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AGREEMENT CONCERNING THE ESTABLISHING OF GLOBAL TECHNICAL REGULATIONS FOR WHEELED VEHICLES, EQUIPMENT AND PARTS WHICH CAN BE FITTED AND/OR BE USED ON WHEELED VEHICLES
(ECE/TRANS/132 and Corr.1)
Done at Geneva on 25 June 1998

Addendum

Global technical regulation No. 2

Corrigendum 1

MEASUREMENT PROCEDURE FOR TWO-WHEELED MOTORCYCLES EQUIPPED WITH A POSITIVE OR COMPRESSION IGNITION ENGINE WITH REGARD TO THE EMISSION OF GASEOUS POLLUTANTS, CO_2 EMISSIONS AND FUEL CONSUMPTION

(Established in the Global Registry on 24 June 2009)

UNITED NATIONS

GE.09-

STATEMENT OF TECHNICAL RATIONALE AND JUSTIFICATION

Page 6, the references to "ISO 6460 (gas sampling)" and to "ISO 7860 (fuel consumption)", correct to read "ISO 6460 (gas sampling and fuel consumption)"

TEXT OF THE REGULATION

Page 19, paragraphs 6.5.5. to 6.5.5.2.3.3., correct to read (deleting also the numbering of several subparagraphs):

"6.5.5. Gearshift prescriptions

6.5.5.1. Test vehicles (motorcycles) with automatic transmission

Vehicles equipped with transfer cases, multiple sprockets, etc., shall be tested in the manufacturer's recommended configuration for street or highway use.

All tests shall be conducted with automatic transmissions in "Drive" (highest gear). Automatic clutch-torque converter transmissions may be shifted as manual transmissions at the option of the manufacturer.

Idle modes shall be run with automatic transmissions in "Drive" and the wheels braked.

Automatic transmissions shall shift automatically through the normal sequence of gears.

The deceleration modes shall be run in gear using brakes or throttle as necessary to maintain the desired speed.

6.5.5.2. Test vehicles (motorcycles) with manual transmission

6.5.5.2.1. Mandatory Requirements

6.5.5.2.1.1. Step 1 – Calculation of shift speeds

Upshift speeds ($v_{1\rightarrow 2}$ and $v_{i\rightarrow i+1}$) in km/h during acceleration phases shall be calculated using the following equations:

Equation 6-1:

$$v_{1\rightarrow 2} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_1}$$

Equation 6-2:

$$v_{i \rightarrow i+1} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_i}, \text{ i = 2 to ng-1}$$

Where:

i	is the gear number (≥ 2),
ng	is the total number of forward gears,
P_n	is the rated power in kW,
m_k	is the kerb mass in kg,
n_{idle}	is the idling speed in min^{-1},
s	is the rated engine speed in min^{-1},
ndv_i	is the ratio between engine speed in min^{-1} and vehicle speed in km/h in gear i.

Downshift speeds ($v_{i \rightarrow i-1}$) in km/h during cruise or deceleration phases in gear 4 (4^{th} gear) to ng shall be calculated using the following equation:

Equation 6-3:

$$v_{i \rightarrow i-1} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_{i-2}}, \text{ i = 4 to ng}$$

Where:

i	is the gear number (≥ 4),
ng	is the total number of forward gears,
P_n	is the rated power in kW,
m_k	is the kerb mass in kg,
n_{idle}	is the idling speed in min^{-1},
s	is the rated engine speed in min^{-1},
ndv_{i-2}	is the ratio between engine speed in min^{-1} and vehicle speed in km/h in gear i-2.

The downshift speed from gear 3 to gear 2 ($v_{3 \rightarrow 2}$) shall be calculated using the following equation:

Equation 6-4:

$$v_{3 \rightarrow 2} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_1}$$

Where:

P_n is the rated power in kW,
m_k is the kerb mass in kg,
n_{idle} is the idling speed in min^{-1},
s is the rated engine speed in min^{-1},
ndv_1 is the ratio between engine speed in min^{-1} and vehicle speed in km/h in gear 1.

