Renold Design Guide

Holroyd worm gears

RENOLD

Superior Gear Technology

INTRODUCTION

Worm gearing is an efficient and convenient means of connecting two non-intersecting shafts, usually at right angles to each other, although other angles are possible. It permits the adoption of a high reduction ratio without undue difference in diameter between worm and wheel.

The worm is a helical gear with a small number of teeth termed 'threads'. Today it is usual practice to make the worm as a helical gear with teeth which are of involute form on a section at right angles to the axis of the gear. This is called an 'involute helicoid'.

The wormwheel teeth are produced by a hob or single point cutter. The hob has a similar size and shape to the worm; the single point cutter matches one thread of the worm. The hob or flycutter is located in a production machine in a position relative to the wormwheel blank which assures correct mesh is achieved in the final installation.

In operation, the gears must be maintained accurately at the designed centre distance, and the wheel must be correctly adjusted axially in relation to the worm. The contact then obtainable between worm and wheel is along lines on closely fitting surfaces, with the result that high torque capacity is secured in a small space. For this reason, worm gears are far superior to spiral gears. Given correct mounting and lubrication, they are the quietest running of all gears.

This booklet is intended to provide the design engineer with a relatively simple means of selecting and compiling the preliminary dimensions of a worm and wormwheel for a drive system.

The powers, efficiencies, and dimensions, listed are based on existing Holroyd tooling. If used, they can immediately provide an economic advantage in terms of machining times with the bonus of a master worm as a reference which ensures interchangeability between batches of the same ratio and size of wormgear sets.

This tooling is usually provided for right-hand threads. But if there is a requirement where left-hand thread gears are needed or one which involves centre distances, speeds, ratios, or power not covered by the contents of this publication then you are invited to consult our Technical Sales department.

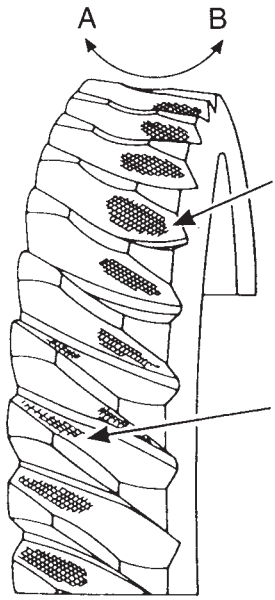
The power and efficiency values assume that (i) the worm is manufactured from a casehardening steel with the thread flanks ground to an involute helicoid form, and that (ii) the wormwheel teeth have been accurately generated in a blank produced from a good quality centrifugally cast phosphor bronze material.

Once the size, ratio and appropriate dimensions have been selected these can then be integrated in a design layout from which the remaining dimensions and details of the wormshaft and wormwheel can be completed together with the bearing positions. With the input and output torques (T_1 and T_2), gear reference diameters (d_{m1} and d_{m2}), and pressure angle (α_o) there is sufficient information to calculate the required capacities of the bearings. The various types of bearings, arrangements, and means of arriving at the necessary sizes, can usually be found in the listings published by the major bearing manufacturers.

The designer should note that in many instances it will be necessary to allow for some means of adjusting the axial clearance in the worm line bearing assembly to accommodate expansion due to heat build-up in the component when in operation.

The location of the bearings in the worm wheel line should incorporate some means of adjustment in positioning the worm wheel relative to the worm so that the correct mesh contact pattern between the two can be achieved as shown in the diagram below.

THIS SHOWS A CORRECT LEAVING SIDE CONTACT ON BOTH FACES OF A WORM WHEEL WHICH IS DESIRABLE WHEN THE GEARS ARE REQUIRED TO RUN IN BOTH DIRECTIONS OF ROTATION



The tabulation of powers, torques and efficiencies cover input speeds from 1800 to 250 rpm. Higher and lower speeds can be achieved but when these are required you are invited to consult with our Technical Sales Department.

Notation

b_1 Worm face length

b_2 Wormwheel face width

C Centre distance

d_{a1} Worm outer diameter

d_{a2} Wormwheel outer diameter

d_{f1} Worm root diameter

d_{f2} Wormwheel root diameter

d_{m1} Worm pitch diameter

d_{m2} Wormwheel pitch diameter

D_2 Maximum recess beneath wormwheel teeth

f_1 Service factor

f_2 Factor for starts per hour

f_3 Factor for operational cycle

f_4 Factor for ambient temperature

i_a Actual ratio

i_n Nominal ratio

n_1 Input speed to worm

n_2 Output speed from wormwheel

p_1 Input power to worm

T_{2sel} Selection output torque @wheel

Z_1 Number of threads in worm

Z_2 Number of teeth in wormwheel

γ Lead angle

α_n Normal pressure angle

η Efficiency

SELECTION OF CENTRE DISTANCE

The powers and torques listed are those which the gears will transmit at the speeds given under uniform load conditions for an operational life of 25,000 hours.

In order to select a gear for a specific duty it is necessary to assess the drive to establish the power or torque requirement, input and output speeds, nature of the load, operating time each day, number of stop/start cycles per hour: in regard to this consideration should be given to the capabilities of the prime mover to ensure this has the capabilities to overcome the effects of the starting efficiencies and the static inertia of the driven machine.

Having arrived at the torque requirement of the driven machine T_{2req} Nm at speed n_2 it is necessary to consider these in conjunction with the various factors f which cover the operating conditions mentioned.

The selection torque therefore becomes

$$T2sel = T_{2req} \times f_1 \times f_2 \times f_4$$

Where f_1 = service factor covering the characteristics of the prime mover and the nature of the drive over a period of hours per day.

f_2 = number of starts per hour. The gears will withstand 50% overload at start up for up to 5 starts per hour.

f_4 = Ambient temperature. This factor becomes 1 if the temperature of the lubricant is controlled by a cooling system but otherwise takes account of the possible variations in viscosity of a lubricant with regard to temperature.

