

COMBI Smc
OPERATING INSTRUCTIONS
V 1.5

TRUVELO

Combi S mc Operators Manual

CONTENTS

	Contents	1
1	Introduction	2
2	General Description	3
3	Setting up the Combi	4
	3.1 Photographic Options / Software Options	4
	3.2 Software Selection	4
	3.3 Installing Combi in Camera Housing	5
	3.4 Memory Card Introduction	6
	3.5 Setting up Combi & Memory Card Procedure	6
	Data Block Set-Up	7
	3.6 Setting up Combi if not using memory card	10
	3.7 Memory Card & Film Change on “live” Combi	10
4	Combi Traffic Statistics	12
5	Troubleshooting	13
6	Secondary Checks	14
	6.1 Single Front Photo	14
	6.2 Single Rear Photo	14
	6.3 Two Rear Photos (Option 2)	15
	6.4 Two Rear Photos (Option 3)	15
7	Statistics Defined	17
8	Film Cassettes	18
	Look-up table: Single front/rear photo (Option 1)	
	Look-up table: First photo 1.8m, second at 20m (Option 2, front or rear)	
	Look-up table: Two rear ½ sec interval photos – metre lines (Option 3)	
	Look-up table: Two rear ½ sec interval photos – 5ft lines (Option 3)	

Additional User Guides Available

Mobile Operation Manual (for Semi Permanent & Mobile Sites)

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1.0 INTRODUCTION

The Combi Smc is type approved for both front or rear photography. There are three software options available and the chosen option is enabled by the camera operator when turning on the camera system.

The Combi Smc is also type approved for use at Automatic Unattended (permanent), Automatic Supervised (semi-permanent) and Attended Actively Operated (mobile sites). Permanently installed sub-surface sensors are used at permanent and semi-permanent sites, and surface mounted piezo cables are used at mobile or temporary sites.

The Combi Smc uses a memory card to record data. The data on the memory card is downloaded into a PC via the Truvelo Dual Card Reader and TMC software. A data-file can be generated for export into the Eric or Eros back-office admin system.

Truvelo (UK) pioneered the use of front photography in the UK and following type approval testing was granted approval for front photography in 1977. The present Combi Smc with memory card was approved in 1999.

We trust that you will find your Truvelo system to be accurate, reliable and user-friendly. Please address any queries or problems to:

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2.0 GENERAL DESCRIPTION



“Combi Smc” shown without bulk film cassette.

- 2.1 The Truvelo Combi is designed for ease of set-up, to be highly portable and requires just two cable connections to provide power and signals from the piezo sensors. It may be used on a tripod for mobile use, or in a permanent camera housing, for automatic, unattended use.
- 2.2 The operating principle of the TRUVELO Combi Smc is based on a time measurement for covering a fixed distance between piezo electric sensors. Being a double instrument, there are two pairs of sensors and therefore two time measurements made. The front axle of a vehicle crossing the sensors will cause a voltage impulse to be transmitted from the "Start Cable" to the instrument that will start the time measurement sequence. Once the "Stop Cable" is crossed a second impulse will cause the time measurement to be completed, which will then be converted to speed using the formula $\text{Speed} = \text{Distance} \div \text{Time}$.

The two pairs of sensors produce two independently generated speed-readings and the results are compared to ensure that they are within 2 mph. If not within 2 mph the instrument rejects that speed measurement and the instrument indicates a zero speed reading.

3.0 SETTING UP THE COMBI

CAUTION !

- a) Please be careful to choose the correct software setting for the site configuration.
- b). Ensure the correct set of sensors is plugged into the Combi at multi-direction sites.
- c). Ensure that magenta filter is always fitted when operating front photography.
- d). Follow instructions carefully regarding use of memory card.
- e) Check speed threshold setting is correct before closing camera housing.
- f) When using the Startraq back-office system the instructions about setting up the memory card do not apply (unless the memory card is also to be used for statistics reasons).

3.1 Photographic Options / Software Options

There are both front and rear photography options available which are selected by choosing the appropriate software option during set-up. See section 6 Secondary Checks, (6.2,6.3 and 6.4) for further information about rear photography options and secondary checks from type approval perspective.

