Comparison Between *oms* Hypodrive Gear Units EC 2-7 / 15 / 25 and Worm & Worm Helical Gears Of The Same Output Power Rating

The *oms* Hypodrive gear units are two stage gear units with a bevel gear input stage and spur gear second (output) stage. The input stage is a highly optimized hypoid bevel gear stage of the GLEASON® type in ground quality. The output stage is an optimized helical spur gear stage, also in ground quality.
The manufacturing technology of the gear toothings are in accordance with the quality requirements of the automobile industry.
The outer dimensions of the gear units and the layout of the motor and the braking unit is similar to those used with standard worm gear units for escalator traction machines.

Picture 1: EC 2-7

Picture 2: EC 2-25

A comparison between worm gear and *oms*Hypodrive type of gear units will be made for commercial applications, and for public applications worm and worm-helical gears will be compared to *oms*Hypodrive gears, comparing the following characteristics, based on the same output power and momentum:

Volume of Gear Unit:
The volume of the *oms*Hypodrive gear unit is more than 30% smaller than a comparable worm gear or worm-helical unit.

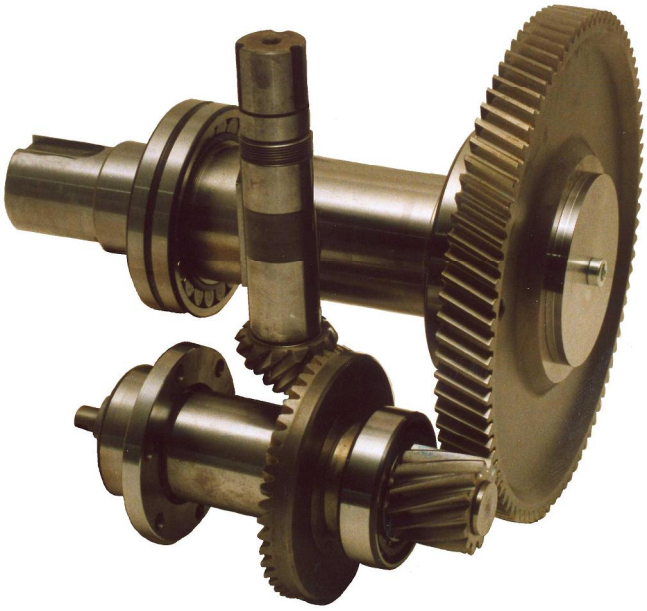
Efficiency:
The efficiency of the *oms*Hypodrive gear unit (96 – 97%) is approx. 10% higher than that of a comparable good worm gear unit (84 – 87%) at rated load. That means losses of 3 – 4 % for **a** *oms*Hypodrive gear unit, versus 13 – 16% for a worm gear unit. At loads smaller than the rated load, the *oms*Hypodrive gear units performs even better compared to a worm gear unit. Compared to worm-helical gears with an efficiency of about 91% at maximum rated gear load, that means losses of 9% for this type of gear. Although efficiency is better than for a pure worm gear, the efficiency of *oms*Hypodrive is still superior.

Sound Emission:
The sound power level of the *oms*Hypodrive gear units are well below the allowed sound levels as required by the major manufacturers of escalators and is comparable to well designed worm gear units. This feature is due to the optimized manufacturing technology using the most advanced GLEASON® grinding and measuring technology.

Performance:
The *oms*Hypodrive gear units can be used continuously at their maximum output power level for indefinite time, without overheating the gear units. A worm gear unit with comparable reduction ratio may not be used continuously at it's maximum power level for more than about one hour without an additional external oil cooler, due to its high thermal losses. Also, a worm helical gear has reduced output power and momentum above $T_{AMBIENT}$ > 30°C, so substantial reduction in capability for realistic operating temperatures in the escalator has to be taken into consideration.

Wear of Toothing:
The gear toothings of the *oms*Hypodrive gears are calculated for indefinite lifetime and are safe against tooth cracking as required by the safety margins claimed by the EN-115:2008 standard. The hardened and ground teeth flanks show a surface smoothing after initial putting into operation, without any abrasion.
For comparison, be reminded that worm gear and worm-helical gear units can only be designed and build with a finite lifetime due to the abrasion of the bronze worm wheel, which is load dependent.

