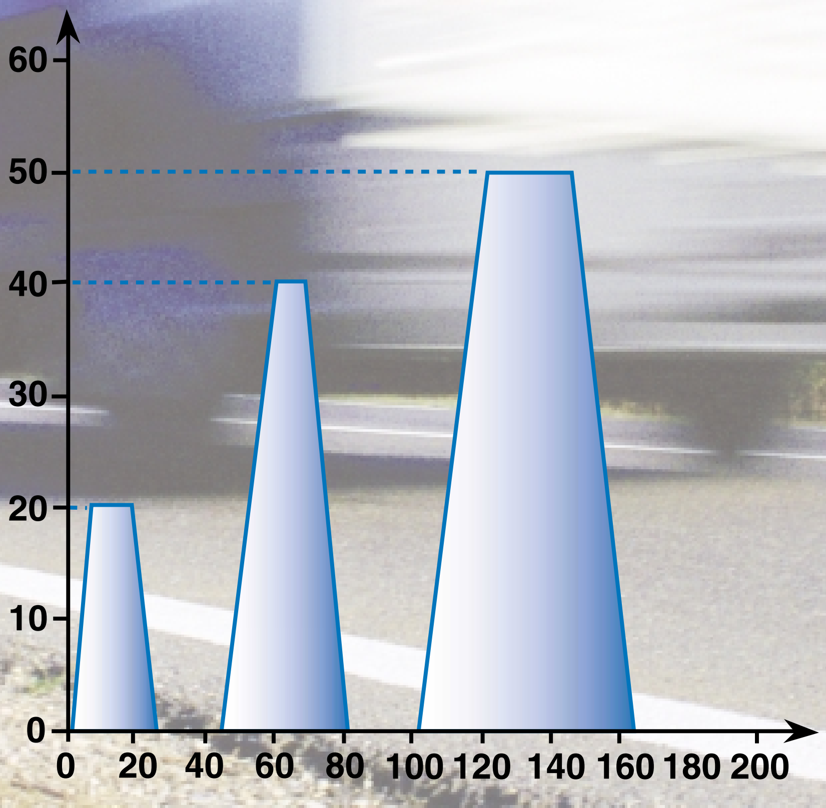
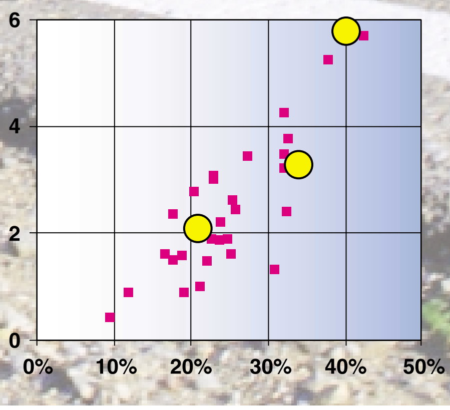
SORT - Standardised On-Road Tests Cycles





Founded in 1885, UITP is the world-wide association of urban and regional passenger transport operators, their authorities and suppliers. Located in Brussels and with over 2.000 members from nearly 80 countries, UITP seeks to promote a better understanding of the potential of Public Transport.

It provides information, research and analysis on all aspects of Public Transport including infrastructure, rolling stock, organisation and management. It also lobbies on behalf of its membership with international institutions such as the EU, UN and OECD.

Objectives

The UITP aims to study all aspects of public transport and mobility in order to promote the development of more efficient and attractive public transport services and gain the maximum benefit from the latest available technology.
It represents the interests of its members through its dealings with international authorities, such as the European institutions, UN, OECD, the World Bank, as well as giving its members opportunities to network with other international transport associations.
It also promotes Public Transport through close contact with decision-makers and the media to develop a favourable climate of opinion for Public Transport.

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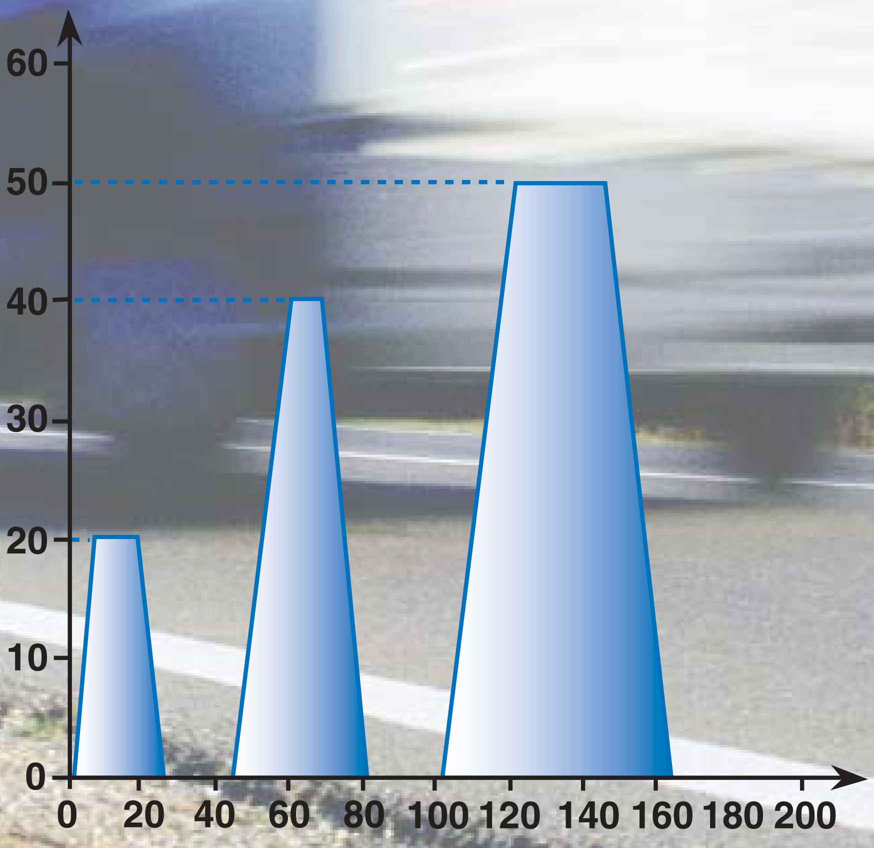
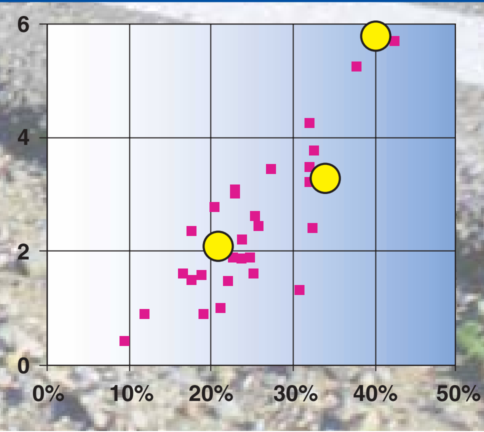




Content

Foreword

Back in 2000, when the idea of standardised testing for bus consumption was first mooted within the UITP Bus Committee, the level of interest in the concept was immediately apparent to us. In addition to the intrinsic benefit for the profession of having comparable data, the initiative also reflected the far-reaching changes taking place within UITP, as it switched from being an association of operators and embraced other profiles of expertise. Over and above the cosmetic operation of revising the statutes, it was important for each sector to find its own place and value in the new-look association.

