	54,453	55,119
24	5,083	7,345	9,446	11,404	19,480	30,156	36,897	41,539	44,932	47,518	49,557	46,722	52,562	53,702	54,673	55,508	56,236	56,874
25	5,357	7,729	9,928	11,971	20,346	31,291	38,128	42,804	46,204	48,787	50,817	47,823	53,801	54,930	55,890	56,716	57,434	58,064
27	5,884	8,466	10,847	13,048	21,961	33,354	40,327	45,035	48,428	50,988	52,989	49,702	55,915	57,017	57,951	58,754	59,450	60,060
28	6,135	8,815	11,280	13,553	22,704	34,276	41,291	45,998	49,375	51,916	53,898	50,478	56,787	57,873	58,793	59,583	60,267	60,867
30	6,643	9,520	12,151	14,567	24,179	36,086	43,173	47,873	51,220	53,723	55,666	51,989	58,487	59,543	60,436	61,201	61,863	62,442
32	7,170	10,248	13,048	15,607	25,677	37,908	45,063	49,759	53,077	55,547	57,456	53,526	60,217	61,246	62,115	62,859	63,502	64,064
33	7,437	10,615	13,500	16,129	26,423	38,806	45,991	50,682	53,987	56,440	58,333	54,280	61,065	62,082	62,940	63,673	64,307	64,861
35	7,973	11,350	14,400	17,168	27,889	40,552	47,783	52,461	55,735	58,154	60,015	55,724	62,689	63,683	64,519	65,233	65,850	66,388
36	8,241	11,717	14,848	17,683	28,609	41,399	48,649	53,317	56,574	58,976	60,821	56,415	63,467	64,449	65,275	65,980	66,588	67,118
40	9,315	13,176	16,621	19,714	31,399	44,624	51,912	56,528	59,714	62,045	63,825	58,990	66,364	67,300	68,087	68,756	69,333	69,835

* Based on steel designation 1045, 20° pressure angle and 63 mm average face width.

Table 10 – Power ratings* of 6.0 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	60	80	100	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800
11	2,819	4,138	5,403	6,616	12,009	20,271	26,303	30,901	34,521	37,446	39,858	38,758	43,603	45,086	46,376	47,509	48,512	49,406
12	3,277	4,802	6,258	7,651	13,784	23,006	29,609	34,570	38,434	41,528	44,062	42,635	47,964	49,498	50,829	51,993	53,021	53,935
13	3,767	5,510	7,169	8,749	15,650	25,839	33,000	38,309	42,402	45,654	48,300	46,529	52,345	53,925	55,291	56,483	57,533	58,464
14	4,273	6,239	8,104	9,874	17,537	28,656	36,335	41,957	46,251	49,637	52,377	50,255	56,537	58,153	59,546	60,759	61,824	62,768
15	4,775	6,960	9,025	10,979	19,365	31,330	39,457	45,337	49,788	53,276	56,082	53,615	60,317	61,955	63,363	64,585	65,658	66,605
16	5,179	7,536	9,755	11,848	20,758	33,265	41,626	47,608	52,101	55,599	58,399	55,648	62,604	64,222	65,610	66,813	67,866	68,795
17	5,612	8,151	10,534	12,774	22,234	35,306	43,912	50,006	54,548	58,065	60,867	57,825	65,054	66,658	68,031	69,219	70,258	71,173
18	6,037	8,753	11,293	13,675	23,649	37,223	46,031	52,207	56,778	60,298	63,091	59,774	67,245	68,832	70,186	71,356	72,377	73,276
19	6,471	9,367	12,066	14,589	25,072	39,131	48,126	54,376	58,971	62,492	65,276	61,686	69,397	70,965	72,302	73,455	74,460	75,344
20	6,916	9,993	12,852	15,516	26,503	41,029	50,200	56,516	61,131	64,651	67,424	63,567	71,513	73,064	74,384	75,521	76,511	77,380
21	7,392	10,663	13,693	16,507	28,028	43,050	52,414	58,810	63,456	66,983	69,753	65,621	73,824	75,363	76,671	77,796	78,775	79,633
22	7,786	11,212	14,376	17,306	29,212	44,529	53,961	60,353	64,971	68,463	71,196	66,844	75,199	76,709	77,990	79,090	80,046	80,884
24	8,583	12,320	15,748	18,904	31,552	47,411	56,953	63,326	67,884	71,305	73,967	69,194	77,843	79,298	80,528	81,584	82,499	83,299
25	9,040	12,954	16,535	19,821	32,902	49,104	58,747	65,143	69,696	73,103	75,747	70,743	79,585	81,022	82,237	83,278	84,179	84,968
27	9,918	14,167	18,030	21,556	35,404	52,158	61,926	68,325	72,840	76,197	78,791	73,366	82,537	83,934	85,112	86,120	86,991	87,752
28	10,335	14,740	18,732	22,366	36,547	53,511	63,306	69,683	74,166	77,490	80,052	74,439	83,744	85,118	86,276	87,266	88,121	88,868
30	11,180	15,895	20,142	23,988	38,810	56,161	65,995	72,328	76,747	80,006	82,508	76,532	86,098	87,430	88,550	89,506	90,331	91,051
32	12,053	17,084	21,590	25,648	41,102	58,824	68,697	74,991	79,352	82,553	85,003	78,670	88,504	89,798	90,886	91,813	92,612	93,308
33	12,495	17,684	22,317	26,480	42,240	60,134	70,022	76,295	80,628	83,802	86,226	79,720	89,685	90,962	92,034	92,947	93,734	94,419
35	13,380	18,880	23,764	28,130	44,470	62,673	72,576	78,802	83,077	86,195	88,570	81,730	91,947	93,190	94,233	95,120	95,884	96,548
36	13,823	19,476	24,482	28,946	45,562	63,903	73,806	80,006	84,252	87,342	89,692	82,692	93,029	94,256	95,285	96,160	96,912	97,567
40	15,592	21,841	27,316	32,151	49,773	68,561	78,430	84,512	88,636	91,617	93,872	86,273	97,057	98,223	99,198	100,026	100,737	101,355