Picture 3: EC 2-15
Options: Weatherproof, Short Motor, Chain Wheel, Brake Function Sensors, Brake Lining Wear Sensors



Picture 4: *oms* Hypodrive Input and Output Stage (Patents pending)

Oil Volumes, Oil Temperatures and Oil Changing Intervals:

The *oms* Hypodrive gear units use substantially less oil than a comparable worm gear or worm-helical gear unit. Nevertheless the operating temperatures of the *oms* Hypodrive gear units will be approx. 30K to 35K lower than for a comparable worm gear unit, and about 20K to 25K lower than for a comparable worm-helical unit with the shelf live of the oil in an *oms* Hypodrive gear unit approaching many times that of a worm gear or worm-helical unit. Due to the much lower heat generated from a *oms* Hypodrive gear unit, the thermal stress for the surrounding materials, electronic equipment, controllers etc. is much less when using an *oms* Hypodrive gear unit as compared to using a worm gear or worm-helical gear unit. This translates into much longer service intervals for the surrounding equipment, too.

For data on the oil consumption over lifetime for both commercial and public applications, the cost impact of the oil usage in terms of the amount of oil needed, and the number of oil service operations required, a detailed comparison of oil service related cost is given in the appendix.

Economical Aspects

General Maintenance:
The maintenance aspect is another cost benefit for the hypoid technology, although it is difficult to quantify according to specific regional conditions. Therefore, the calculation of the cost advantage of the *oms*Hypodrive traction machines compared to worm gear and worm-helical gear based machines will focus only on: energy efficiency, lower oil consumption and the associated cost of oil exchange.

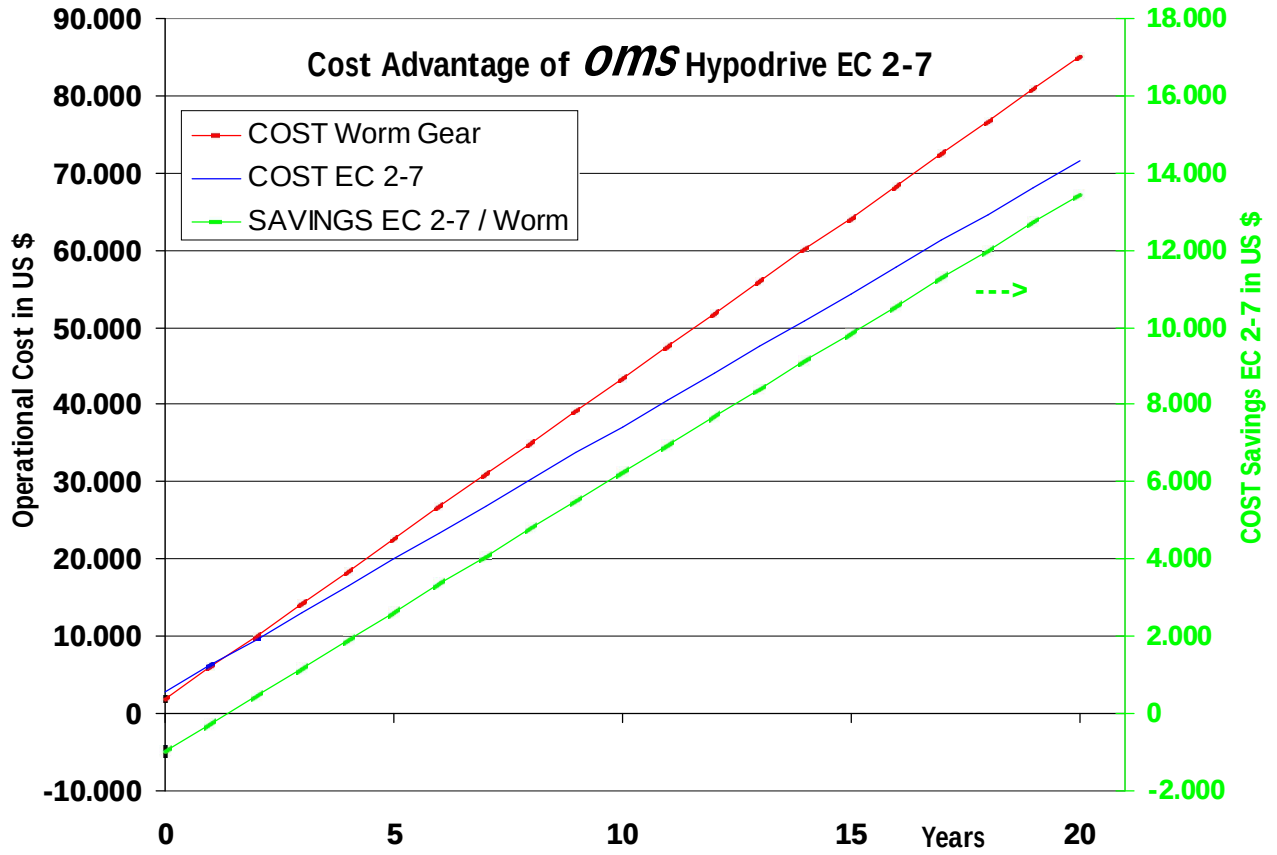
The *oms*Hypodrive unit needs a check of the oil via the oil level gauge initially after 10.000 and 20.000 hours, and then every 5.000 hours. This is many times the oil exchange interval for a *complete oil change for both worm gear and worm-helical drives* (6,000h). The de facto oil exchange intervals for the *oms*Hypodrive units reach 35,000 - 40.000 hours for the EC 2-25, and 20.000 – 30.000 hours for the EC 2-7, depending on the type of application, usage and environment. The change of the oil does not require the removal of the drive unit. This effectively translates into lower cost of service.