SORT has demonstrated that fruitful work is possible between manufacturers and operators. Although things were difficult initially, the constant and positive involvement of industry representatives and operators, driven by a belief in the ultimate value of the task and the work in general, allowed the deliberations to start in a positive manner. The brochure you are now holding provides tangible evidence of the results, which have been produced on schedule. In our opinion, this alone makes it all worthwhile.

Back to the issue at hand: although standardised consumption figures for private cars are easily found in the specialised press, no such information is available for buses. Indeed, networks have hitherto tended to make purchases based on their experiences, or in accordance with the figures listed in offers they receive, or even sometimes on the basis of the results of locally specific testing. These complex results obtained under differing conditions were of little general use. A solution was required that would be capable of providing an objective tool, defined under accurate and explicit measuring conditions, for comparing fuel consumption. This tool is now available. Its success depends on public transport companies `coming on board´ and using the methodology prepared for your attention by the operator-constructor joint working group.

Of course, we know full well that fuel consumption is but one of the criteria that govern purchase choices. However, it was important to do as much as possible to add objectivity to the figures in question.

Let us hope that our initiative will follow its course and be used by a large number of companies wishing to make their purchases in full possession of the facts! To be successful, and we don´t doubt that it will be, SORT will naturally be expected to evolve in order to incorporate other bus types (midi, articulated, etc.).

Finally, our sincere thanks go to all those who have taken part in this working group. At the same time, we hope these efforts will contribute to quality improvements within our business in the service of our members and the public.

Hans RAT — Secretary General

Wolfgang MEYER — President

Chapter I

General Presentation of the Project

The SORT project arose as an initiative of the UITP Bus Committee, but rapidly began to extend far beyond the scope of the Committee working programme.

This project is a result of co-operation established between UITP, VDV, and the European manufacturers of vehicles and transmissions.

The main aim of the SORT project is to design reproducible test cycles for on-road tests of buses in order to measure their fuel consumption.

Vehicle tests versus engine tests

Today, engine tests are carried out at the test bench for type approval. However, nor the ESC cycle (European Steady Cycle), prescribing 13 fixed points of measuring nor the ETC cycle (European Transient Cycle), with more dynamic characteristics, take into account the whole vehicle. Furthermore these engines test cycles in no way adequately reflect the stop-and-go operation of a scheduled service bus.

For these reasons, classic normative tests are not sufficient to simulate the operation of a public transport vehicle. It therefore seemed indispensable to design on-road test cycles for the whole vehicle in the framework of the SORT project, based on statistically generated data from several European transport companies (commercial speed, average time spent at stops, average distance between them, the load, etc.).

With SORT, a reproducible comparison of the fuel consumption of different vehicles is theoretically made possible for the first time, but only within a specific framework. Of course, the results of measurement of the test cycles must not be strictly compared with every day fuel consumption, because real life consumption also depends on driving style, number of passengers aboard, topographic and climate conditions, etc.

The fact that many European transport companies use their own on-road test cycle is another reason in favour of standardisation.

Modular design of the SORT cycles

On-road test cycles were developed for the urban range. A cycle is composed of "modules" (base cycles), repeated as many times as necessary to attain sufficient precision. Each "module" is composed of three individual "sections" (trapezoids). Each of the "sections" is characterised by an acceleration process, travel at constant speed, and deceleration. At the end of each "section" a "stop time" is provided, in order to reflect traffic-dependent stops (without door operation). Each "module" is concluded with the provision of a "stop time" representing passenger boarding and alighting (therefore including door opening and closing). In this way, repetition by combining identical "modules" defines a standardised operating cycle.

Typical but ideal operating cycles (base cycles), in each case with fixed ***characteristic average commercial speeds***, corresponding to typical values observed under actual operating conditions, were defined for three types of operating patterns.

- "urban" = SORT Cycle 1
- "mixed" = SORT Cycle 2
- "suburban" = SORT Cycle 3.

The SORT project was completed by an accurate description of the measuring conditions relating to the vehicle and components, geographical topology and climatic conditions.

Validating measurements

SThe results obtained from the tests using cycles 1, 2 and 3 correspond to three specific situations, namely the test situations.

It is therefore logical that the measured fuel consumptions in real life operation differ from the projected consumptions.

The figures for the SORT fuel consumptions provided by the vehicle manufacturers allow comparisons to be made between different bus builders.

It is up to the operator to position himself vis-à-vis these three cycles by giving each of them a certain weight. And this can only be done by the user!

Generally, the following relationships can be established:

It is therefore noticeable that, acceleration aside, every factor that increases commercial speed has a positive influence on consumption. Acceleration, however, is less influential than the other factors as it is tightly restricted by passenger comfort.

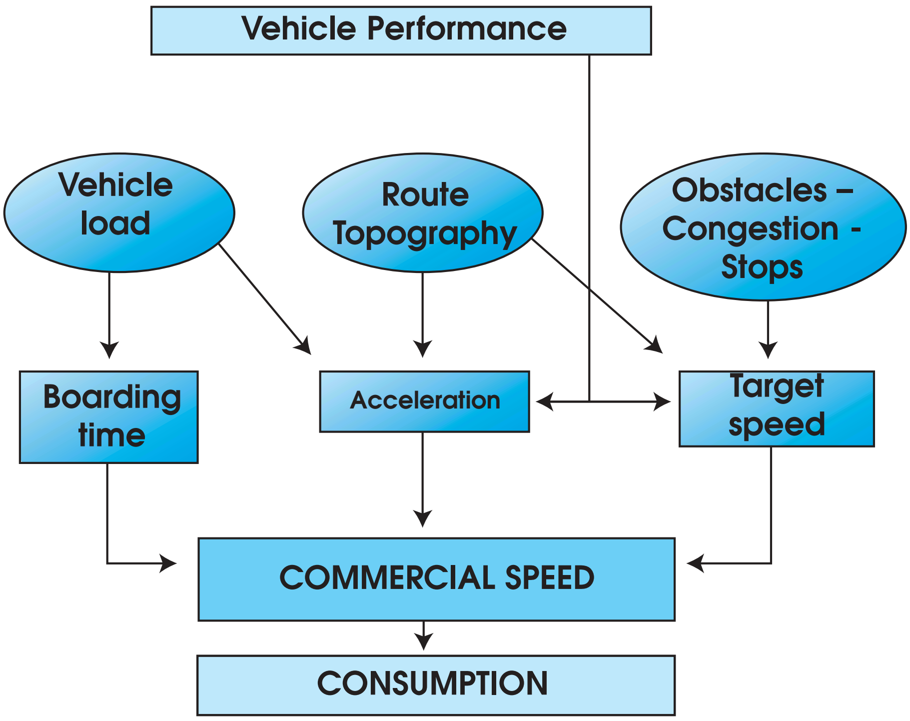
As an initial assumption, it is reasonable to accept that a route's commercial speed defines this in sufficient detail and may therefore be taken as a "typical parameter" of SORT test cycles.

A key parameter : commercial speed

n order to describe a route, it is necessary to take into account a number of typical parameters such as traffic density, numbers of stops (either for the boarding and alighting of passengers or simply required by the environment), route topography, vehicle loads, and commercial speed.

Although integrating so many variables is a difficult process, these parameters can all be seen to have a direct influence on commercial speed, which therefore becomes a kind of common denominator for the different variables.

Let us examine which elements, characteristical for each city, have an impact on consumption?



Commercial speed can be seen as the key parameter differentiating distinct operation patterns. Indeed, the graph above shows that any change of route severity impacts on commercial speed and thus on consumption (which is inversely proportional).