The downshift speed from gear 2 to gear 1 ($v_{2\rightarrow1}$) should be calculated using the following equation:

Equation 6-5:

$$v_{2\rightarrow1} = \left[0.03 \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_2}$$

Where:

ndv_2 is the ratio between engine speed in min^{-1} and vehicle speed in km/h in gear 2.

Since the cruise phases are defined by the phase indicator, slight speed increases could occur and it may be meaningful to apply an upshift. The upshift speeds ($v_{1\rightarrow2}$, $v_{2\rightarrow3}$ and $v_{i\rightarrow i+1}$) in km/h during cruise phases may be calculated using the following equations:

Equation 6-6:

$$v_{1\rightarrow2} = \left[0.03 \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_2}$$

Equation 6-7:

$$v_{2\rightarrow3} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_1}$$

Equation 6-8:

$$v_{i\rightarrow i+1} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_{i-1}},\ i = 3 \text{ to } ng$$

6.5.5.2.1.2. Step 2 – Gear choice for each cycle sample

In order to avoid different interpretations about acceleration, deceleration, cruise and stop phases corresponding indicators are added to the vehicle speed pattern as integral parts of the cycles (see tables in Annex 5).

The appropriate gear for each sample shall then be calculated according to the vehicle speed ranges resulting from the shift speed equations of paragraph 6.5.5.2.1.1. and these phase indicators for the cycle parts appropriate for the test vehicle as follows:

Gear choice for stop phases:

For the last 5 seconds of a stop phase the gear lever shall be set to gear 1 and the clutch shall be disengaged. For the previous part of a stop phase the gear lever shall be set to neutral or the clutch shall be disengaged.

Gear choice for acceleration phases:

gear 1, if $v \leq v_{1\rightarrow2}$,
gear 2, if $v_{1\rightarrow2} < v \leq v_{2\rightarrow3}$,
gear 3, if $v_{2\rightarrow3} < v \leq v_{3\rightarrow4}$,
gear 4, if $v_{3\rightarrow4} < v \leq v_{4\rightarrow5}$,
gear 5, if $v_{4\rightarrow5} < v \leq v_{5\rightarrow6}$,
gear 6, if $v > v_{5\rightarrow6}$.

Gear choice for deceleration or cruise phases:

gear 1, if $v < v_{2\rightarrow1}$,
gear 2, if $v < v_{3\rightarrow2}$,
gear 3, if $v_{3\rightarrow2} \leq v < v_{4\rightarrow3}$,
gear 4, if $v_{4\rightarrow3} \leq v < v_{5\rightarrow4}$,
gear 5, if $v_{5\rightarrow4} \leq v < v_{6\rightarrow5}$,
gear 6, if $v \geq v_{4\rightarrow5}$.

The clutch shall be disengaged, if:

(a) The vehicle speed drops below 10 km/h; or

(b) The engine speed drops below $n_{idle} + 0.03 \times (s - n_{idle})$;

(c) There is a risk of engine stalling during cold start phase.

6.5.5.2.1.3. Step 3 – Corrections according to additional requirements

The gear choice has then to be modified according to the following requirements:

(a) No gearshift at a transition from an acceleration phase to a deceleration phase. The gear that was used for the last second of the acceleration phase shall be kept for the following deceleration phase unless the speed drops below a downshift speed.

(b) No upshifts or downshifts by more than 1 gear, except from gear 2 to neutral during decelerations down to stop.

(c) Upshifts or downshifts for up to 4 seconds are replaced by the gear before, if the gears before and after are identical. (Examples: 2 3 3 3 2 will be replaced by 2 2 2 2 2, 4 3 3 3 3 4 will be replaced by 4 4 4 4 4 4).

(d) No downshift during an acceleration phase.