* Based on steel designation 1045, 20° pressure angle and 75 mm average face width.

Table 11 – Power ratings* of 8.0 module spur gears, watts

Number of teeth	rpm (driver)																	
	40	60	80	100	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800
11	6,586	9,605	12,461	15,167	26,814	43,523	54,935	63,223	69,516	74,456	78,438	75,076	84,461	86,793	88,800	90,544	92,074	93,428
12	7,647	11,126	14,403	17,493	30,648	49,115	61,458	70,291	76,925	82,089	86,224	82,162	92,432	94,821	96,870	98,646	100,201	101,573
13	8,780	12,745	16,462	19,954	34,654	54,865	68,105	77,451	84,399	89,768	94,041	89,258	100,415	102,855	104,941	106,745	108,321	109,709
14	9,948	14,407	18,568	22,461	38,681	60,540	74,591	84,383	91,598	97,134	101,517	96,014	108,016	110,492	112,603	114,425	116,014	117,411
15	11,104	16,044	20,635	24,912	42,552	65,874	80,598	90,740	98,150	103,801	108,253	102,061	114,819	117,309	119,428	121,254	122,843	124,238
16	12,029	17,342	22,258	26,819	45,447	69,626	84,636	94,862	102,275	107,897	112,306	105,581	118,778	121,223	123,300	125,086	126,638	127,999
17	13,018	18,727	23,986	28,847	48,507	73,581	88,900	99,228	106,664	112,272	116,654	109,384	123,057	125,467	127,511	129,265	130,788	132,122
18	13,987	20,077	25,664	30,807	51,417	77,262	92,813	103,198	110,625	116,200	120,539	112,761	126,856	129,226	131,232	132,951	134,442	135,747
19	14,977	21,451	27,366	32,791	54,332	80,908	96,669	107,101	114,515	120,056	124,354	116,078	130,587	132,919	134,890	136,578	138,039	139,316
20	15,987	22,849	29,092	34,797	57,251	84,521	100,473	110,943	118,342	123,848	128,106	119,343	134,260	136,556	138,494	140,152	141,585	142,838
21	17,069	24,344	30,936	36,938	60,358	88,374	104,550	115,083	122,487	127,975	132,207	122,937	138,305	140,574	142,487	144,121	145,533	146,766
22	17,957	25,557	32,417	38,640	62,719	91,107	107,295	117,756	125,073	130,478	134,634	124,982	140,605	142,822	144,689	146,282	147,658	148,858
24	19,752	27,997	35,380	42,032	67,357	96,400	112,580	122,893	130,041	135,287	139,300	128,923	145,038	147,159	148,942	150,460	151,770	152,910
25	20,780	29,395	37,081	43,980	70,048	99,551	115,810	126,108	133,216	138,416	142,387	131,600	148,050	150,140	151,894	153,387	154,674	155,795
27	22,749	32,053	40,292	47,638	74,984	105,168	121,466	131,668	138,656	143,742	147,610	136,090	153,102	155,122	156,815	158,254	159,492	160,570