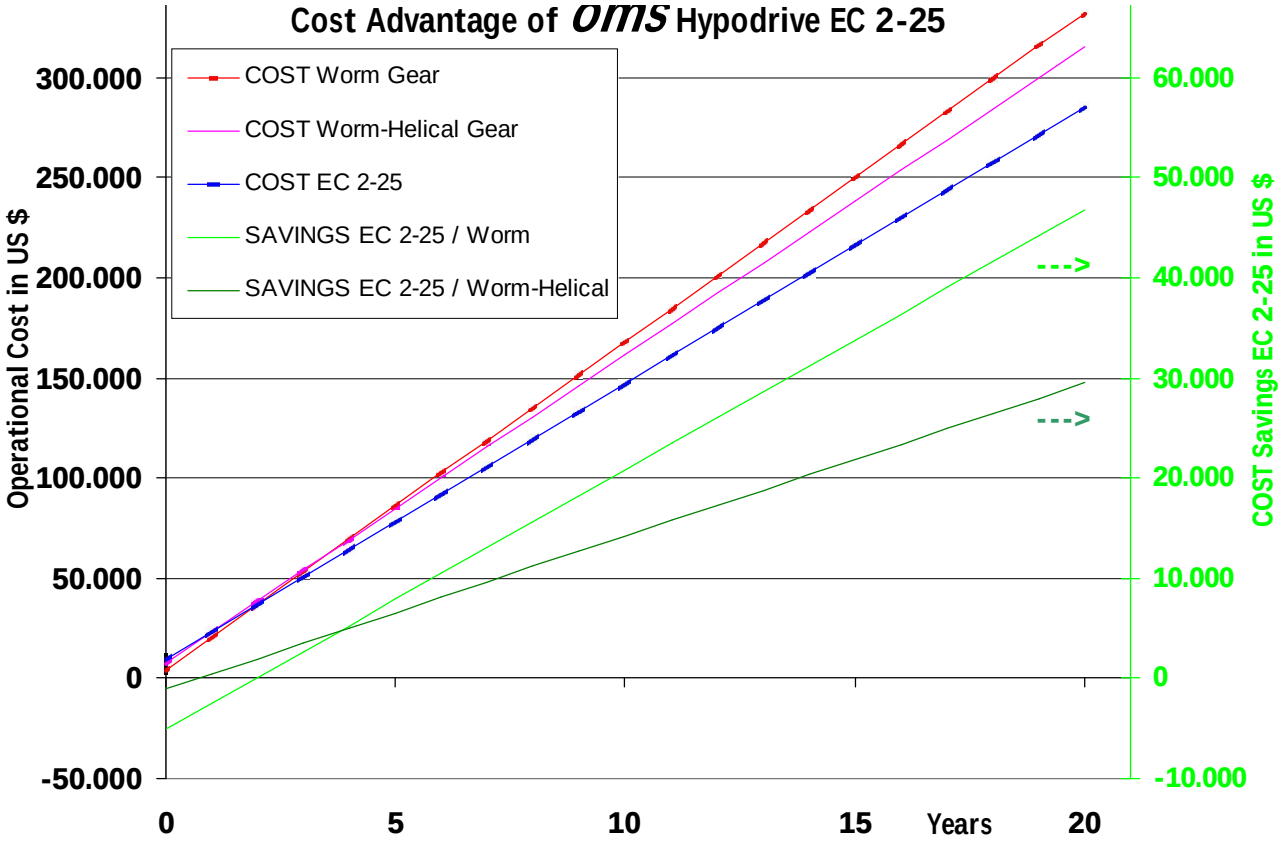
A worm gear and a worm-helical gear usually has to be replaced after approximately 70.000 h for commercial and 146.000h for public gears due to the wear of the worm wheel (with a reduced life time in the field, down from 26 years to now about 20 years, due to the higher daily usage due to longer opening times of shopping centres over the past few years, and thus the increased number of operating hours per year. This translates into lifetimes of about 20years for both applications). Due to the wear resistant toothing technology used in the *oms*Hypodrive gears, the lifetime of the *oms*Hypodrive as compared to worm gears and worm-helical gears is limited by the finite lifetime of the bearings only.