Photo Mode	Software Mode
Single photo at 1.8 metres after last sensor.(Front)	Option 1
Single photo at 1.8 metres after last sensor.(Rear)	Option 1
Two photos, the first at 1.8m, the second 20m later, (Rear)	Option 2
Two photos, the first at 1.8m & the second ½ sec later.(Rear)	Option 3

Option 1 is designed for front photography and has the benefit of showing the front axle, number plate, last piezo sensor and secondary speed mark, all in the foreground of the photograph. This option is also available for a single rear photo **providing** there are 3 secondary check lines at 1.8m mark.

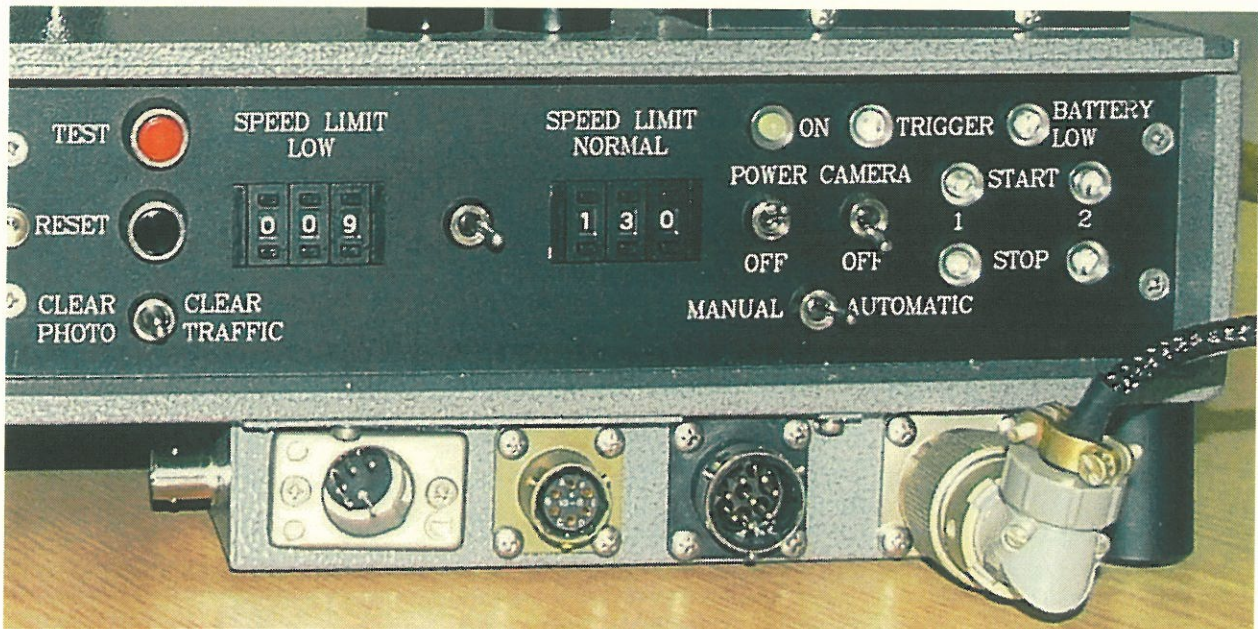
Option 2 is also designed for front photography but can also be used when photographing from behind. Two photos at 1.8m and 20m.

Option 3 is intended only for rear photography. Photos at 1.8m and ½ sec later.

The choice of software option will be determined by the site configuration and the presence of appropriate permanent secondary check marks on the road. See comments in Section 6 regarding secondary checks, particularly 6.2, 6.3 and 6.4 relating to rear photography.

3.2 Software selection

The desired software option is selected by using the hundreds decade on the Low and Normal numerals on the speed setting selectors. The others are used for hours and minutes.



	LOW	NORMAL	
Option 1	0 x x	0 x x	single front or rear photo
Option 2	1 x x	0 x x	front or rear photos at 1.8m & 20m
Option 3	0 x x	1 x x	rear photo at 1.8m and ½ sec

(x = hours & mins)

Example 1 for a single photo and a time of 09:30 hrs the speed settings will be

LOW	NORMAL
0 0 9	0 3 0 (single front/rear photo)

Example 2 For Option 3 the speed settings would be (as per photo above).

0 0 9	1 3 0 (2 rear photos ½ sec apart)
-------	-----------------------------------

Note: in example 2 above, the 1 in the Normal numerals needs to be removed when the threshold speed is set. This must only be done after the instrument has completed it's self calibration.