Consumption reduction following increased commercial speed is a paradox well-known to operators: commercial speed can only be influenced by structural measures such as dedicated bus lanes, and consequently a reduction of congestion-related stops, which has a favourable impact on consumption.

Chapter II : Commercial speed

Generally, the following relationships can be established:

Parameters		Commercial speed	Consumption
Acceleration	↗	↗	↗
Time lost at stops	↘	↗	↘
Load	↘	↗	↘
Number of stops	↘	↗	↘
Commercial speed	↗	↗	↘

It is therefore noticeable that, acceleration aside, every factor that increases commercial speed has a positive influence on consumption. Acceleration, however, is less influential than the other factors as it is tightly restricted by passenger comfort.

As an initial assumption, it is reasonable to accept that a route's commercial speed defines this in sufficient detail and may therefore be taken as a "typical parameter" of SORT test cycles.

Chapter III

Cycle design

Each company would like to have a cycle that reflects its operation pattern. This is clearly not feasible. As many cycles as bus routes would be needed. Moreover, in some cities, the same vehicles run on different routes, with their own features.

Out of this situation, the basic SORT philosophy was born: designing a given number of cycles in such a way that companies can assess their operation as a combination of several base cycles (modules).

Cycles as such are therefore not representative, but their **combinations** are!

Each company will thus have to assess the proposed cycles, and define its own weighting coefficients (which can be as numerous as the local situation requires).

With a degree of experience and using past statistics for help, each network will be able to define the characteristics of each route and thus forecast consumption by every type of existing vehicle on its routes.

To do this, some trials and control tests will be needed, which clearly lie with the operator's exclusive responsibility

The weighting coefficients chosen can be stated in the specifications at tender stage and serve to define the theoretical consumption based on individual cycle results announced by manufacturers.

Beyond this concept of ***relative representativity***, it is also important that cycles be easily ***repeatable*** (for sufficient confidence), ***simple*** (for easy and low-cost procedures), ***accurate***, (to avoid any disruption in interpreting results), and carried out on " ***standardised*** " vehicles, (the impact of optional equipment, such as air conditioning, on consumption can be assessed separately).

Due to the need for simple and reproducible tests, we propose relatively long cycles; But they consist of identical modules so that the test driver can adopt a stabilised driving pattern. Under such conditions, more realistic results will be produced, which are closer to the "real-life" driving conditions of professional drivers.

Repeating a certain number of measurements on identical modules also has the advantage of allowing a double-check of result quality and even making it possible to discard from the sample those results which are too distant from the agreed data (excessive acceleration, too short stops, non-compliance with target speed, etc). We could also even discard a complete test if the value of the variance exceeds a preset threshold.

A complete cycle is made up of repetition of the base cycle

A proposed cycle is thus made up of the repetition of the identical base cycle featured by an average speed and a length, and driven with a simulated load (see later).

The need for result confidence could require increasing the number of repetitions in a complete cycle until the overall results lie within a given standard deviation.

A base cycle is made up of several trapezes, punctuated by stops

The trapezes are intended to reflect the driving conditions of a public transport vehicle: frequent stops (either with opening of doors for boarding/alighting, or due to traffic conditions (traffic lights, congestion)). Total idle time within a trapeze will be defined, as well as total duration of the base cycle module, in order to reach a pre-established mean speed, which will be dealt with later.

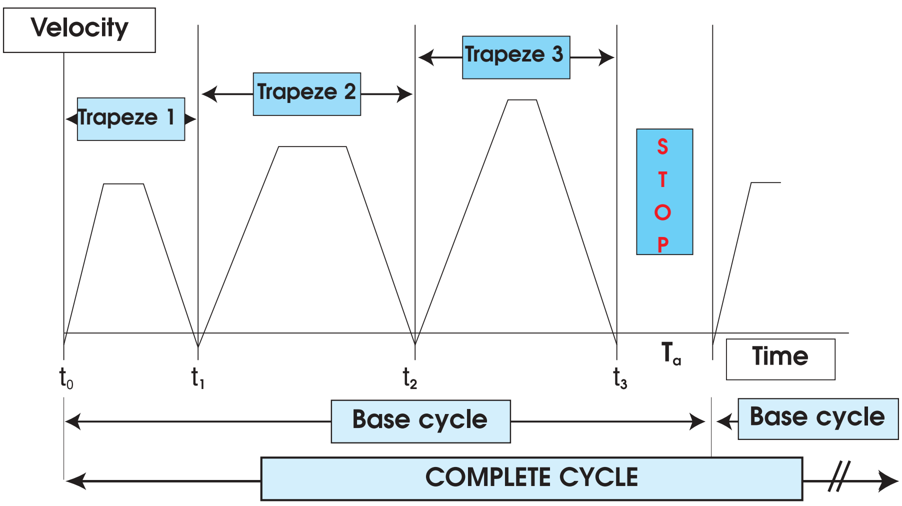
These stops mark the trapezes, each of which defined is by an acceleration, a constant speed stretch (section target speed), and a braking phase.

Proposed cycles (on the basis of commercial speed)

Urbanisation and traffic levels in each city, the specific operating environment of each transport company make it necessary to have a real diversification and it would be over-simplistic to keep only one "urban" cycle. Moreover, most companies also operate suburban routes, with part of the route outside urban high traffic density areas.

Consequently, bearing the essential need for simple cycles, AND the desired widespread use of the results by operators, we propose three typical base cycles, each of them featured by the mean "commercial speed" indicated in the annual reports of every public transport company.

The structure of the cycles can be sketched as follows:



The following need to be determined:

- The number of trapezes
- The number of base cycles
- The acceleration values
- The target speeds
- The braking values
- The idle time at stops

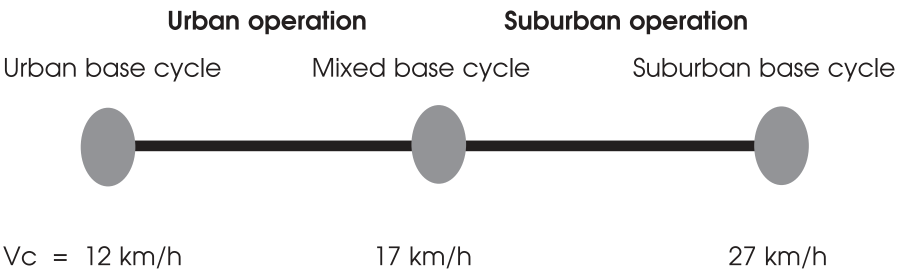
in order to set the average commercial speeds assumed at the beginning. This will be further explained in the next chapter

Number of different base cycles necessary

Absolute accuracy would call for an infinite number of cycles.

The very principle of relative representativity, described earlier, makes it possible to limit the number of cycles.

After long discussion, 3 base cycles appear to offer a reasonable solution:



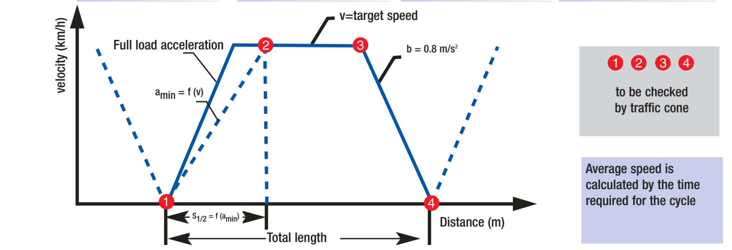
In this context, any vehicle could be defined according to 2 of the above test cycles, depending on its primary use on urban / suburban routes.