Break Even Point:
The comparison between the *oms*Hypodrive and worm gear drive, both in a commercial applications, shows that the efficiency of the hypoid technology is significantly influencing the break even point of the investment for the escalator traction machine, due to its much lower energy usage.

Also a major influencing factor is the oil consumption of the gear box and the associated cost for the oil service. In this respect the *oms*Hypodrive machines deliver an outstanding performance, which is not met by any other currently available technology suited for escalator traction machines of the same performance.

As shown in the following diagrams, all this adds up to shorten the break even point in favour of the *oms*Hypodrive machines. The moderately higher price of the *oms*Hypodrive technology has an almost negligible effect on the total operational cost over the lifetime of the machine.


Cost Advantage of oms Hypodrive EC 2-7
COST Worm Gear
COST EC 2-7
SAVINGS EC 2-7 / Worm
Operational Cost in US $
COST Savings EC 2-7 in US $
--->
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
-10.000
18.000
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0
-2.000
0
5
10
15
Years
20


Cost Advantage of oms Hypodrive EC 2-25
COST Worm Gear
COST Worm-Helical Gear
COST EC 2-25
SAVINGS EC 2-25 / Worm
SAVINGS EC 2-25 / Worm-Helical
Operational Cost in US $
COST Savings EC 2-25 in US $
--->
--->
300.000
250.000
200.000
150.000
100.000
50.000
0
-50.000
60.000
50.000
40.000
30.000
20.000
10.000
0
-10.000
0
5
10
15
Years
20

Remarks: The Difference in the investment of the *oms*Hypodrive and Worm Gear Drive appears to be negligible in view of the difference in operational cost. The higher energy and maintenance cost of a worm gear drive as compared to the *oms*Hypodrive are determining the slopes of the ascending cost graphs. This accumulated difference over lifetime is not only much larger than the cost difference of the two gear types, it is also much larger than the *initial purchasing cost* of either escalator traction machine!

For public applications, although the worm-helical gear has a higher efficiency than a worm gear drive, the superior effectiveness of the *oms*Hypodrive in both efficiency and cost of service is evident, still with substantial savings as compared to a worm-helical drive.
Examples given are for an escalator for commercial applications, with *oms*Hypodrive EC 2-7, and for public applications with *oms*Hypodrive EC 2-25. Both diagrams are based on current unit cost and energy cost as of September 2010.

Conclusion

Due to its much better efficiency, its highly optimized gear toothing and its low thermal output, the *oms*Hypodrive gear units achieve a much higher level of usability as compared to a worm gear unit or a worm-helical unit. The *oms*Hypodrive gear units will pay itself off within a very short time of operation.

The cost savings due to the higher efficiency of the *oms*Hypodrive and the lower total cost of service adds up to more than many times the purchasing cost of these escalator traction machines. Savings for the EC 2-7 amounts to more than US $ 13,000 as compared to a worm gear drive, and for the EC 2-25 to more than US $ 50,000 as compared to a worm gear drive, and is still more than US $ 30,000 as compared to a worm-helical drive over the lifetime of 20 years. The respective differences in the initial purchasing cost of the two machine types is already reflected in both diagrams.

In our resource hungry world, with continuing price increases for materials and resources, and most recently very dramatic increases in energy costs, this shows very clearly the advantages of using a *oms*Hypodrive gear as the traction machine in escalators.

Of course the cost savings potential will scale with the power of the escalator traction machines. For a Tandem machine as pictured on the next page in picture 5, with 2 x 15kW, the cost savings potential will just double. The EC 2-25 escalator traction machines are available with a power rating up to 2 x 30kW at 1.500 min^{-1}, and for this calibre of escalator traction machines the *savings in electricity alone* will amount to an astounding US $ 140.000.- over the machines lifetime of 20 years. Now one can easily figure out what this will mean in terms of cost savings for a metro station with a multitude of escalators, or what huge operational cost benefits may be expected when extending an existing or building a new metro line.
The *oms*Hypodrive machines are environmental friendly escalator traction machines, regarding their minimized usage of resources like energy and lubricants.