3.3 Installing Combi in Camera Housing

The Power Module at the top of the camera housing should be left permanently turned on.. It has a 220V indicator light, a 12V indicator light and a "Flash Ready" light. The 220V light indicates that 220 volts is reaching the Power Module from the electrical feeder pillar. If not lit it generally means there is a problem with the mains supply to the site.

At a battery powered site install and connect the batteries before connecting the power cable to the Combi.

Note: all connectors can only be installed one way. It is advisable to look into the end of the connector and at the socket in order to determine the correct alignment.

The Combi sits on the shelf within the camera housing and should be pushed fully forward on the shelf. Check that the rubber bellows on the camera lens is extended and covers the camera window. Then check that the Power and Camera switches on the instrument and the Camera/Camera + Flash switch on the camera electronics are all in the OFF position. Connect the Power Module cable to the instrument. **Do not plug in sensors yet.**

Please read section 3.4 and 3.5 right through first before starting set up.

3.4 Memory Card – Introduction

Please follow these detailed procedures carefully to avoid inadvertently creating spurious data on the memory card. If the back-office software is ERIC or EROS then problems may well arise exporting data into these programs.

The Combi software assigns a frame number to every frame used, i.e both “test” photos and speed violations. The frame number is displayed on the data panel at the time of camera activation and simultaneously recorded onto the memory card (if inserted).

Due to constraints arising from the interface with the Serco back-office software the memory card should only be used to record speed violations and not “wind-ons” or “official” test photos. Therefore the frame counter should be cleared immediately after the test photos and before the memory card is installed ready to record speed violations.

NB:- Para 3.5, 1 to 10 refers to installing a Combi into an empty housing. A slightly different procedure applies when changing film and memory card on a live Combi. See 3.6 on page 9.

StarTraq customers should read 3.5 below and then carry out steps listed in 3.6. References to memory card do not apply for StarTraq.

3.5 Setting up Combi & Memory Card Procedure (installing into empty housing)

**DO NOT INSERT MEMORY CARD YET. WAIT UNTIL 5 BELOW.
SENSOR CABLE SHOULD NOT BE PLUGGED IN AT THIS POINT
ALL TOGGLE SWITCHES IN OFF POSITION**

1). Set time / software mode on instrument: Using “Low” and “Normal” numerals set the hundreds decades for the desired software mode (0 & 0 for single front or single rear photo or 0 & 1 for two ½ sec interval rear photos).

Set time with hours on the Low and minutes on Normal. See example in 3.2. Now turn POWER switch ON.

NOTE: When choosing 0 & 1 for two rear photos do not cancel the 1 from the hundreds decade of Normal until the instrument has completed it’s self-calibration routine.

2). Set switch to “**Camera & Flash**” at top of camera electronics tower. An automatic segment test takes place. DO NOT turn on “CAMERA” yet.

3). Data Block Set-up

Press A on keypad to enter set-up mode.

This will automatically set FUJI film as the default setting. This setting to be used for Fuji and all other film types except Kodak.

ONLY if using Kodak film press A again to select Kodak

Note that all lines on the display MUST have 6 digits of information.

Film number / Site Code: enter 2 digits for film number and enter 4 digits for site on same line. Use zeros as necessary to enter 6 digits of information.

Date: Use day day, month month, year year format eg 07 02 03.(6 digits)