Chapter IV

Practical cycle construction

Design of the 5 SORT-Trapezes

V. const. (km/h)	Total lenght (m) Distance cone (1-4)	Position Cone 2 (m) [a Sort= v*v/2s]	Position Cone 3 (m) [Braking distance]	Distance of const. Speed (m) Cone 2 to 3
20	100	15 [1.03 m/s²]	80,7 [19.3]	65.7
30	200	45 [0.77 m/s²]	156,6 [43.4]	111.6
40	220	100 [0.62 m/s²]	142,8 [77.2]	42.8
50	600	170 [0.57 m/s²]	479,4 [120.6]	309.4
60	650	300 [0.46 m/s²]	476,4 [173.6]	176.4



It is an absolute must for any test cycles that they have to be easily repeatable. Therefore, the basic cycle design was defined as a combination of 3 trapezes or sections, with each of them: acceleration, constant (target) speed, and deceleration.

Even if a given (fixed) acceleration would ideally be desirable, this is technically not feasible at present. Hence, it was decided to perform the test with full-throttle acceleration and to reach the target speed within a certain distance. This maximum distance for acceleration is based on the evaluation of the acceleration capability of today´s driveline configurations used in city buses, given by all participating OEMs (Original Equipment Manufacturers).

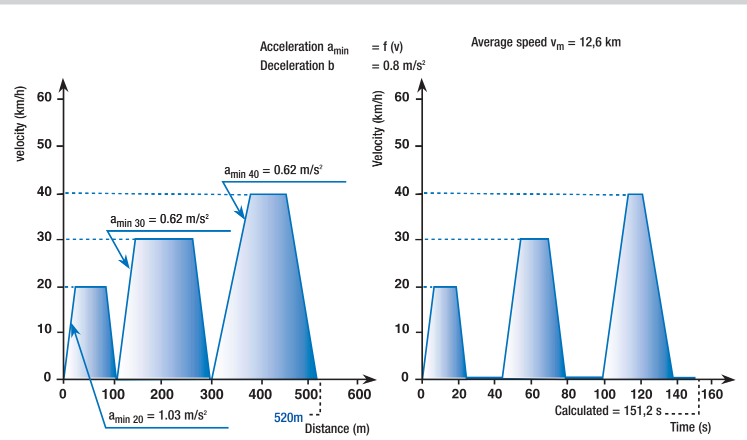
Comparison of the 3 SORT-Cycles (14,3 t)

	SORT 1	SORT 2	SORT 3
Rated average speed	12.6	18.6	26.3
Stops/km	5.8	3.3	2.1
Stop time (%)	39.7	33.4	20.1
Trapeze 1 v-const. (km/h) /length (m)	20 / 100	20 / 100	30 / 200
Acceleration (m/s²)	1.03	1.03	0.77
Trapeze 2 v-const. (km/h) /length (m)	30 / 200	40 / 220	50 / 600
Acceleration (m/s²)	0.77	0.62	0.57
Trapeze 3 v-const. (km/h) /length	40 / 220	50 / 600	60 / 650
Acceleration (m/s²)	0.62	0.57	0.46
Length of stops (s)	20 / 20 / 20	20 / 20 / 20	20 / 10 / 10
Total length (m)	520	920	1 450
Deceleration (m/s²)	0.8	0.8	0.8
Fuel consumption (l/100 km)	ca. 50	ca. 42	ca. 39

Based on 5 basic trapezes, 3 different base cycles have been defined to represent urban traffic (SORT 1), mixed traffic (SORT 2), and suburban traffic (SORT 3). Each cycle includes a certain time of standstill. The time of standstill was adapted to the average speed of each cycle (e.g. distance vs. time incl. stops). The percentage of standstill corresponds largely with practical experience.

Another criterion for each cycle was to feature realistic fuel consumption values. These calculated values are considered realistic and match the experience of operators and OEMs.

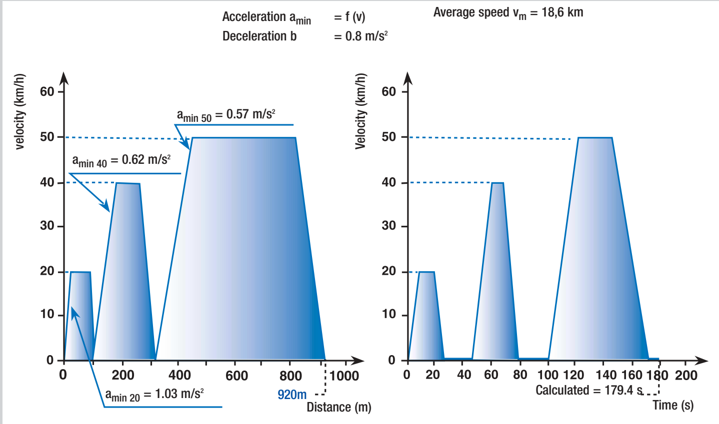
SORT 1: Urban



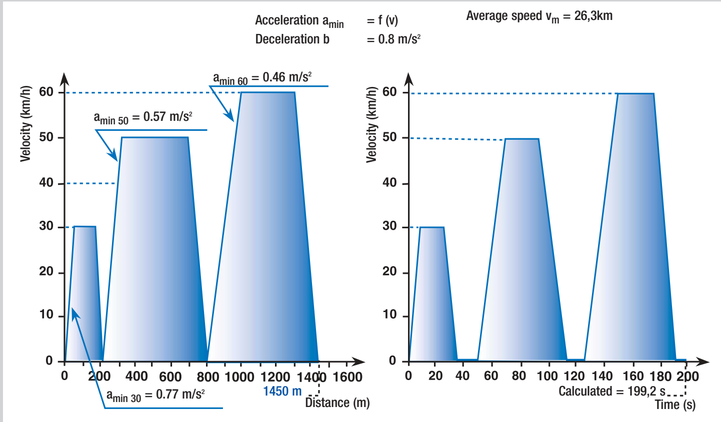
As an example, SORT 1 (Urban traffic) is explained in detail. This cycle is made up of 3 trapezes with the target constant speed of 20 km/h, 30 km/h, and 40 km/h. After each trapezoid a stop time of 20 sec. is provided, so that the cycles features a total idlle time of 60 sec. The average speed (commercial speed) of this cycle is about 12 km/h.

As with SORT 1, SORT 2 and 3 cycles are a combination of 3 basic trapezes. The only difference for the SORT 3 cycle (suburban) is a reduced stop time for each stop: 40 sec. instead of 60 sec for SORT 1 and SORT 2. This is justified by a statistically lower load.

SORT 2: Mixed



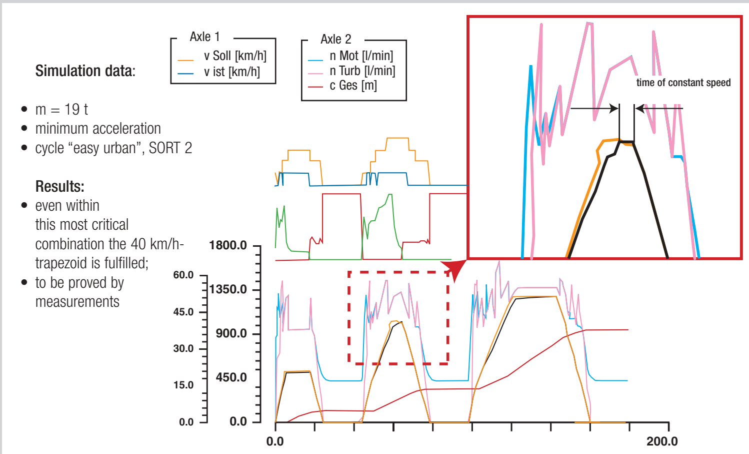
SORT 3: Suburban



Computer simulations helped the team to design the cycles. The main focus of these simulations was to ensure that even in the worst case (e.g. minimum acceleration), a trapeze could be achieved without getting a "triangle". The "40 km/h-trapeze" was regarded to be the most critical. To be on the safe side, the simulations were done even for a heavier weight as the standard SORT conditions, e.g. up to 19 instead of 14.3 tons. The simulations showed that the constant speed of 40 km/h could be achieved even under this "worst-case" scenario.