Service factor f_1

Prime mover (Drive input)	Duration of service hours/day	Driven Machinery Characteristics		
		Steady	Medium Impulsive	Highly Impulsive
Electric Motor (steady input)	intermittent - 3 hrs/day max	0.80	1.00	1.25
	3 - 10	1.00	1.25	1.50
	over 10	1.25	1.50	2.00
Multi -cylinder I.C. Engine (medium impulsive input)	intermittent - 3 hrs/day max	1.00	1.25	1.50
	3 - 10	1.25	1.50	1.75
	over 10	1.50	1.75	2.00
Single cylinder I.C. Engine (Highly impulsive input)	intermittent - 3 hrs/day max	1.25	1.50	1.75
	3 - 10	1.50	1.75	2.00
	over 10	1.75	2.00	2.25

Frequency of starts f_2

Starts per hour	Up to 5	5 to 50	above 50
f_2	1	1.1	1.2

Ambient temperature condition f_4

°C	10	20	30	40	50
f_4	0.85	1.0	1.2	1.5	1.9

The nominal ratio i_n will be the speed of the prime mover n_1 divided by the output speed at the wormwheel n_2

$$\text{Ratio } i_n = \frac{n_1}{n_2}$$

Having calculated the torque T_{2sel} it is then possible to select the size from the rating charts on pages 14 to 16.
The approximate efficiency values η are listed in the chart on page 13 and these can be used in relating T_{2sel} to P_{1req}.

$$\text{i.e.} \quad P_{1req} = \frac{T_{2sel} \times n_2 \times 100}{9550 \times \eta}$$

$$\text{or} \quad T_{1req} = \frac{T_{2req} \times 100}{i_a . \eta}$$

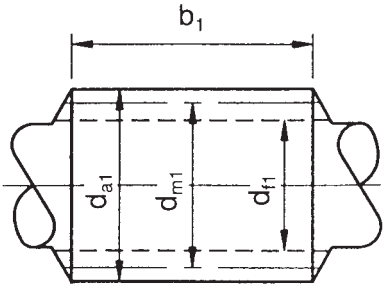
Example
A gear is required to transmit 1600Nm to a machine at 50rpm under moderate shock load conditions applied for 9 hours per day, 10 starts pe hour with 80% of each hour under load. The drive is from a 1500rpm nominal speed electric motor, ambient temperature 20°C.

$$T_2 = T_{2sel} \times f_1 \times f_2 \times f_4$$
$$= 1600 \times 1.25 \times 1.1 \times 0.94 \times 1$$
$$= 2068\text{Nm}$$

$$i_n = \frac{n_1}{n_2} = \frac{1440}{50}$$

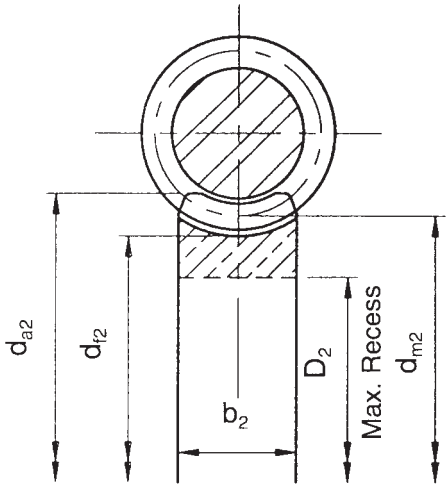
$$= 28.8$$

The closest actual ratio i_a is 30/1 and from the rating charts we find that the 177.8mm (7.0") centres gears have a capacity of 2191Nm at 1500rpm.



WORM DIMENSIONS

WORMWHEEL DIMENSIONS



All dimensions in mm unless stated

Z_1 - number of threads in worm. Z_2 - number of teeth in wormwheel

D_2 - ensures sufficient material is retained between the bottom of the teeth spaces and any recess or provision for securement.

Centre Distance (C) 76.2(3.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
l_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	6	34.54	26.42	22.55	50	31	132	125.98	116.63	102	26	42°-42'
7.5	4	35.05	26.37	19.61	55	29	135	126.03	115.87	100	27	33°-24'
10	3	35.05	24.47	17.93	55	29	137	126.03	115.82	100	27	26°-19'
12.5	3	33.86	27.76	19.94	50	37	134	125.32	117.29	105	25	20°-34'
15	2	36.37	28.34	19.40	60	31	135	124.05	114.35	100	27	15°-46'
20	2	31.52	25.32	18.26	45	41	136	127.05	119.66	108	23	13°-45'
25	1	39.70	29.89	18.41	70	25	137	122.50	110.77	93	31	9°-19'
30	1	37.16	28.93	19.22	60	30	136	123.47	113.61	99	28	8°-06'
40	1	31.70	25.35	17.83	50	40	136	127.05	119.43	108	23	7°-09'
50	1	30.43	25.35	19.30	40	50	135	127.05	120.95	112	21	5°-43'
60	1	27.73	23.47	18.39	35	60	135	128.93	123.80	116	18	5°-14'
70	1	29.16	25.55	21.23	30	70	132	126.85	122.53	116	18	4°-03'

Centre Distance (C) 88.9(3.5")						Pressure angle (α_n) 20° - 00'						
WORMSHAFT						**WORMWHEEL**						
l_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	6	42.06	32.71	27.13	55	31	154	145.08	134.31	117	32	40°-36'
7.5	4	40.64	30.48	23.77	65	29	157	147.32	135.48	117	32	33°-41'
10	3	44.55	34.64	24.53	67	29	156	143.15	131.42	114	33	23°-13'
12.5	3	41.02	33.20	24.81	56	37	155	144.60	135.30	119	29	19°-27'
15	2	43.92	34.67	24.26	60	31	156	143.13	132.10	115	32	14°-56'
20	2	39.11	32.00	23.88	54	41	156	145.79	137.31	124	27	12°-32'
25	2	38.63	32.69	27.78	45	49	154	145.11	138.00	127	25	10°-18'
30	1	43.13	35.63	24.40	72	30	156	142.16	130.78	114	33	7°-35'
40	1	41.20	34.03	25.55	55	40	154	143.76	135.18	122	28	6°-00'
50	1	37.97	32.13	25.17	45	50	154	145.67	138.66	128	24	5°-12'
60	1	36.57	31.70	25.91	40	60	153	146.10	140.26	131	22	4°-24'
70	1	35.41	31.24	26.26	35	70	153	146.56	141.58	134	20	3°-49'