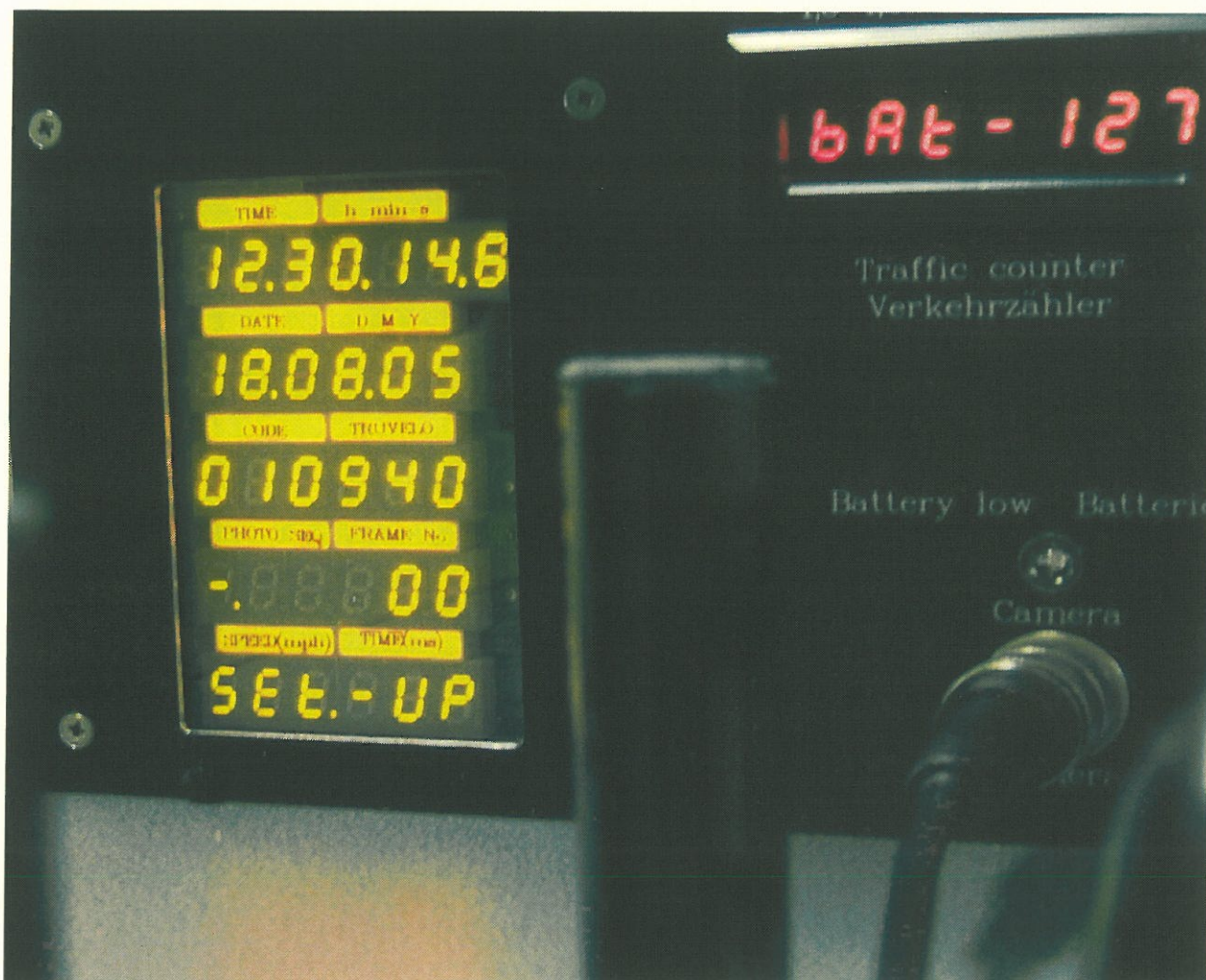
Time: enter 9am as 09:00:00 with seconds. (6 digits)

Use C as a backspace key to make corrections. Check data panel for accuracy.

If the data panel is not set up correctly, or not set up at all, the bottom two lines will show “not set up” and the Combi won’t function. When correctly set the display will show “set up”.

If mistakes are only noticed after the data panel set-up is complete either press A to start again or switch off camera electronics and start again. Mistakes discovered prior to complete set up of all the data can be corrected using the C key to backspace. Always observe that data panel shows “set up”.

Pressing D turns the data panel display on and off. After set-up it will turn off automatically after 60 secs. To check data display, or to view display /frame counter press D.



Example of Data Block

Time 12:30:14 (last digit on right of top line is 8/10th sec and sets itself.)

Date: 18.08.05 **Film No.** 01 **Site Code:** 0940

Film type setting: the duration of the data block illumination is controlled by the software. This facility is designed to prevent any over exposure of the data block that may arise with colour film, due to the use of automatic colour film processing machines. They automatically alter the film processing to compensate for different light conditions arising during the day, in order to produce uniform results. Unless the data block illumination time was varied also, the film processing may degrade the clarity of the data block and the labels for the different data fields. FUJI is the default setting for Fuji and other film types except Kodak. Kodak should be selected for Kodak film.

4). Film wind-ons: First turn ON "CAMERA". Film cassette must be fitted. Press TEST 6 times, pausing 2 seconds in between each activation. This is purely to remove exposed portion of film on the cassette. NOW TURN OFF CAMERA. (NB. Rapid test activations may reduce life of flash bulb.