Comparing the expected fuel consumption for the 3 SORT cycles with values provided from different operators shows that the SORT cycles seem to cover the various duty cycles very well.

Result of Computersimulation: Variation of acceleration and load



Influence of the load on the SORT Cycles

	SORT 1	SORT 2	SORT 3
Weight (t)	14.3	14.3	14.3
Average speed (km/h) gradiant acceleration	12.4	18.5	26.2
Average speed (km/h) full load acceleration	13.0	19.6	28.5
Fuel consumption (l/100 km) full load acceleration	ca. 50	ca. 42	ca. 39
Influence of weight on the Fuel consumption in Liter/100 km per ton	ca. 1.9	ca. 1.7	ca. 1.5

For each SORT-cycle the load was defined at 3,2 tons as the reference load of the SORT test vehicle, a representative load of low-floor city bus. As in practice the bus weight average load will be different from this „average weight" (according to peak/off peak patronage), fuel consumption will stray from the SORT consumption figures.. This is shown by the expected fuel consumption for the 3 SORT cycles varying the weight from 14.3 tons. Depending on the cycle, the fuel consumption will increase by 1.5 up to 1.9 litres per 100 kilometres and per ton of additional weight.

Fuel consumption depends also on the duty cycle (e.g. the average speed), and topography. The SORT values of fuel consumption are based on a plain topography not considering gradients or descents.

Unlike the influence of weight, it is not possible to estimate the effect of topography on the SORT fuel consumption only via the different commercial speeds - see table p.8)

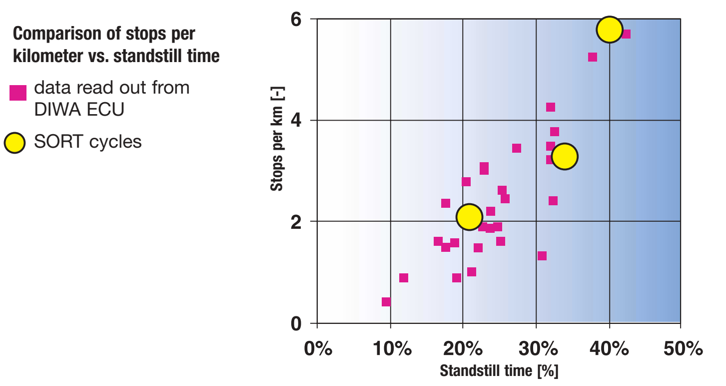
As the SORT cycles are purely synthetic cycles based on a combination of different trapezes, it was very important to double-check the proposals against reality. One possibility to achieve this was to compare typical data of these cycles with statistical data from practical experience. To this purpose, operation data read out from the ECU of the Voith DIWA transmission were used. This data represents the traffic situation of many operators world-wide and is based on more than 10 million kilometres.

Evaluating the operation data, the idlle time can be up 40 .. 45% of time esp. for inner-city traffic. Even for suburban traffic, the time share of idlling is up to 20%. This time share includes only the stops while the bus is on the route, and not the time in the depot or at terminus.

The number of stops includes not only the boarding-alighting stops but also traffic-related halts (traffic lights, congestion). It ranges from roughly 2 stops per kilometre for suburban traffic situation up to 6 for urban traffic.

Comparing the SORT cycles with this data shows a good match with reality. SORT 1 (urban) with a standstill time of 40% and roughly 6 stops per kilometre fits very well to typical inner-city traffic situation (e.g. central Paris or London). SORT 2 (mixed urban) with 35% standstill time and roughly 3 stops per kilometre is closer to the situation at certain routes in Madrid or Munich.

Comparison of SORT-cycles with operation data



Sheet 3
Test protocol

For tests to be repeatable, it is necessary to define with accuracy the vehicle actually tested, especially because a certain level of margin is left to manufacturers.

The test must consequently be documented with accuracy in a test protocol describing the most relevant elements, so that in case of later confirmation tests, the tested bus is clearly defined and cannot give rise to dispute or misinterpretation.

Date of test	
Time of test begin	
Time of test end	
Place of test	

A. Test external conditions (for information)

1. Street conditions

N°	Item	*Value*	*Unit*
1.1	State of track surface		
1.2	Max. longitudinal gradient		%
1.3	Track altitude		m
1.4	Min. radius		m
1.5	Track length		m

2. Weather conditions

N°	Item	*Value*		*Unit*
1.1		*Test begin*	*Test end*	
2.1	Wind speed			m/s
2.2	Temperature			° C
2.3	Humidity			%
2.4	Atmospheric pressure			bar

B. Vehicle set-up

1. Vehicle characteristics

1.1 Type and dimensions

N°	Item	Value	Unit
1.1.1	Vehicle type		
1.1.2	Length		m
1.1.3	Width		m
1.1.4	Height		m
1.1.5	Empty weight		kg
1.1.6	Mileage		km

1.2 Engine

N°	*Item*	*Value*	*Unit*	*at (rpm)*
1.2.1	Manufacturer and type			
1.2.2	Engine capacity		cc	Non relevant
1.2.3	Max. power		kW	
1.2.4	Max torque		Nm	
1.2.5	Driving mode of engine ventilator			

SoRT

N°	*Item*	*Value*
1.3.1	Manufacturer and type	
1.3.2	Programme used	

N°.	*Item*	*Value*	*Unit*
1.4.1	Manufacturer and type		
1.4.2	Dimensions		
1.4.3	Front axle nominal pressure		bar
1.4.4	Rear axle nominal pressure		bar
1.4.5	Pattern depth of new tyres		mm
1.4.6	Actual pattern depth measured		mm

N°	*Item*	*Value*
1.5.1	Manufacturer and type	
1.5.2	Reduction ratio	

N°	*Item*	*Value*
1.6.1	Type	
1.6.2	SAE Grade	
1.6.3	Other features	

N°	*Item*	*Value*
1.7.1	Type	
1.7.2	SAE Grade	
1.7.3	Other features	

N°	*Item*	*Value*	*Unit*
1.8.1	Type		
1.8.2	Number		Pieces
1.8.3	Nominal unit voltage		V
1.8.4	Unit weight		kg

N°	*Item*	*Value*
1.9.1	Number of doors	
1.9.2	ABS/ASR	
1.9.3	Retarder	
1.9.4	Heating for passengers	
1.9.5	Other	

N°	*Item*	*Weight to deduct from lump load*
1.10.1	Air-conditioning	kg
1.10.2	Ramp for wheelchair users	kg
1.10.3	Ticketing equipment (excl? pay desk)	kg
1.10.4	Automatic vehicle monitoring system (AVM)	kg
1.10.5	Information equipment	kg
1.10.6	Video camera equipment	kg
1.10.7	Security driver cabin	kg
1.10.8	Double glazing	kg
1.10.9	Exhaust filters	kg
1.10.10	Lubrimatic equipment	kg
(1)	**Total weight to be deducted from lump load**	**kg**