6.5.5.2.2. Optional Provisions

The gear choice may be modified according to the following provisions:

(a) The use of lower gears than determined by the requirements described in paragraph 6.5.5.2.1. is permitted in any cycle phase. Manufacturers' recommendations for gear use shall be followed, if they do not result in higher gears than determined by the requirements described in paragraph 6.5.5.2.1.

Note 5 The calculation program to be found on the UN website at the URL below may be used as an aid for the gear selection:
http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/wmtc.html

Explanations about the approach and the gearshift strategy and a calculation example are given in Annex 13."

Paragraph 7.2.7.2.(r), amend to read:

"7.2.7.2. For comparison and analysis reasons besides the bag results also second by second data of the emissions (diluted gas) have to be monitored."

Annex 13, amend to read:

"Annex 13

EXPLANATORY NOTE ON GEARSHIFT PROCEDURE

This explanatory note is not a part of the standard, but explains matters specified or described in the standard or appendix, and matters related thereto.

1. Approach

1.1. The development of the gearshift procedure was based on an analysis of the gearshift points in the in-use data. In order to get generalised relations between technical specifications of the vehicles and gearshift speeds the engine speeds were normalised to the utilisable band between rated speed and idling speed.

1.2. In a second step the end speeds (vehicle speed as well as normalised engine speed) for upshifts and downshifts were determined and collected in a separate table. The averages of these speeds for each gear and vehicle were calculated and correlated with technical specifications of the vehicles.

1.3. The results of these analyses and calculations can be summarised as follows:

(a) The gearshift behaviour is engine speed related rather than vehicle speed related.

(b) The best correlation between gearshift speeds and technical data was found for normalised engine speeds and the power to mass ratio (rated power/(unladen mass + 75 kg)).

(c) The residual variations cannot be explained by other technical data or by different transmission ratios. They are most probably assigned to differences in traffic conditions and individual driver behaviour.

(d) The best approximation between gearshift speeds and power to mass ratio was found for exponential functions.

(e) The gearshift function for the first gear is significantly lower than for all other gears.

(f) The gearshift speeds for all other gears can be approximated by one common function.

(g) No differences were found between five-speed and six-speed gearboxes.

(h) The gearshift behaviour in Japan is significantly different from the equal-type gearshift behaviour in the European Union (EU) and in the United States of America (USA).

1.4. In order to find a balanced compromise between the three regions a new approximation function for normalised upshift speeds versus power to mass ratio was calculated as weighted average of the EU/USA curve (with 2/3 weighting) and the Japanese curve (with 1/3 weighting), resulting in the following equations for normalised engine upshift speeds:

Equation A13-1, normalised upshift speed in 1st gear (gear 1).

$$n\_max\_acc(1) = (0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle}$$

Equation A13-2, normalised upshift speed in gears > 1

$$n\_max\_acc(i) = (0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle}$$

1.5. In use driving behaviour data from India was added to the WMTC database at a later stage. This resulted in modifications of the part 1 cycles and the part 2, reduced speed cycle. Within this modification work also the gearshift behaviour was checked. Fortunately, it could be proven that the WMTC gearshift prescriptions are also suitable for the Indian gearshift behaviour.

2. Example

Figure A13-1 shows an example of gearshift use for a small vehicle.

(a) The lines in bold show the gear use for acceleration phases.

(b) The dotted lines show the downshift points for deceleration phases.

(c) The cruising phases the whole speed range between downshift speed and upshift speed may be used.

In case of gradually increase of vehicle speed during cruise phases, upshift speeds ($v_{1\rightarrow2}$, $v_{2\rightarrow3}$ and $v_{i\rightarrow i+1}$) in km/h may be calculated using the following equations:

Equation A13-3:

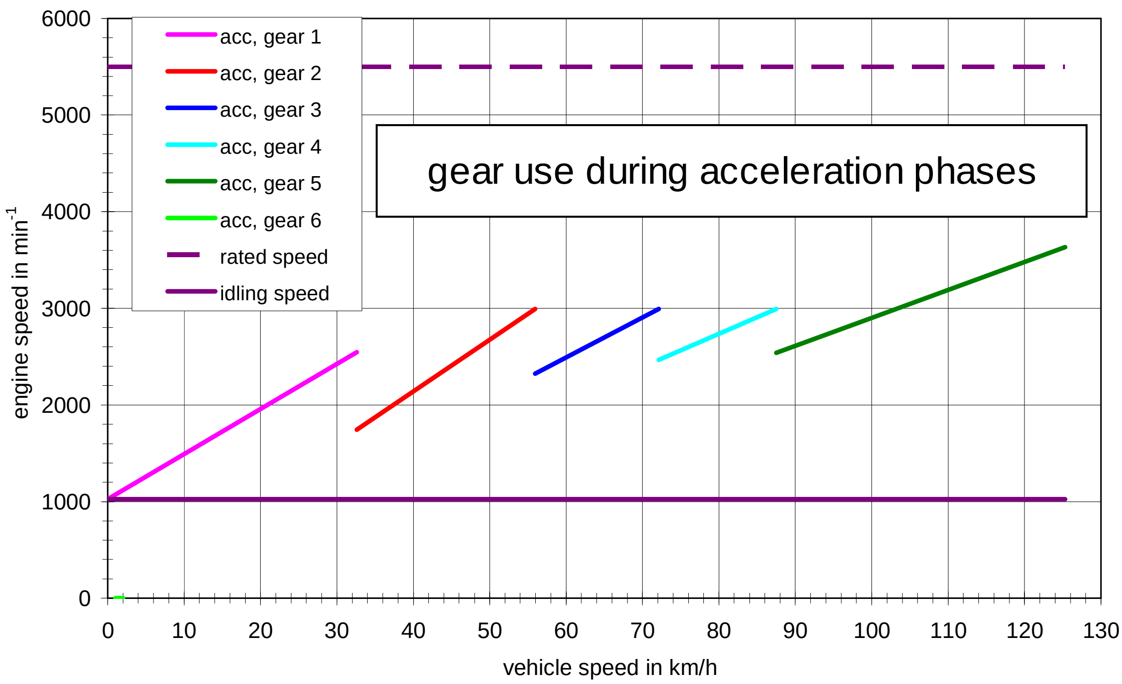
$$v_{1\rightarrow2} = \left[0.03 \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_2}$$

Equation A13-4:

$$v_{2\rightarrow3} = \left[\left(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1\right) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_1}$$

Equation A13-5:

$$v_{i\rightarrow i+1} = \left[\left(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}\right) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_{i-1}}, \; i = 3 \text{ to } ng$$