Centre Distance (C) 101.6(4.0")						Pressure angle (α_n) 20° - 30'						
WORMSHAFT						**WORMWHEEL**						
l_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	6	47.78	37.06	29.94	60	31	177	166.14	153.80	135	36	40°-57'
7.5	4	46.12	34.49	25.80	70	29	181	168.71	155.14	134	36	34°-00'
10	3	46.18	34.54	23.31	75	29	183	168.65	154.94	134	36	26°-48'
12.5	3	43.38	34.26	24.74	64	37	181	168.94	158.11	142	32	21°-48'
15	2	46.33	35.51	23.57	75	31	183	167.69	154.79	135	35	16°-57'
20	2	41.73	33.45	24.05	60	41	181	169.75	159.84	145	30	13°-43'
25	1	52.47	39.37	24.02	95	25	183	163.83	148.13	125	40	9°-27'
30	1	45.33	34.06	25.62	80	30	181	169.14	155.62	135	35	9°-23'
40	1	42.04	33.55	23.54	64	40	182	169.65	159.48	144	31	7°-12'
50	1	36.85	29.95	21.76	53	50	183	173.25	164.97	152	26	6°-36'
60	1	34.64	28.85	21.94	45	60	183	174.34	167.38	157	23	5°-45'
70	1	36.70	31.82	25.98	40	70	178	171.37	165.53	156	22	4°-24'

Centre Distance (C) 127(5.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
I_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	6	57.66	44.09	35.71	75	31	223	209.91	194.31	170	44	42°-42'
7.5	4	57.91	43.38	32.36	90	29	226	210.61	193.65	168	45	33°-49'
10	3	57.86	43.33	29.31	90	29	229	210.67	193.55	168	45	26°-42'
12.5	3	54.23	42.80	30.91	80	37	226	210.67	197.69	177	39	21°-48'
15	2	55.11	41.40	26.46	95	31	231	212.60	196.29	172	43	18°-20'
20	2	51.94	41.58	29.79	75	41	227	212.42	200.02	181	37	14°-00'
25	2	48.67	39.93	29.87	65	49	226	214.07	203.60	188	33	12°-21'
30	1	55.88	41.76	25.24	100	30	232	212.24	195.32	170	44	9°-37'
40	1	51.20	40.54	27.94	80	40	229	213.46	200.66	181	37	7°-30'
50	1	47.83	39.24	29.03	65	50	227	214.76	204.44	189	33	6°-15'
60	1	43.59	36.32	27.68	55	60	228	217.68	208.99	196	29	5°-42'
70	1	45.85	39.75	32.43	46	70	223	214.25	206.93	196	28	4°-24'

Centre Distance (C) 152.4(6.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
I_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	8	60.91	48.41	41.81	65	41	267	256.39	242.16	220	44	45°-55'
7.5	5	62.20	48.41	37.51	85	37	272	256.41	240.36	216	46	35°-36'
10	4	59.49	46.23	34.19	85	39	275	258.57	243.02	219	44	29°-51'
12.5	4	54.71	44.27	33.98	70	49	274	260.53	248.23	230	38	25°-13'
15	3	58.34	46.61	34.21	80	44	274	258.19	244.27	223	41	20°-41'
20	2	62.26	49.81	35.69	90	41	273	254.99	240.10	218	43	14°-01'
25	2	57.81	47.29	35.25	75	49	272	257.50	244.95	226	39	12°-32'
30	1	60.96	51.05	31.19	120	30	278	253.75	240.59	210	52	9°-24'
40	1	60.60	47.75	32.56	95	40	276	257.05	241.65	219	44	7°-40'
50	1	57.33	47.01	34.77	75	50	273	257.78	245.44	227	39	6°-15'
60	1	52.22	43.53	33.22	65	60	274	261.26	250.85	235	34	5°-43'
70	1	54.86	47.55	38.81	55	70	268	257.25	248.46	235	32	4°-25'

Centre Distance (C) 177.8(7.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
I_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	8	72.64	58.11	50.09	75.	41	310	297.48	280.87	255	51	45°-00'
7.5	5	72.62	56.46	43.71	95	37	317	299.14	280.34	252	54	35°-36'
10	4	70.05	54.61	40.49	100	39	320	300.99	282.85	255	52	29°-29'
12.5	4	67.44	55.19	42.80	84	49	316	300.99	285.93	264	46	23°-57'
15	3	68.63	54.97	40.43	95	44	319	300.63	284.38	260	48	20°-27'
20	2	72.31	57.78	41.43	102	41	318	297.81	280.49	255	51	14°-07'
25	2	67.89	55.65	41.58	87	49	317	299.95	285.32	263	46	12°-24'
30	2	61.82	51.51	39.57	75	59	319	304.09	291.74	273	41	11°-19'
40	1	69.93	54.89	37.16	110	40	323	300.71	282.67	256	51	7°-49'
50	1	66.70	54.66	40.38	90	50	318	300.94	286.51	265	45	6°-17'
60	1	60.86	50.70	38.61	76	60	320	304.90	292.71	274	40	5°-43'
70	1	64.29	55.70	45.49	65	70	312	299.90	289.63	274	38	4°-24'

Centre Distance (C) 203.2(8.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
I_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	8	83.06	66.44	57.25	86	41	355	339.95	321.00	291	58	45°-00'
7.5	5	83.00	64.51	49.93	110	37	362	341.88	320.39	283	61	35°-36'
10	4	79.20	61.52	45.46	110	39	366	344.88	324.15	293	59	29°-54'
12.5	4	77.11	63.09	48.93	93	49	362	343.30	326.69	302	52	23°-58'
15	3	78.15	62.51	45.95	105	44	365	343.89	325.29	297	55	20°-34'
20	2	83.18	66.62	47.83	115	41	363	339.77	320.01	291	58	13°-58'
25	2	77.06	63.04	46.94	100	49	363	343.36	326.59	302	52	12°-32'
30	2	66.09	54.30	40.79	86	59	369	352.09	338.02	317	45	12°-24'
40	1	78.66	61.44	41.17	124	40	370	344.96	324.33	294	58	7°-59'
50	1	75.79	62.03	45.67	100	50	364	344.37	327.86	303	51	6°-20'
60	1	69.75	58.11	44.29	86	60	365	348.28	334.36	314	46	5°-42'
70	1	73.45	63.65	51.97	74	70	357	342.75	331.01	313	43	4°-24'