N°	*Item*	*Actual weight (A)*	*Reference weight (B)*	*Difference (A - B)*	
1.11.1	External destination displays		100 kg		kg
1.11.2	Seats (number : 30)		30 x 10 kg		kg
1.11.3	Fuel tank capacity (litres x 0.840)		200 x 0,840		kg
1.11.3	On-board persons (number Y) excl. driver		Real weight measured		kg
1.11.4	Fuel measuring equipment		None		kg
(2)	**Total weight to be deducted from lump load**				**Kg**

N°	*Item*	*Value*
1.12.1	Lump (half)load	3.200 kg
1.12.2	Optional equipment (1)	kg
1.12.3	Other factors (2)	kg
Load	= 3.200 – (1) – (2)	kg

N°	*Item*	
2.1	EC standard	
2.2	Sulphur rate	ppm
2.3	Fuel temperature at test begin	°C
2.4	Fuel temperature at test end	°C

Sheet 4

Test results

N°	Item	Value	Unit
1.1	Cycle 1 urban		Liter/100 km
1.2	Cycle 2 mixed		Liter/100 km
1.3	Cycle 3 suburban		Liter/100 km

N°	Item	Length	Average time elapsed	Average speed
2.1	Cycle 1	m	sec	km/h
2.2	Cycle 2	m	sec	km/h
2.3	Cycle 3	m	sec	km/h

N°	Item	Time elapsed (sec)		
		Urban bus	Mixed bus	Suburban bus
3.1	from 0 to 50 metres			
3.2	from 0 to 100 metres			
3.3	from 0 to 200 metres			
3.4	from 0 to 300 metres			
3.5	from 0 to 400 metres			
3.6	from 0 to 500 metres			
3.7	from 0 to 30 km/h			
3.8	from 0 to 50 km/h			
3.9	from 30 to 50 km/h			

SoRT

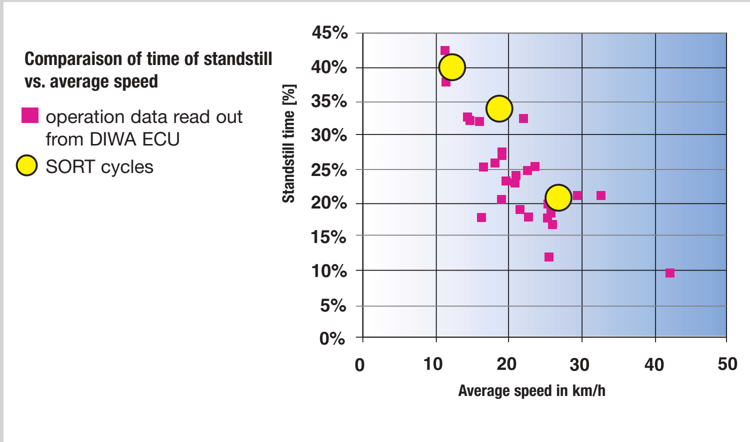
And last, SORT 3 (suburban) is representative for the traffic in smaller cities (e.g. Klagenfurt/Austria or the suburban areas of Paris).

Another important parameter to assess the traffic situation is the average (commercial) speed. Again this average speed is based only on the time the bus is on the route; it does not consider e.g. the time while the bus is waiting at the terminus.

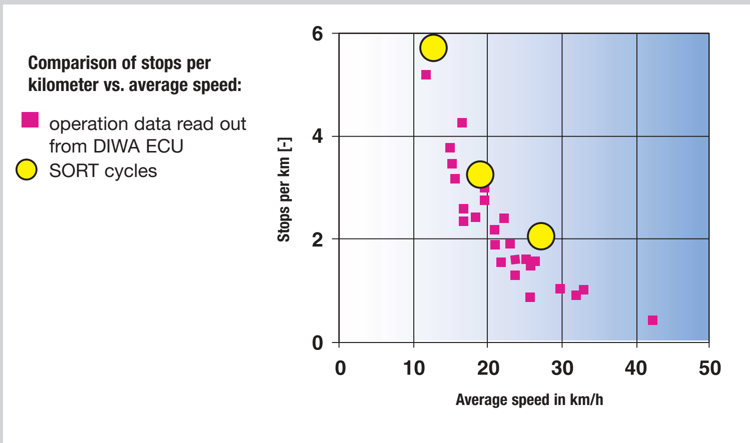
Typical values for the average speed in inner-city traffic in big cities is 10-14 km/h; for smaller cities it is around 16-20 km/h; Suburban traffic reaches an average speed of 25-30 km/h.

Comparing either the standstill time or the number of stops vs. the average speed, each of the three SORT cycles shows a very good match with practical experience.

Comparison of SORT-cycles with operation data



Comparison of SORT-cycles with operation data

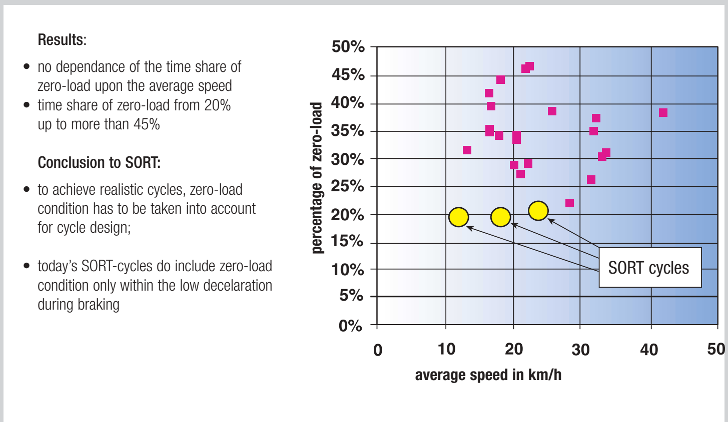


A major disadvantage of the SORT cycles is how to consider the time spent in coasting, e.g. the driver using the kinetic energy of the bus by driving with zero-load of the accelerator pedal. This mode is of very big influence to the consumption as during coasting, fuel consumption is nearly nil.

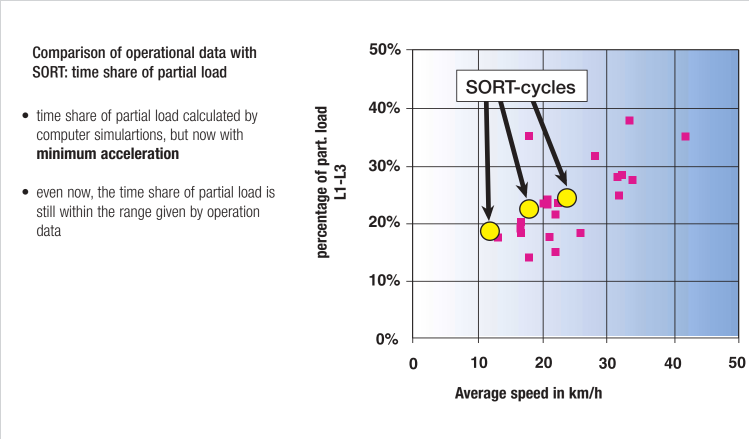
As the coasting mode is difficult to reproduce on a test track, the SORT cycles take this mode into account through lower deceleration (0.8 m/s^2). The deceleration time is compared with the time spent at zero load (i.e. coasting) out of the operation data.