Press “Reset counter” above keypad to cancel the frame count.

5). NOW INSERT MEMORY CARD: Card must be clean with no data on it. This must be checked. Insert card and observe Traffic Counter Display on side of tower. The **log** should show zero to show no photos have been taken. The capacity of the card will be shown and possibly an internal ID code if used, as well as date and time card was last used.

When changing film and removing card, check that data has been written to the card. **Log** should show number of camera activations. **d & t** will show time and date of last activation.

The Traffic Counter Display will show the following in rotation:-

bat-	136	Internal battery level
d	ddmmyy	Date card last cleared.
t	hhmmss	Time card last cleared.
log	000	Log should show zero for clean cards.
---	32	Card memory size
c	xxxxxx	Film number and site number entered during set-up.

NB: the memory card will not be recognised unless the data panel set-up has been completed correctly.

6). Switching on the CAMERA

First check the camera focal distance, 15m or 19 m for one or two lane sites respectively. Three lane sites 23-24m. Adjust as necessary. Set aperture at F5.6. Ensure camera is correctly aligned in mounting bracket before locking in position with lever.

Turn “CAMERA” on. Activate test button 6 times to create “test” photos at start of film. Pressing the TEST button causes a self-calibration check of the instrument. The display will show:-

Instrument 1 = 188.8mph Instrument 2 = 188.8mph
MPC Calibrated (Version x.x) 09:30:30

The calibration figure of 188.8 appears on the instrument display twice and 188 will appear twice on the data panel thus providing a record at the start of the film (or work period) that the calibration was checked. The word “test” also appears on the data panel above the 188, 188. If the calibration was not within +/- 0.1mph then the instrument would lock out and it’s display would show “ERROR- test out of range- ERROR”.

7). Plug in SENSOR SIGNAL CABLE, & set SPEED LIMIT threshold (use “Normal”). Ensure correct set of sensors is connected to Combi. Ensure “Manual/Automatic” switch is always in Automatic position.. Close camera housing door. System is now set-up.

8) On returning to site activate TEST button 6 times. This will create “Test” photos on the film and memory card and prove that the instrument calibrated correctly. The display will show:-

Instrument 1 = 188.8mph Instrument 2 = 188.8mph
MPC Calibrated (Versionx.x) 09:30:30

The data panel will also show 188, 188 and “test” as in (6) above.

Press D and view display on side of tower to check data is present on card. This will also tell you how many frames have been used since the camera was installed. The count includes violations and test photos. Remove memory card.

9). When installing a new film and new memory card on a “live” Combi refer to section 3.7.

ALWAYS ensure Manual/Automatic toggle switch is set for Automatic

3.6 Setting up Combi (if NOT using memory card)

Please read section 3.5 and then carry out the following steps which ignore all references to memory card.

Install Combi onto shelf. Connect Power and Sensor cables.

Select software mode and set time.

Turn on Power.

Turn on Camera Electronics.

Press A on keypad to enter set-up mode. Wait for segment test to finish.

Only if using Kodak film, press A again. Display will indicate Kodak.

Enter 2 digits of film number and 4 digits of site code. (use 6 digits to fill line up)

Enter time as hr hr, min min, sec sec. 1/10 sec runs on it's own.

Enter date as DD, MM, YY (again 6 digits required).

Enter threshold speed in “Normal bank of numerals.

Turn “Camera” on. Wind on film. Create test photos. Reset frame counter if desired so that on return to site pressing D will reveal number of violations (not frames used).

Close housing door.

3.7 Memory Card & Film Cassette Change on “Live” Camera

Unplug sensor cable. Make 6 test photos.

Remove film cassette and memory card.

Press A on keypad.

Input new data

Fit new film cassette.

Make 6 “wind-ons”
Make 6 test photos.
Clear Traffic /Clear Photo data.
Reset frame counter.
Install clean memory card.
Plug in sensors.
Close housing door.

NB: On a multi-direction site it is likely that the Combi will be left installed but for a different direction of enforcement. In this scenario Truvelo recommends that the Combi is turned off and the complete set-up procedure started afresh. This should ensure that the correct set of sensors is plugged in and that the correct site number, film number, software option and clean memory card are all used.