Centre Distance (C) 288.6(9.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
I_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	8	93.22	74.57	64.26	96	41	399	382.63	361.34	328	66	45°-00'
7.5	6	88.09	70.51	57.10	102	44	406	386.69	366.27	335	62	36°-47'
10	4	89.71	69.85	51.71	125	39	412	387.35	364.03	329	66	29°-38'
12.5	4	86.69	70.94	55.04	105	49	407	386.25	367.66	340	59	23°-58'
15	3	88.09	70.51	51.86	120	44	410	386.69	365.81	335	62	20°-30'
20	2	93.67	75.03	53.85	131	41	409	382.17	359.87	327	65	13°-57'
25	2	87.10	71.35	53.26	112	49	408	385.85	367.00	339	59	12°-27'
30	2	79.30	66.04	50.70	95	59	410	391.16	371.19	352	52	11°-21'
40	1	89.46	70.10	47.29	140	40	415	387.09	363.93	330	64	7°-52'
50	1	85.29	69.80	51.41	112	50	410	387.40	368.81	341	58	6°-20'
60	1	78.43	65.38	49.88	96	60	411	391.82	376.17	353	51	5°-42'
70	1	82.68	71.65	58.49	83	70	402	385.55	372.34	353	49	4°-24'

Centre Distance (C) 254(10.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
I_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	8	103.63	82.91	71.42	107	41	444	425.09	401.42	365	73	45°-00'
7.5	6	97.69	78.13	63.29	115	44	451	429.87	407.21	372	69	36°-53'
10	4	99.57	77.47	57.35	140	39	457	430.53	404.62	365	73	29°-41'
12.5	4	96.34	78.81	61.13	117	49	452	429.18	408.46	377	65	23°-58'
15	3	97.69	78.13	57.40	134	44	456	429.87	406.65	372	69	20°-34'
20	2	103.58	82.85	59.33	145	41	455	425.14	400.40	364	73	14°-03'
25	2	96.37	78.84	58.72	125	49	454	429.16	408.23	377	65	12°-32'
30	2	88.29	73.56	56.49	107	59	456	434.44	416.81	391	57	11°-19'
40	1	99.36	77.87	52.53	155	40	462	430.12	404.37	366	72	7°-52'
50	1	94.89	77.67	57.25	125	50	456	430.33	409.70	379	64	6°-19'
60	1	87.17	72.64	55.37	106	60	457	435.35	417.93	392	57	5°-42'
70	1	91.82	79.58	65.00	92	70	446	428.42	413.74	392	54	4°-24'

Centre Distance (C) 304.8(12.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
I_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	9	112.77	90.22	79.86	110	46	538	519.38	493.88	454	79	48°-22'
7.5	6	117.09	93.67	75.89	145	44	541	515.92	488.74	447	82	36°-54'
10	4	119.35	92.84	68.71	166	39	549	516.76	485.37	439	88	29°-43'
12.5	4	115.62	94.59	73.35	140	49	542	515.01	490.12	453	82	23°-58'
15	3	117.14	93.67	68.78	160	44	548	515.92	488.03	446	82	20°-35'
20	2	119.10	93.95	65.66	175	41	551	515.64	485.62	441	86	14°-59'
25	2	115.62	94.59	70.46	150	49	545	515.01	489.86	453	82	12°-32'
30	2	105.74	88.06	67.64	126	59	547	521.54	500.40	469	69	11°-21'
40	1	119.28	93.47	69.39	185	40	548	516.13	485.24	440	87	7°-52'
50	1	113.36	92.68	68.14	150	50	547	516.91	492.10	455	77	6°-22'
60	1	104.29	86.87	66.14	125	60	548	522.73	501.85	471	68	5°-44'
70	1	110.13	95.45	77.93	107	70	536	514.15	496.52	470	64	4°-24'

Centre Distance (C) 355.6(14.0")						Pressure angle (α_n) 22° - 30'						
WORMSHAFT						**WORMWHEEL**						
I_n	Z_1	d_{a1}	d_{m1}	d_{f1}	b_1	Z_2	d_{a2}	d_{m2}	d_{f2}	D_2	b_2	γ
5	10	130.45	106.73	95.50	112	51	624	604.47	577.54	536	88	48°-01'
7.5	7	125.83	102.41	85.60	133	52	633	608.79	581.71	540	86	38°-40'
10	5	129.89	105.15	83.06	155	49	636	606.04	577.03	533	89	30°-28'
12.5	4	129.89	105.15	80.67	160	49	684	606.05	563.12	519	89	25°-12'
15	4	123.70	103.07	81.53	139	59	631	608.13	583.69	547	81	21°-48'
20	3	123.70	103.07	80.21	143	59	637	608.13	583.44	547	81	16°-42'
25	2	129.84	105.10	76.91	173	49	641	606.09	576.53	533	90	13°-14'
30	2	123.70	103.07	79.20	146	59	638	608.13	583.44	547	81	11°-19'
40	2	112.72	97.18	78.89	112	79	636	614.02	595.32	568	68	9°-05'
50	1	127.40	103.12	74.37	175	50	644	608.07	579.02	536	88	6°-42'
60	1	121.92	101.60	77.42	147	60	639	609.60	585.21	549	80	5°-43'
70	1	128.50	111.38	90.90	125	70	625	599.82	579.25	549	75	4°-24'