In practice, the time spent coasting varies between 20 and 45%, and there is no correlation between the time spent driving in this very economical way and the average speed. Comparing this with the 3 SORT cycles shows that these synthetic cycles are at the bottom limit but still within the range of practise-based data.

Comparison of SORT-cycles with operation data: Zero load



Comparison of SORT-cycles with operation data: Partial Load L1 - L3



While during the acceleration section the driver operates at full-load condition (e.g. accelerator pedal at full power = 100%), the sections of constant speed are operated at partial load (e.g. accelerator pedal at L1 - L3). Therefore, the time share of constant speed of each SORT cycle is to be compared to the time share of partial load given by the operation data. The graph above shows that the SORT cycles reflect operation reality quite fairly.

Therefore, the SORT cycles as defined above fit very well to the practical experience and cover the range of traffic situation from inner-city up to suburban traffic in different cities world-wide. This allows each operator to reflect his own duty cycles by an individual combination of the 3 SORT cycles.

Chapter V

Measurement conditions

Influence of driving technique

All networks are aware of the extreme variations in consumption measured on vehicles that are similar, but driven over identical stretches by different drivers.

This fact cannot be ascribed solely to the vehicle itself, but must be taken into account when determining the procedure.

For that reason, the vehicle should be driven by the constructor's designated driver. In all likelihood, this driver will have undergone special training in the art of "economical driving". Provided that the minimum performances required by the network are maintained, this state of affairs matters little. The results measured can simply be regarded as targets to be achieved by good drivers!

The calibre of a driver is not the whole story.

In reality, it is noticeable that the results of measurements of this type follow a roughly parabolic curve, which reaches a minimum point after a period of acclimatisation, then increases with fatigue.

For this reason, the measured data that will be taken into account should display certain characteristics, including a maximum permitted standard difference, which will be defined later on.

Influence of the road surface

The quality of the road surface and its geometric and topographical characteristics, have a significant influence on test results.

The choice of route will therefore be left to the driver, although he will have to respect minimum conditions.

Conditions for actual measurements

The accurateness of the consumption data measured with the SORT cycles and methodology depends heavily on a sufficient standardisation of the measurement conditions. External conditions are an essential part of this requirement.

External conditions are related to street and weather environment.

The vehicle set-up, its equipment and the main fluids incl. fuel characteristics will have to be precisely documented.

Since it is nearly impossible to find " optimal " environment conditions having no influence on the test results, it is advisable to carry out tests in both directions in order to offset, as much as possible, the influence of any of these parameters. These tests in two directions must be done immediately after one another.

The mostly used reference will be DIN 70030 standard, which defines acceptable parameters for test tracks as well as standard weather conditions. Within the limits given below, the choice of the track, and the test period (with specific weather conditions associated) is entirely left to manufacturers. None can reproach the manufacturers for choosing the most favourable conditions within the limits described below.

Manufacturers perform and are responsible for their own tests. However, confirmation tests may be needed at a later stage. In such cases, they will be carried out by the manufacturer and the operator together, under the

conditions described in sheets 1 and 2.

For tests to be repeatable, it is necessary to define with accuracy the vehicle actually tested, especially because a certain level of margin is left to manufacturers.

The test details must be recorded with accurately in a test protocol describing the most relevant elements, so that in case of later confirmation tests, the tested bus is clearly defined and cannot give rise to dispute or misinterpretation.

The cycles presently prepared are related to a " standard 12 meter " vehicle", but could be adapted at a later stage to other types of vehicles available on the market.

The following test protocol is made up of 4 different "sheets"

1. External test conditions
2. Vehicle set-up
3. Test protocol
4. Test results

The two latter sheets are found in the central pages of this brochure and can be easily removed.

Sheet 1

External test conditions

1) Street conditions

1.1. Track surface

The track chosen will be in good condition and dry.

1.2. Longitudinal gradient

The track will be horizontal with a max. gradient of 1.5 %.

1.3. Track altitude

The altitude of the track is closely interlinked with the atmospheric pressure. See item 2.5 below.

1.4. Curve radius

The test is normally performed on a straight track. Curves use energy, which will have a negative impact on consumption. However, large radii such as on ring-shaped track will probably hardly have impact on consumption. Again, the choice of the test track remains under the responsibility of the manufacturers.

1.5. Track length

The track must be at least long enough to perform one full cycle.

2. Weather conditions

2.1. Wind speed:

Wind speed will be below 3 m/s. Short wind gusts up to 8 m/s are acceptable.

2.2. Wind direction

Wind direction is not relevant since tests can be carried out in both directions.

2.3. External temperature

External temperature will range between 0 and 30° C. The actual test temperature will be mentioned in the test protocol. Later possible confirmation test will be performed within a +/- 5°C margin compared to this reference temperature.

2.4. Humidity level

Humidity level will be under 95 %.

2.5. Atmospheric pressure

The acceptable pressure is as described in DIN 70030-1:

Ambient temperature and pressure are measured. These data allows to calculate air density according to a given formula. The result must be within a ± 7.5% margin of the reference pressure of 1 bar.

Sheet 2

Vehicle set-up

1) Vehicle

1.1. Type

Standard, 2-axled, operational vehicle, identical as series vehicle (batch).

1.2. Dimensions

- Length : between 11 and 12 meters ;
- Width: between 2.50 and 2.55 meters.

1.3. Load

For test purpose, the vehicle will be half-loaded, i.e. with 3.200 kg + driver. The weight of test operators and equipment will be deducted from this lump load. The weight of optional fixed equipment is deducted as well (see 1.4 below).

1.4. Equipment to deduct from lump load

Principle : The vehicle is tested without (non-standard or) EC non-compulsory equipment - However, if the vehicle tested is equipped with such devices, their weight can be deducted from load. (see 1.3) :

- **Air conditioning** : additional equipment non related to heating or ventilation (e.g. compressors, motors etc.) functions which are considered standard. This is valid for air-conditioning in driver's cabin as well as in passengers' compartment, and also for possible additional roof heating. If the air-conditioning system remains installed, the compressor driving belt can be removed to avoid any influence ;
- **Ramps for wheelchair users** : if it represents a significant weight difference compared to the vehicle without it ;
- **Various inside equipment** : automatic vehicle monitoring system (AVMS), validators, sale equipment, passenger information systems, surveillance camera ;

However, external route number and direction display are considered as part of the standard equipment. To avoid any result misinterpretation, those displays are considered as an on-board lump load of 100 kg. Any difference compared to this lump load will be adjusted (+ or -) from the 3200 kg load;

- **Double-glazing**;
- **Driver's security screens**;
- **Particulate filters** and other exhaust gas after-treatment systems, as long as not mandatory to comply with legal emission requirements;
- **Lubrimatic device;**
- **Engine encapsulating bonnet**, as long as not mandatory to comply with legal noise requirements.

1.5. Heating and ventilation

This equipment is switched off.

1.6. Lightning

Interior lightning is switched off. Dipped headlights on.

1.7. Tyres

- Standard type, " series " availability for the tested vehicle;
- Non remoulded tyres;

- Pattern > 80 % of original depth;
- Maker's recommended pressure;

1.8. Gearbox

- automatic ;
- keyboard position " drive " ;
- kick down switched off;
- retarder or any alternative energy recuperation device switched on, if available on vehicle; The retarder will be activated through brake pedal ;
- Gearbox programme available in series (and clearly mentioned in test protocol) ; this programme must be compatible with minimum performance (requirement outside SORT itself).