28	23,681	33,301	41,789	49,333	77,211	107,619	123,881	134,006	140,917	145,934	149,742	137,902	155,139	157,122	158,781	160,192	161,405	162,459
30	25,562	35,808	44,784	52,711	81,601	112,404	128,584	138,555	145,317	150,204	153,900	141,442	159,122	161,034	162,633	163,990	165,157	166,169
32	27,502	38,381	47,846	56,154	86,030	117,210	133,317	143,153	149,783	154,555	158,154	145,087	163,223	165,074	166,620	167,931	169,057	170,034
33	28,481	39,675	49,379	57,872	88,219	119,569	135,635	145,404	151,972	156,690	160,243	146,880	165,240	167,063	168,585	169,874	170,981	171,941
35	30,437	42,247	52,416	61,264	92,490	124,121	140,092	149,724	156,167	160,779	164,243	150,313	169,102	170,872	172,347	173,596	174,667	175,596
36	31,413	43,524	53,918	62,936	94,571	126,317	142,232	151,795	158,175	162,736	166,158	151,956	170,950	172,694	174,147	175,377	176,431	177,345
40	35,292	48,562	59,805	69,452	102,534	134,588	150,244	159,522	165,660	170,021	173,280	158,066	177,824	179,472	180,842	182,001	182,992	183,851

* Based on steel designation 1045, 20° pressure angle and 100 mm average face width.

7.3 Service factors

Selection of gears is based on type of load and the method of lubrication. Service factors for type of load and type of lubrication are given in Tables 12 and 13 respectively. The service is computed as follows:

Service factor = service factor for load + service factor for lubrication...…….....[Eq. 1]

Table 12 – Additional service factors for type of load

Hours of operation per day	Uniform loading	Light shock	Heavy shock
8-10	1.0	1.2	1.4
11-16	1.1	1.3	1.5
17-24	1.2.	1.4	1.6

Table 13 – Service factors for type of lubrication

Type of lubrication	Service factor
Intermittent	0.7
Grease	0.4
Oil, drip	0.2
Oil, bath	0

7.4 Minimum number of teeth

The minimum number of teeth to mesh with another gear is shown on Figure 5.

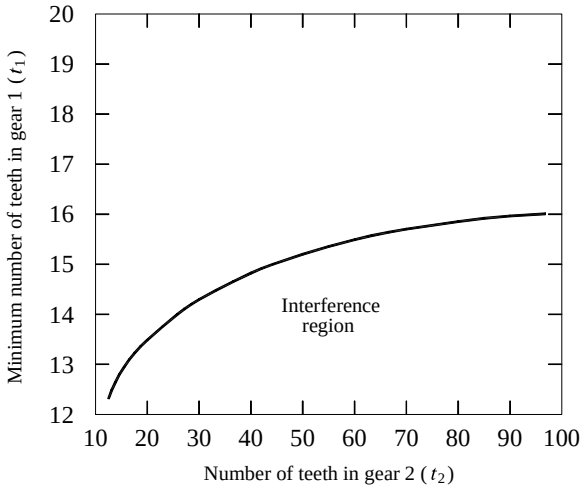

Fig. 5 – Minimum number of teeth for 20° full-depth

7.5 Gear ratio

7.5.1 Definition

Gear ratio is the ratio between the number of teeth of the driver and the driven gear (see Equation 2).

$$Gear\ ratio = \frac{t_2}{t_1} \quad \text{.....[Eq.2]}$$

7.5.2 Hunting tooth gear ratio

7.5.2.1 When using a hunting tooth gear ratio, a particular tooth in the pinion must mesh once with every tooth on the meshing gear when the pinion has completed as many revolutions as the number of teeth in the meshing gear. This is done in order to distribute the wear more evenly.