EFFICIENCY VALUES η %

C	n_1	i_n											
	(rpm)	5	7.5	10	12.5	15	20	25	30	40	50	60	70
76.2 mm	1800	94	93	92	90	89	87	84	81	78	74	71	68
(3.0")	1500	94	93	91	90	88	86	84	80	76	72	69	66
to	1000	93	92	90	89	86	84	81	77	73	69	66	62
101.6 mm	500	91	89	88	86	83	80	77	73	67	64	60	56
(4.0")	250	89	87	85	83	80	77	74	68	63	59	55	51
	Static	76	75	73	70	65	62	53	50	47	42	40	34
127 mm	1800	95	94	94	92	92	89	88	86	83	79	77	73
(5.0")	1500	95	94	94	92	92	89	88	85	82	79	77	72
to	1000	94	93	92	91	90	87	86	83	79	76	73	69
177.8 mm	500	92	91	90	88	88	84	82	79	75	71	68	63
(7.0")	250	90	89	88	86	85	81	79	75	70	66	63	58
	Static	76	75	74	70	68	63	60	54	49	44	42	36
203.2 mm	1800	95	95	94	94	93	90	89	88	85	81	80	76
(8.0")	1500	95	95	94	94	93	90	89	88	84	81	79	76
to	1000	95	94	94	93	92	89	88	86	82	79	77	72
254 mm	500	93	93	92	91	89	86	84	83	78	74	71	67
(10.0")	250	91	91	90	88	87	82	81	79	73	69	66	61
	Static	76	76	75	72	70	63	60	60	50	44	42	36
304.8 mm	1800	96	96	95	94	94	92	91	90	87	84	82	78
(12.0")	1500	96	96	95	94	94	92	91	90	87	84	82	78
to	1000	95	95	94	94	93	91	90	88	86	82	80	76
355.6 mm	500	94	94	93	92	91	89	87	85	82	78	75	70
(14.0")	250	92	92	91	89	89	86	84	81	78	73	69	64
	Static	76	76	74	72	70	64	60	58	49	44	42	36

GEAR RATINGS

INPUT POWER P_1 (KW) /OUTPUT TORQUE T_2 (Nm)							INPUT POWER P_1 (KW) /OUTPUT TORQUE T_2 (Nm)						
Centres C	Ratio i_a	1800 rpm	1500 rpm	1000 rpm	500 rpm	250 rpm	Centres C	Ratio i_a	1800 rpm	1500 rpm	1000 rpm	500 rpm	250 rpm
76.2 (3.00")	5.17	7.3 188	6.7 207	5.4 248	3.6 322	2.3 407	88.9 (3.50")	5.17	10.9 283	9.9 306	8.1 372	5.4 483	3.4 602
	7.25	4.5 160	4.1 176	3.2 203	2.1 258	1.3 313		7.25	6.9 249	6.3 270	5.0 318	3.3 406	2.1 505
	9.67	3.7 175	3.3 185	2.6 217	1.7 276	1.1 346		9.67	6.1 287	5.5 308	4.3 359	2.8 455	1.8 566
	12.33	4.0 235	3.6 255	2.8 293	1.8 369	1.1 436		12.33	6.1 365	5.5 390	4.4 461	2.8 575	1.8 713
	15.50	3.1 224	2.8 242	2.2 280	1.4 346	0.9 429		15.50	4.7 342	4.3 372	3.3 420	2.2 545	1.4 668
	20.50	2.7 254	2.4 270	1.9 311	1.2 382	0.8 490		20.50	4.0 375	3.6 405	2.8 442	1.8 573	1.1 674
	25.00	2.4 259	2.1 280	1.7 328	1.1 404	0.7 494		24.50	3.0 332	2.7 361	2.1 406	1.4 514	0.9 636
	30.00	2.0 255	1.8 275	1.4 312	0.9 375	0.6 469		30.00	2.6 379	2.6 397	2.1 468	1.4 584	0.9 704
	40.00	1.7 276	1.5 290	1.2 334	0.8 409	0.5 481		40.00	2.4 385	2.2 425	1.7 474	1.1 563	0.7 673
	50.00	1.2 243	1.1 252	0.9 296	0.6 366	0.4 450		50.00	1.8 348	1.6 366	1.3 428	0.8 489	0.5 563
	60.00	1.0 220	0.9 237	0.7 264	0.4 276	0.3 377		60.00	1.5 329	1.3 342	1.1 415	0.7 483	0.4 503
	70.00	0.9 209	0.8 235	0.6 248	0.4 301	0.3 405		70.00	1.3 309	1.1 324	0.9 372	0.6 452	0.4 541
101.6 (4.00")	5.17	15.9 413	14.5 449	11.8 543	7.8 699	5.0 885	127.0 (5.00")	5.17	26.2 680	23.7 741	19.3 898	12.9 1168	8.3 1486
	7.25	10.0 361	9.2 394	7.2 458	4.8 591	3.0 722		7.25	15.8 571	14.4 624	11.5 740	7.6 957	4.8 1182
	9.67	8.4 399	7.5 420	6.0 500	3.8 617	2.4 755		9.67	13.1 626	11.9 689	9.4 801	6.1 1014	3.9 1270
	12.33	8.5 507	7.5 532	6.0 629	3.9 800	2.4 951		12.33	13.8 833	12.3 893	9.8 1051	6.3 1323	4.0 1642
	15.50	7.2 534	6.5 563	5.1 649	3.3 817	2.1 1002		15.50	11.7 878	10.5 951	8.2 1092	5.4 1418	3.4 1725
	20.50	5.6 539	5.1 573	4.0 654	2.6 827	1.6 950		20.50	9.6 930	8.8 1024	6.9 1169	4.5 1504	2.8 1805
	25.00	5.3 588	4.7 628	3.7 715	2.4 882	1.5 1060		24.50	8.1 924	7.3 1002	5.7 1147	3.7 1420	2.3 1701
	30.00	5.0 665	4.5 687	3.5 780	2.3 960	1.4 1095		30.00	7.8 1050	7.0 1136	5.5 1321	3.6 1626	2.2 1898
	40.00	3.5 583	3.2 619	2.5 697	1.6 819	1.0 962		40.00	6.1 1050	5.5 1148	4.3 1297	2.8 1604	1.8 1925
	50.00	2.7 544	2.4 550	1.9 626	1.2 733	0.8 901		50.00	4.7 969	4.2 1056	3.3 1197	2.1 1424	1.4 2116
	60.00	2.1 493	1.9 500	1.5 566	0.9 621	0.6 755		60.00	3.7 887	3.3 970	2.6 1085	1.7 1330	1.1 1587
	70.00	1.7 450	1.6 471	1.2 496	0.8 602	0.5 676		70.00	3.0 807	2.7 867	2.2 1013	1.4 1186	0.9 1384