1.9. Driveline

- On the basis of customer needs (particularly the weighting coefficient of the 3 SORT cycles and the performance requirements provided by the operator), the manufacturer determines the most appropriate driveline (engine-gearbox-rear axle). The consumption figures provided by the manufacturers for all SORT cycles are measured with this very same driveline, as clearly identified in the test protocol;
- Any energy recuperation device must be switched on;
- The driveline must be run-in (min 20.000 km and max 60.000 km / one year after vehicle registration) before any confirmation test.

1.10. Air tanks

- Full cut-off pressure at start;
- During test, air tank pressure should never come below the minimum level.

1.11. Doors

- The number of doors is to be indicated in test protocol.
- When it is appropriate during the cycle, one door (2 halves) will be completely opened; Generally, it will be the middle door, linked to the halt break/boarding brake/safe boarding brake; The door can be immediately closed afterwards ;
- The kneeling system will not be operated during door operation.

1.12. Floor height

- standard height for urban type vehicle: low-floor as defined in EC Directive 2001/85.

1.13. Seating

- An average lump weight was chosen as an average seat number (30) x average unit weight (10 kg) ;
- difference between actual and theoretical seat weight will be adjusted (+/-) from load.

1.14. Miscellaneous

- ABS/ASR : in service ;
- Lubricant oil : quality according to manufacturer recommendation ; maximum level ;
- Miscellaneous fluids (cooling water, screen-wipers, etc…): fully tanked;
- Batteries: standard and, operational.

2) Fuels

Diesel

2.1. Type

- Standard quality, EC norm in force (EC 98/70) ;
- If local fuel quality requirements are more stringent (e.g. sulphur level), this shall be indicated in the test protocol.

2.2. Quantity

- The fuel tank is to be full at the start of the test ;
- Weight difference between full tank capacity and 200 l. is deducted from the 3200 kg load;

2.3. Gasoil temperature

- Ideally, gasoil temperature shall be maintained at 20°C;
- If not possible, and in case of volumetric measure method, density correction shall be applied; To this purpose, use will be made of existing density/temperature tables or else the formula given in DIN 70030-1 §5.4.2;
- Fuel temperature shall be measured at test begin and test end of each cycle measure;
- In case of gravimetric method, the exact density of the fuel at 20°C has to be measured and documented;
- Sufficient care will be given to maintaining gasoil temperature at such a level that no bubbles will appear which would distort the results measured.

Chapter VI

Measuring method

Measuring instruments

In order to achieve comparable and reproducible measuring results, the instruments must fulfil the minimum requirements listed below:

The meas. instrument calibration and maintenance must comply with the requirements as under DIN EN ISO 9000.

Meas. Instrument	Accuracy
Fuel-flow meter	± 2%
Gravimetric fuel meter	± 2%
Speed	± 0,5%
Distance measuring device (for positioning of traffic cones)	± 0,2%

Measuring process

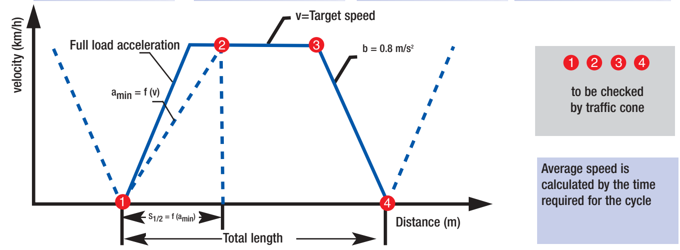
Test performance is contingent on both the external conditions and vehicle configuration complying with the specifications as under Sheet 1 and 2 of the test protocol.

The following procedure is recommended for the measuring process:

- Measure out route points (1, 2, 3, 4) for the individual SORT cycles and mark them using traffic cones
- The SORT 1 cycle, which is only 520 m, must be run through at least twice in succession (= 1040 m)
- The SORT 2 (920 m) and SORT 3 (1450 m) cycles need to be run through, at least once
- Should the cycle be run through more than once, without pause between two runs, the results of the overall distance shall be taken into account.
- The consumption measurements for each respective cycle are to be repeated until 3 successive measurements lie within an accuracy requirement of 2%. To calculate the accuracy, the difference between the maximum and minimum consumption value of the three measurements is divided by the maximum value ($(C_{max}-C_{min})/C_{max} \times 100$).
- The tolerance for the trapezoidal target speed is ± 1 km/h. During the transition from acceleration to steady-state driving, a maximum deviation of +3 km/h is permitted for a brief period.
- No more than 10 minutes should elapse between each measurement

Design of the 5 SORT-Trapezes

V. const. (km/h)	Total lenght (m) Distance cone (1-4)	Position Cone 2 (m) [a Sort= v*v/2s]	Position Cone 3 (m) [Braking distance]	Distance of const. Speed (m) Cone 2 to 3
20	100	15 [1.03 m/s²]	80,7 [19.3]	65.7
30	200	45 [0.77 m/s²]	156,6 [43.4]	111.6
40	220	100 [0.62 m/s²]	142,8 [77.2]	42.8
50	600	170 [0.57 m/s²]	479,4 [120.6]	309.4
60	650	300 [0.46 m/s²]	476,4 [173.6]	176.4



Measured variables

Speed

Vehicle speed is recorded during the measuring run. Here, the recording serves to monitor adherence to the trapezoidal speed. The correctness of the measurement must be checked during the breaks between two measurements. In the event of any deviations the measurement is to be repeated.

Time

The time required for the SORT cycles (including each stop period) is documented. The time and the resulting average speed are entered into the report.

Fuel consumption

The fuel consumption of the individual measuring runs is documented.

For volumetric measurement of the fuel consumption, the measured values have to be corrected for a temperature of 20 °C (see DIN 70030 Section 1 § 5.4.2)

Fuel temperature

The fuel temperature is measured (for volumetric measurement) at the start and end of each cycle in the area of the measuring chamber. The mean value is used for converting the fuel consumption to standard conditions.

Fuel density

The density of the fuel used is measured at a temperature of 20 °C and entered into the report.

Permissible fuel consumption deviation

The maximum deviation between the SORT consumption values, as stated by the manufacturer, and the result of the repeat measurement, may not exceed 5%.

This deviation margin of 5% is absolutely necessary to take into account:

- Accuracy of measurement,
- Tolerance of complete driveline (transmission efficiency, engine performance, tyre influence...),
- External Test conditions (external temperature, air pressure, humidity, wind speed, state of track surface...).

Performance measurement

Vehicle performance measurements must be conducted in such a way that data can be properly compared.

- The vehicle must be tested with the same configuration as for the consumption measurements.
- Measurements are conducted in drive position "D" without the "halt brake", without kick down.
- The time measurement starts when the accelerator pedal is pressed.

Measured variables:

- Distance
- Time
- Speed

In addition to this, the minimum acceleration must be checked to ensure that it complies with the cycle definition.

The results of the acceleration measurements are to be documented in the report.

The results of the acceleration measurements are to be documented in the report.

Chapter VII

Perspectives

The SORT working group has endeavoured to carry out normative work. Beyond its technical relevance, this project further demonstrated that co-operation between operators and manufacturers is possible.

However, the day-to-day implementation of the SORT recommendations might need minor adaptation.

Yet, the SORT group carried out its work hoping that as many operators as possible would accept and use the SORT results and methodology.

These specifications relate to standard city buses. The SORT tests can be easily adapted to other types of vehicles (midi, articulated etc.). This will be the next step.

When it comes to alternatives to diesel technology, they will be addressed at a later stage when these represent a mature and sheer industrial alternative.

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UITP would like to extend its warmest thanks to all those who made this work possible

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