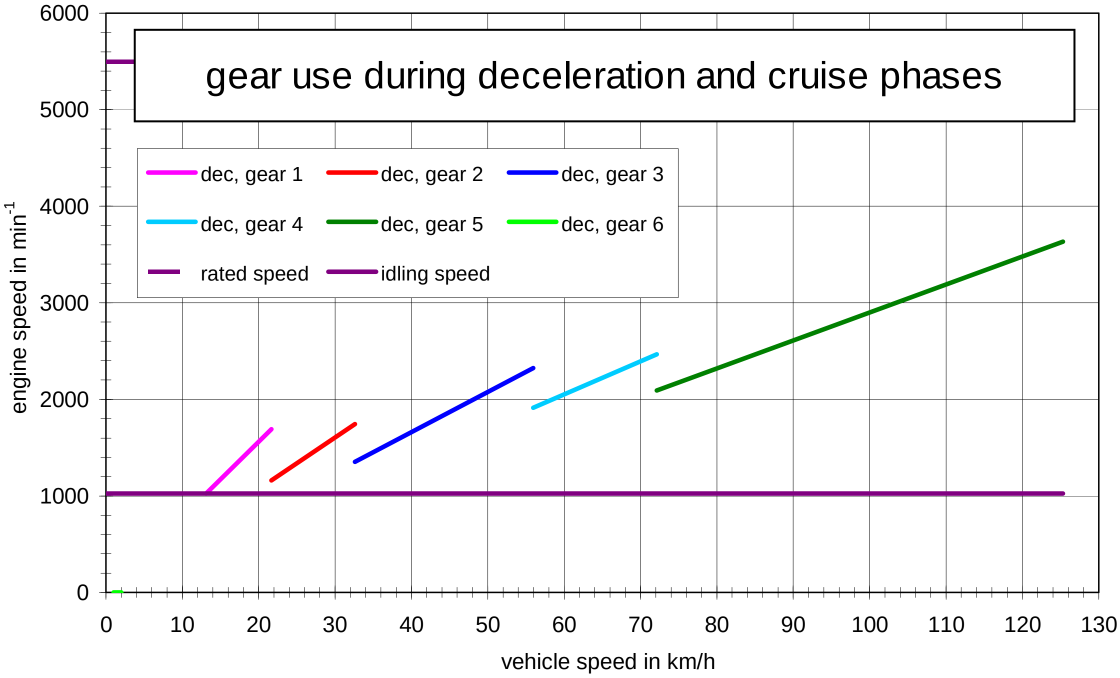


Figure A13-1: Example of a gearshift sketch

In order to allow to the test service more flexibility and to assure driveability the gearshift regression functions should be considered as lower limits. Higher engine speeds are permitted in any cycle phase.

3. Phase indicators

In order to avoid different interpretations in the application of the gearshift equations and thus to improve the comparability of the test, fixed phase indicators are assigned to the speed pattern of the cycles. The specification of the phase indicators is based on JARI's definition of the 4 driving modes as shown in the following table:

Table A13-1: Definition of driving modes

4 modes	Definition
Idle mode	vehicle speed < 5 km/h and -0.5 km/h/s (-0.139 m/s2) < acceleration < 0.5 km/h/s (0.139 m/s2)
Acceleration mode	acceleration ≥ 0.5 km/h/s (0.139 m/s2)
Deceleration mode	acceleration ≤ - 0.5 km/h/s (- 0.139 m/s2)
Cruise mode	vehicle speed ≥ 5 km/h and -0.5 km/h/s (-0.139 m/s2) < acceleration < 0.5 km/h/s (0.139 m/s2)

The indicators were then modified in order to avoid frequent changes during relatively homogeneous cycle parts and thus improve the driveability. Figure A13-2 shows an example from cycle part 1.