GEAR RATINGS

INPUT POWER P_1 (KW) /OUTPUT TORQUE T_2 (Nm)							INPUT POWER P_1 (KW) /OUTPUT TORQUE T_2 (Nm)						
Centres C	Ratio i_a	1800 rpm	1500 rpm	1000 rpm	500 rpm	250 rpm	Centres C	Ratio i_a	1800 rpm	1500 rpm	1000 rpm	500 rpm	250 rpm
152.4 (6.00")	5.12	46.2 1195	41.5 1285	34.0 1565	22.8 2052	14.5 2553	177.8 (7.00")	5.12	62.7 1625	56.7 1755	46.0 2117	30.9 2784	19.8 2553
	7.40	28.0 1041	25.4 1128	20.3 1335	13.4 1725	8.6 2169		7.40	39.0 1450	35.0 1550	28.3 1861	18.6 2394	12.0 3026
	9.75	22.3 1081	20.4 1190	15.9 1369	10.4 1752	6.6 2175		9.75	30.6 1490	28.3 1651	22.0 1895	14.6 2460	9.3 3065
	12.25	23.3 1409	20.8 1498	16.5 1757	10.7 2204	6.7 2697		12.25	33.4 2026	30.1 2167	23.6 2513	15.4 3172	9.7 3617
	14.67	19.7 1411	17.5 1507	13.8 1741	9.0 2224	5.6 2674		14.67	27.4 1968	24.4 2101	19.3 3079	12.6 3114	7.9 3772
	20.50	14.2 1378	12.8 1486	10.0 1706	6.5 2145	4.1 2621		20.50	19.7 1927	17.5 2032	13.8 2354	9.1 3004	5.7 3644
	24.5	12.8 1473	11.7 1606	9.21 1852	5.9 2265	3.7 3736		24.50	17.7 2041	16.1 2210	12.6 2536	8.3 3186	5.2 3846
	30.00	11.3 1533	10.2 1656	8.0 1921	5.2 2349	3.3 2847		29.50	14.9 2036	13.5 2191	10.6 2546	6.8 3035	4.2 3551
	40.00	8.8 1545	7.9 1649	6.2 1871	4.1 2349	2.6 2781		40.00	12.5 2206	11.1 2318	8.8 2655	5.7 3266	3.6 3850
	50.00	7.4 1560	6.7 1685	5.3 1923	3.4 2305	2.2 2773		50.00	10.4 2218	9.3 2338	7.3 2649	4.8 3254	3.1 3907
	60.00	5.8 1414	5.2 1529	4.1 1711	2.6 2034	1.7 2452		60.00	8.5 2125	7.7 2264	6.1 2525	3.9 3051	2.5 3607
	70.00	4.8 1290	4.3 1381	3.4 1600	2.2 1864	1.4 2154		70.00	7.0 1921	6.4 2056	5.0 2353	3.3 2796	2.1 3231
203.2 (8.00")	5.12	85.9 2231	78.3 2424	62.9 2926	42.7 4077	27.5 4887	228.6 (9.00")	5.12	113.5 2949	104.0 3220	83.6 3889	56.9 5434	37.0 6575
	7.40	53.6 1999	48.5 2170	39.2 2606	25.5 3355	16.6 4280		7.33	83.8 3106	76.3 3393	61.8 4079	40.4 5261	26.2 6677
	9.75	42.3 2062	38.9 2270	30.4 2675	20.1 3462	12.8 4314		9.75	56.3 2754	52.0 2035	40.6 3573	26.8 4617	17.1 5763
	12.25	46.0 2800	41.5 3053	32.3 3515	21.3 4536	13.4 5520		12.25	61.0 3720	55.3 4069	42.6 4636	28.3 6028	17.9 7374
	14.67	37.7 2720	33.7 2934	26.5 3419	17.3 4334	10.9 5327		14.67	50.0 3618	44.9 3909	35.2 4541	22.9 5724	14.6 7135
	20.50	27.2 2677	24.1 2831	19.2 3350	12.5 4224	7.9 5112		20.50	37.4 3682	33.2 3899	26.4 4607	17.0 5745	10.9 7054
	24.50	24.5 2842	22.0 3055	17.3 3563	11.3 4443	7.1 5384		24.50	32.7 3810	29.5 4096	23.1 4758	15.0 5898	9.4 7128
	29.50	21.7 3002	19.6 3294	15.3 3807	9.9 4643	6.1 5433		29.50	28.6 3962	25.7 4319	20.0 4977	13.1 6144	8.1 7215
	40.00	17.3 3099	15.4 3294	12.2 3821	7.9 4707	5.0 5577		40.00	22.8 4093	20.3 4342	15.9 4980	10.3 6138	6.5 7250
	50.00	14.3 3079	12.7 3274	10.1 3809	6.5 4593	4.2 5535		50.00	19.0 4109	16.9 4357	13.3 5017	8.6 6077	5.5 7248
	60.00	12.0 3024	10.8 3259	8.4 3698	5.5 4493	3.5 5290		60.00	16.2 4116	14.4 4345	11.4 5019	7.4 6045	4.8 7255
	70.00	9.8 2739	8.9 3018	7.0 3438	4.6 4145	3.0 4854		70.00	13.3 3736	12.0 4070	9.4 4616	6.2 5587	4.0 6472