7.5.2.2 In a hunting tooth gear ratio, the teeth in a pair of meshing gears are such that they do not have a common divisor. Hunting tooth gear ratios are obtained by having the sum of the teeth in each pair equal to a prime number.

7.5.2.3 Hunting tooth is used when both gears are hardened or hardened and ground. It is also used for gear pairs that are subjected to high cyclic loads.

7.6 Design power

The required power is computed as follows:

Design power = Power to be transmitted x service factor…….[Eq. 3]

7.7 Center distance

Desired center distance given the module and speed ratio can be computed using the following equation:

$$\text{Center distance} = \frac{\text{module}(t_1 + t_2)}{2} \quad \text{.....[Eq. 4]}$$

8 Markings

8.1 The following information shall be marked on the gear:

a) Type

b) Module

c) Number of teeth

d) Manufacturer’s name and/or its trademark

8.2 The following information shall be marked on the packaging:

e) Type

f) Module

g) Number of teeth

h) Manufacturer’s name, trademark and address

9 Safety

9.1 Enclosing the drive with covers is recommended for safety and to avoid foreign materials from getting in contact with the drive.

9.2 Make drive inspection on a periodic basis. Inspect gears for wear and tear, for quality of lubricant, and for its alignment. Tightness of keys and setscrews should also be inspected periodically.

9.3 Use gears with proper markings.

9.4 Use proper keys as specified in PAES 304:2000, Keys and Keyways for Agricultural Machines.

Annex A
(Informative)

Example of spur gear drive selection

A.1 Given parameters

A drive is desired for 1,500 W, 200 rpm drive shaft to 70 rpm driven shaft to operate at 11—16 h/day and at a center distance of approximately 80 mm, with light shock load and with drip lubrication.

A.2 Speed ratio

The speed ratio is computed as

$$Speed\ ratio = \frac{n_1}{n_2}$$

where:

n_1 = rpm of driver gear
n_2 = rpm of driven gear

$$Speed\ ratio = \frac{n_1}{n_2} = \frac{200}{100} = 2.0$$

A.3 Service factor

From Table 12 and 13, the service factor for load and lubrication are 1.3 and 0.2 respectively. Thus, the service factor is computed as:

Service factor = 1.3 + 0.2 = 1.5

A.4 Design power

The design power is computed as:

Design power = 1,500 W x 1.5 = 2,250 W

A.5 Module and number of teeth of driving gear

A.5.1 Selection of the module and number of teeth shall be based on the design power of the drive, the gear with the next higher power rating to the design power can be considered suitable for the drive (assuming an allowable 10% deviation of the design power to the power rating).

A.5.2 Given a driving gear rpm of 200 and the design power, a gear with a power rating that surpasses the design power can be selected by scanning through Tables 3-11. Table A.1 presents the gears that are suitable for the drive based on power rating.

Table A.1 – Summary of gear selection data

	Number of teeth		Module	Power rating, watts	Center distance, mm
	Driver	Driven			
1	35	70	2.0	2,286	105.00
2	36	72	2.0	2,357	108.00
3	20	40	2.5	2,366	75.00

A.6 Number of teeth of driven gear

The number of teeth of the driven gear is computed using the following equation (see Table A.1 for computed values):

$$Gear\ ratio = \frac{t_2}{t_1}$$

where: t_2 = number of teeth of the driven gear
t_1 = number of teeth of the driver gear
Gear ratio = speed ratio

A.7 Center distance

The center distance can be computed as follows (see Table A.1 for computed values):

$$Center\ distance = \frac{module(t_1 + t_2)}{2}$$

A.8 Gear selection

Since the requirement for center distance is approximately 80 mm, the most suitable for the drive is a gear of module 2.5 and 20 teeth (driver gear) since it conforms to both the design power and the requirement for the center distance.