Picture 5: Tandem EC 2-25 2 x 15kW, 1.000 min^{-1}

Appendix

The comparison of the *oms*Hypodrive and worm (worm-helical) gear drives is based on the following assumptions for commercial and public applications, respectively: escalator load is **60%** of nominal load (nominal load: commercial 7.5kW for approx. 4m rise, public 15kW for approx. 9m rise); power input to gear is corrected for by the gear efficiency O; both type of machines use the same type of synthetic gear oil. For the comparison of service cost for *oms*Hypodrive and Worm Gear Drive the cost savings potential due to the reduced handling and depositing cost for the waste oil has not been included.

Escalator for Commercial Applications (70,000 h lifetime)

Average running time of escalator / day		12 h
Average running time of escalator / year		300 days
Average electricity rate in US $/KWh		0.20
	***oms*Hypodrive**	**Worm Gear Drive**
Gear oil volume:	3.5l	15 – 17l
Gear efficiency: O	96%	85%
Gear output power to escalator at 60% load: $P_{OUT,\ 60\%}$	4.5 kW	4.5kW
Gear input power to escalator at 60% load: $P_{OUT,\ 60\%}$ / O	4.7 KW	5.3 KW
Average energy consumption / day: W_{DAY}	56.4 KWh	63,6 KWh
Average energy consumption / year: W_{YEAR}	16,920 KWh	19,080 KWh
Energy cost / year	US $ 3,384.-	US $ 3,816.-
Savings of electricity / year compared to		**US $ 432.-**
Savings of electricity / lifetime (20 a) compared to		**US $ 8,640.-**
First oil exchange	20.000h (5 years)	1.000h
Oil shelf life	20.000h (5 years)	6.000h
Gear oil volume	3.2l	15l
Oil refill to end of lifetime (70.000h)	**9.6l** (3 x 3.2l)	**195l** (13 x 15l)
Cost of oil for refills during lifetime (at US $ 15 / l)	**US $ 144.-** (9.6l x 15 $/l)	**US $ 2,925.-** (195l x 15$/l)
Cost of Service For refilling oil (at US $ 300 per service)	**US $ 900.-** (1 x US $ 300)	**US $ 3,900.-** (13 x US $ 300)

***oms*Hypodrive** cost savings: lower oil usage US $ 2,781,00 and lower service cost: US $ 3,000.00

Total Savings in Oil-Service / lifetime (20 a) compared to **US $ 5,781.-**

Total cost advantage in favour of *oms*Hypodrive EC 2-7 US $ 14,421.-

Escalator for Public Applications (146,000 h lifetime)

Average running time of escalator / day	20 h
Average running time of escalator / year	365 days
Average electricity rate in US $/KWh	0.20

	*oms*Hypodrive	Worm Gear Drive	Worm- Helical Gear Drive
Gear Oil Volume	13l	25l	23l
Gear efficiency: O	96%	85%	91%
Gear output power to escalator at 60% load: $P_{OUT, 60\%}$	9.0 kW	9.0 kW	9.0kW
Gear input power to escalator at 60% load: $P_{OUT, 60\%}$ / O	9.4 kW	10.6 kW	9.9kW
Average energy consumption / day: W_{DAY}	188 kWh	212 kWh	198kWh
Average energy consumption / year: W_{YEAR}	68,620 KWh	77,380 KWh	72,270kWh
Energy cost / year	US $ 13,724.-	US $ 15,476.-	US $ 14,454.-
***oms*Hypodrive Savings of electricity / year compared to**		**US $ 1,752.-**	**US $ 730.-**
Savings of electricity / lifetime (20 a) compared to		**US $ 35,040.-**	**US $ 14,600.-**
First oil exchange	35,000h	1,000h	1.000h
Oil shelf life	35,000h	6,000h	6,000h
Gear oil volume	13l	25l	23l
Oil refill to end of lifetime (140.000h)	**39l** (3 x 13l)	**600l** (24 x 25l)	**552l** (24 x 23l)
Cost of oil for refills during lifetime (at US $ 15 / l)	**US $ 585.-** (39l x 15 $/l)	**US $ 9,000.-** (600l x 15$/l)	**US $ 8,200.-** (552l x 15$/l)
Cost of Service For refilling oil (at US $ 400 per service)	**US $ 1,200.-** (3 x US $ 400)	**US $ 9,600.-** (24 x US $ 400)	**US $ 9,600.-** (24 x US $ 400)
***oms*Hypodrive** :			
cost savings lower oil usage		**US $ 8,415.-**	**US $ 7,675.-**
cost savings lower service cost:		**US $ 8,400.-**	**US $ 8,400.-**
Total Savings in Oil-Service / lifetime (20 a)		**US $ 16,815.-**	**US $ 16.095.-**
Total cost advantage in favour of *oms*Hypodrive EC 2-25		**US $ 51,855.-**	**US $ 30,695.-**