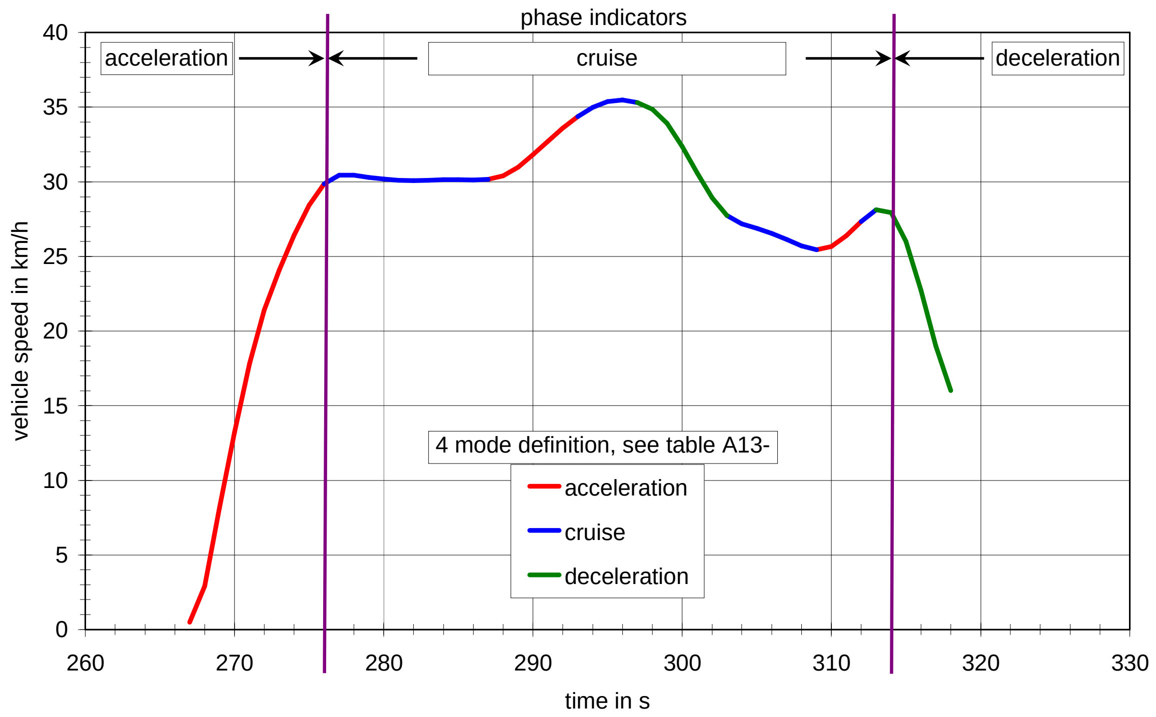


Figure A13-2: Example for modified phase indicators

4. Calculation example

4.1. An example of input data necessary for the calculation of shift speeds is shown in table A13-1. The upshift speeds for acceleration phases for the first gear and higher gears are calculated using equations 6-1 and 6-2. The denormalisation of engine speeds can be performed by using the equation n = n_norm x (s – n_{idle}) + n_{idle}.

4.2. The downshift speeds for deceleration phases can be calculated with equations 6-3 and 6-4. The ndv values in table A13-2 can be used as gear ratios. These values can also be used to calculate the affiliated vehicle speeds (vehicle shift speed in gear i = engine shift speed in gear i / ndv_i). The corresponding results are shown in tables A13-3 and A13-4.

4.3. In a further step the possibility of a simplification of the above-described gearshift algorithms was examined by additional analyses and calculations. It should especially be checked whether engine shift speeds could be replaced by vehicle shift speeds. The analysis showed that vehicle speeds could not be brought in line with the gearshift behaviour of the in-use data.

Table A13-2: Input data for the calculation of engine and vehicle shift speeds

Item	Input Data
Engine capacity in cm^3	600
P_n in kW	72
m_k in kg	199
s in min^{-1}	11,800
n_{idle} in min^{-1}	1,150
ndv_1 */	133.66
ndv_2	94.91
ndv_3	76.16
ndv_4	65.69
ndv_5	58.85
ndv_6	54.04
pmr **/ in kW/t	262.8

*/ ndv means the ratio between engine speed in min^{-1} and vehicle speed in km/h

**/ pmr means the power to mass ratio calculated by P_n / (m_k+75) × 1,000; P_n in kW, m_k in kg

Table A13-3: Shift speeds for acceleration phases for the first gear and for higher gears (according to table A13-2)

Engine Speed	Upshift speeds	
	n_acc_max (1)	n_acc_max (i)
n_norm */ in per cent	24.9	34.9
n in min^{-1}	3,804	4,869

*/ n_norm means the calculated value by equation A13-1 and equation A13-2.

Table A13-4: Engine and vehicle shift speeds according to table A13-2

Gearshift		Shift speeds		
		v in km/h	n_norm (i) in per cent	n in min^{-1}
Upshift	1→2	28.5	24.9	3,804
	2→3	51.3	34.9	4,869
	3→4	63.9	34.9	4,869
	4→5	74.1	34.9	4,869
	5→6	82.7	34.9	4,869
Downshift	2→cl */	15.5	3.0	1,470
	3→2	28.5	9.6	2,167
	4→3	51.3	20.8	3,370
	5→4	63.9	24.5	3,762
	6→5	74.1	26.8	4,005

*/ "cl" means "Clutch-Off" timing. "