GEAR RATINGS

INPUT POWER P_1 (KW) /OUTPUT TORQUE T_2 (Nm)							INPUT POWER P_1 (KW) /OUTPUT TORQUE T_2 (Nm)						
Centres C	Ratio ia	1800 rpm	1500 rpm	1000 rpm	500 rpm	250 rpm	Centres C	Ratio ia	1800 rpm	1500 rpm	1000 rpm	500 rpm	250 rpm
254.0 (10.00")	5.12	150.8 3923	137.5 4287	111.5 5187	75.4 6861	49.5 8815	304.8 (12.00")	5.11	260.1 6751	235.6 7372	192.9 8974	130.2 11975	85.9 15465
	7.33	110.6 4102	101.3 4505	82.2 5425	54.0 7032	35.0 8919		7.33	169.8 6308	156.7 7042	128.7 8585	84.8 11162	54.9 14145
	9.75	74.7 3656	68.9 4021	54.3 4779	35.7 6150	22.8 7685		9.75	115.0 5639	106.2 6264	85.2 7498	55.7 9700	35.8 12200
	12.25	80.6 4922	73.4 5400	56.9 6193	37.7 8030	24.0 9887		12.25	123 7530	113.3 8336	89.1 9802	58.7 12640	37.7 15707
	14.67	66.0 4787	59.6 5189	46.6 6012	30.5 7624	19.4 9481		14.67	100.9 7337	92.1 8105	71.9 9377	47.8 12217	30.5 15249
	20.50	47.9 4737	43.0 5055	34.0 5933	21.9 7401	14.0 9060		20.50	75.0 7465	67.9 8161	53.6 9565	34.7 12137	22.1 15000
	24.50	43.5 5083	39.3 5458	30.6 6303	19.9 7825	12.5 9036		24.50	67.6 7929	61.3 8704	47.9 10090	31.1 12666	19.6 14694
	29.50	37.6 5228	33.9 5698	26.0 6470	17.0 8068	10.6 9635		29.50	59.4 8302	53.6 9213	41.4 10303	26.9 13075	16.9 15750
	40.00	30.2 5451	27.0 5730	21.0 6578	13.6 8104	8.6 9592		40.00	46.5 8445	41.8 9187	32.3 10611	21.3 13344	13.5 16089
	50.00	25.1 5463	22.4 5775	17.6 6639	11.3 7985	7.3 9620		50.00	38.4 8447	34.6 9252	27.2 10650	17.7 13184	11.4 15895
	60.00	21.2 5419	19.0 5733	15.0 6605	9.7 7924	6.2 9416		60.00	33.5 8651	30.3 9491	23.8 10888	15.5 13375	9.9 15719
	70.00	17.3 4917	15.7 5324	12.3 6041	8.1 7404	5.2 8414		70.00	274 7858	25.0 8702	19.6 10161	12.8 12224	8.3 14091
355.6 (14.00")	5.10	394.0 10205	360.8 11171	293.2 13641	198.4 18248	131.3 23639							
	7.43	281.5 10607	256.7 11536	212.1 14149	140.2 18454	90.6 23343							
	9.80	217.7 10766	197.4 11644	160.6 13984	104.9 18268	67.5 23004							
	12.25	182.3 11193	168.3 12383	134.5 14796	87.9 18928	56.7 23623							
	14.75	168.0 12343	153.5 13123	121.8 15956	80.4 20612	51.4 25775							
	19.67	127.4 12284	117.0 13480	92.5 15812	59.9 20478	38.1 24620							
	24.50	99.1 11700	94.8 13461	74.5 15694	48.0 19549	30.4 22791							
	29.50	88.8 12440	80.4 13820	62.5 15916	40.3 19589	25.5 23672							
	39.50	59.1 10781	53.2 11693	40.9 13436	26.9 16852	17.0 20261							
	50.00	59.1 13160	53.4 14279	42.3 16562	27.5 20484	17.6 24539							
	60.00	49.1 12739	44.8 14033	35.4 16195	23.0 19847	14.7 23341							
	70.00	40.4 11652	36.7 12774	29.0 15034	18.9 18049	12.3 20882							

BACKLASH

Backlash, or clearance between the worm threads and wormwheel teeth, is not usually critical. The amounts allowed for in the tooling used for the gears listed in this booklet would be as follows:

Centre Distance	Backlash
76.2 (3.00") - 88.9 (3.5 ")	0.07 - 0.15 (0.003" - 0.006")
101.6(4.00") - 127.0 (5.0")	0.10 - 0.20 (0.004" - 0.008")
152.4(6.00") - 203.2 (8.0")	0.15 - 0.30 (0.006" - 0.012")
228.6(9.00") - 355.6 (14.0")	0.20 - 0.35 (0.008" - 0.014")

Where reduced backlash is essential to the application we can usually meet the requirement and this question can be discussed with our Technical Department.

Holroyd also has the capability to produce wormgear sets to precision tolerances where the accuracy of positioning can be measured in seconds of arc. Many of the wormgear sets of this class incorporate the duplex or dual lead feature which allows for adjustment of the backlash on assembly and in use without the need for centre distance variation or dismantling of the gear.

PRODUCTION CAPACITY

Holroyd have the capacity to produce worm gearing ranging from a centre distance of 28.5 (1.125") up to around 1110 (43.7") with the upper limits generally as listed below.

Worm-thread ground

Maximum outside diameter	457 (18")
Maximum Length (dependent upon shaft diameters)	3050 (120")
Maximum Lead	914 (36")
Maximum Lead Angle	45°

Gas carburised and case hardening can be carried out on wormshafts up to these dimensions.

Wormwheels

1:1 Ratio	Maximum outside diameter 228 (9")
2:1 Ratio	Maximum outside diameter 457 (18")
3:1 Ratio	Maximum outside diameter 685 (27")
4:1 Ratio	Maximum outside diameter 914 (36")
5:1 and upwards	Maximum outside diameter 2133 (84")

LUBRICATION

The power/torque and efficiency values listed assume lubrication is provided by a good quality mineral oil having a viscosity of about 30 centistokes at the normal working temperature.

When selecting a lubricant for use in a wormgear application, care should be taken that the pour point is approximately 5°C below the lowest ambient temperature likely in the area in which the drive will be housed and that the maximum operating temperature is within that of the lubricant. It should be noted that habitual operation close to the higher limit of an oil will reduce its operational life.

There are technical advantages in adopting lubricants based on synthesised hydrocarbons (SHC's) or polyglycols (synthetics) which have a wider operational temperature range than straight mineral oils and also have characteristics which reduce the efficiency losses, allow the transmission of higher powers/torques, and the benefit of a longer operational life. Care should be taken with the synthetics however in assuring the compatibility of sealants, paints, and shaft seals.

It can generally be assumed that the SHC lubricants allow the power/torque throughputs of a specific worm gear set to be increased by 10%, polyglycols by 15 - 20%.

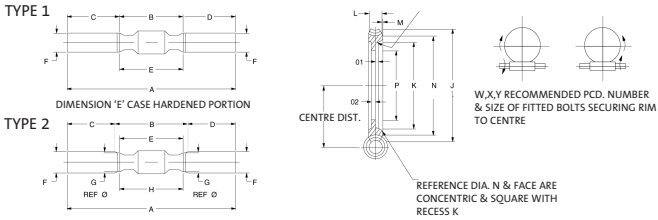
If it is intended that these advantages are to be utilised, it should be noted when selecting the bearings that the higher power/torque values should be used in the calculations since the characteristics of these lubricants do not confer the gains to these components.

At the speeds listed in this brochure, a static sump lubrication system should be adequate but if this is not practicable and a forced feed system has to be used, the lubricant should be fed to the mesh at a viscosity of 30Cs and quantity: -

$$\frac{C(\text{inches})}{4} \text{ in gallons/minute or } \frac{C(\text{mm})}{22} \text{ in litres/minute}$$

Mineral Oil	Light		Medium		Heavy	
		Temp°C		Temp°C		Temp°C
Mobil DTE	BB	-7 to 90	AA	2 to 90	HH	2 to 90
Castrol Alpha ZN	220	-9 to 120	320	-9 to 120	460	-9 to 120
Shell Vitrea	220	-24 to 120	320	-18 to 120	460	-15 to 120
Esso Teresso	220	-18 to 120	320	-12 to 120	460	-9 to 120
Kluberoil GEM 1	220	-18 to 100	320	0 to 100	460	0 to 100
Synthetic (Polyalphaolefin)	**Light**		**Medium**		**Heavy**	
		Temp°C		Temp°C		Temp°C
Mobil Gear SHC	630	-42 to 160	632	-42 to 160	634	-39 to 160
Castrol Alpha T	220	-36 to 80	320	-33 to 80	460	-33 to 80
Shell Omala RL	220	-40 to 80	320	-40 to 80	460	-40 to 80
Esso Teresso SHP	220	-42 to 150	320	-36 to 150	460	-30 to 150

VERSATILE GEARS - CENTRE DISTANCE
76.2MM (3.0") TO 508.0MM (20.0")



WORMSHAFT

SIZE	CENTRE DISTANCE MIN.	CENTRE DISTANCE MAX.	TYPE	A	B	C	D	E	F	G	H	MAX. WORM DIA.
WVG 3	76.20 (3.000)	76.25 (3.002)	1	390.5	92.1	176.2	122.2	96.9	41.28	-	-	39.70
WVG 3.5	88.90 (3.500)	88.95 (3.502)	1	428.6	127.0	174.6	127.0	133.4	41.28	-	-	45.14
WVG 4	101.60 (4.000)	101.65 (4.002)	2	517.5	155.6	211.1	150.8	114.3	50.80	44.45	107.95	52.48
WVG 5	127.00 (5.000)	127.05 (5.002)	2	600.0	181.0	249.2	169.8	155.6	60.33	50.80	146.05	57.91
WVG 6	152.40 (6.000)	152.45 (6.002)	2	647.7	209.6	263.5	174.6	177.8	66.68	60.33	168.28	62.26
WVG 7	177.80 (7.000)	177.85 (7.002)	2	723.9	235.0	288.9	200.0	203.2	73.03	63.50	193.68	72.64
WVG 8	203.20 (8.000)	203.25 (8.002)	2	774.7	260.4	301.6	212.7	219.1	79.38	69.85	209.55	83.19
WVG 9	228.60 (9.000)	228.65 (9.002)	2	866.8	288.9	335.0	242.9	244.5	82.55	79.38	234.95	93.68
WVG 10	254.00 (10.000)	254.05 (10.002)	1	933.5	279.4	368.3	285.8	292.1	88.90	-	-	103.63
WVG 12	304.80 (12.000)	304.85 (12.002)	1	1082.7	311.2	431.8	339.7	323.9	95.25	-	-	119.35
WVG 14	355.60 (14.000)	355.65 (14.002)	1	1251.0	362.0	498.5	390.5	374.7	104.78	-	-	130.45
WVG 17	431.80 (17.000)	431.85 (17.002)	1	1536.7	425.5	625.5	485.7	441.3	117.48	-	-	160.63
WVG 20	508.00 (20.000)	508.05 (20.002)	1	1784.4	387.4	777.9	619.1	409.6	152.40	-	-	180.14

WORMWHEEL

SIZE	J	K MIN.	K MAX.	L	M	N	D1	D2	P	Q	W PCD	X	Y
WVG 3	133.35	95.25	95.28	25.4	3.2	107.95	12.70	12.70	71.45	1.5	84.1	6	6
WVG 3.5	157.18	114.30	114.33	31.8	3.2	127.00	15.88	15.88	84.12	1.5	101.6	8	6
WVG 4	180.98	127.00	127.04	38.1	3.2	146.05	19.05	19.05	92.08	1.5	111.1	8	10
WVG 5	225.43	171.45	171.49	41.3	3.2	190.50	20.65	20.65	120.65	1.5	146.1	6	14
WVG 6	273.05	215.90	215.94	44.5	3.2	234.95	19.05	15.88	158.75	1.5	187.3	6	14
WVG 7	317.50	247.65	247.69	47.6	3.2	269.88	19.05	19.05	171.45	1.5	209.6	6	16
WVG 8	365.13	295.28	295.32	50.8	3.2	323.85	19.05	19.05	222.25	1.5	260.4	6	16
WVG 9	409.58	330.20	330.25	57.2	3.2	365.13	19.05	19.05	254.00	1.5	292.1	6	16
WVG 10	454.03	368.30	368.35	63.5	4.7	400.05	22.23	22.23	285.75	1.5	330.2	6	20
WVG 12	542.93	444.50	444.56	76.2	4.7	482.60	25.40	25.40	349.25	1.5	400.1	12	20
WVG 14	641.35	533.40	533.47	82.6	4.7	584.20	25.40	25.40	431.80	1.5	482.6	12	24
WVG 17	774.70	647.70	647.77	95.3	4.7	704.85	25.40	25.40	533.40	3.3	596.9	12	27
WVG 20	914.40	781.05	781.13	101.6	4.7	838.20	31.75	31.75	666.75	3.3	723.9	12	24

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