4.0 COMBI TRAFFIC STATISTICS

4.1 The instrument display alternates between several formats to show various traffic statistics.

Format 1:

SPEED 1 = XX X / SPEED 2 = XXX mph 09:30:30
Vol = XXX Vio = XXX x =XXX σ=XX 09:30:30

Format 2:

SPEED 1 = XXX / SPEED 2 = XXX mph 09:30:30
HIGH =XXX LOW = XX 85% = XX 09:30:30

Format 3:

SPEED 1 = XXX / SPEED 2 = XXX mph 09:30:30
Peak flow = XXXX Avg flow = XXXX 09:30:30

4.2 When a speed violation occurs the instrument will display

SPEED 1 = XXX / SPEED 2 = XXX mph at 09:30:30
-- VIOLATION -- Current time is 09:30:30

NOTES

a) In all cases the speeds of instruments 1 and 2 as well as the real time will always be displayed.

b) Peak/Avg flow will remain at zero until the instrument has been on for 15 mins.

c) When a speed violation occurs it overrides the above formats.

4.3 When enough data has been collected (100 -200 vehicles) the speed distribution bar graph can be viewed by pressing TEST.

4.4 To zero the Frame Counter press the reset button on the front of the camera electronics tower. To cancel any statistical data flick the Clear Photo/Clear Traffic switch to the left and right. See section 3 regarding memory card set-up.

These operations would normally be carried out at the start of a work session. The photo count might also be cancelled after each 36 exposure film was used.

See Section 7 Statistics Defined for definitions of various statistical data.

5.0 TROUBLESHOOTING

- 5.1 If the camera system appears not to be working the following observations and tests will help to identify the source of the problem. The problem could be due to a faulty Combi, faulty equipment in the camera housing, sensor problems or a mains electricity failure. If help or advice are sought from our Service Dept it is preferable to call from site if possible.

Is the 220 volt indicator light on the Power Module lit ?

“No” indicates a problem with the mains supply to the site.

Is the Battery Low light on Combi illuminated.

“Yes” also indicates mains power to site has failed.

Has the trip switch at left hand end of Power Module tripped ?

“Yes” indicates a problem with the Power Module.(not the mains supply).

Is the Flash Ready light illuminated ?

“No” indicates a problem with the Power Module or mains supply.

Does pressing the Flash Test button activate the flash ?

“No” indicates a problem with th Power Module or flash bulb.

Does the Combi measure speeds when the sensors are plugged in ?

Do the two red and green lights pulse on and off as vehicles cross sensors?.

Is one of the lights permanently on, or flickering on/off when no vehicles are present.

Will plugging in one of the other sensor cables at a multi-way site give speed readings.

Does the film advance when Test button on the Combi is pressed? (with cassette fitted).

Does the Combi display read MPC Calibrated after pressing Test button.

Is there a continuous high pitched whine coming from the Combi?

“Yes” indicates film has run out or jammed.

The green and red Start and Stop lights illuminate briefly as a vehicle crosses the piezo sensors or cables. If any do not illuminate this normally indicates a sensor failure. If one of the lights is permanently lit or flickers on and off in the absence of a vehicle it indicates a sensor problem, or a problem with an impedance cable or impedance convertor.

After the instrument registers four incorrect readings a warning message will appear on the screen and will remain until the fault has been rectified and the message cancelled by pressing the TEST button. The message might state “Check Stop Cable 2”. This does not necessarily mean a sensor problem. This situation might arise if slow moving traffic meant that sensor 4 did not produce a signal or if a vehicle turned off the road and did not cross all the sensors in the array.

6.0 SECONDARY CHECK

6.1 Single Front Photo (Software Option 1)

The Truvelo secondary check consists of a line at 1.8 metres beyond the last sensor, with supplementary lines 18 centimetres before and after. These outer lines represent the Home Office requirement for an accuracy of +/- 10%. The distance therefore between the mid points of lines 1 and 3 is 360 mm. Each line is 50mm wide and will span the full width of the lane.

The vehicle's speed is measured twice by two pairs of sensors to a resolution of 0.1 mph. The two speeds must be within 2mph of each other otherwise the instrument will give a zero reading. The lower of the two speeds is used and is rounded down to whole miles per hour.

Knowing the speed of the vehicle the system calculates the **time** needed for the vehicle to travel a further 1.8 metres, and delays taking the photograph until the vehicle front wheels should have reached the 1.8 metre line. Providing the tyre footprint falls within the outer two lines the secondary check is proven visually.

The tyre footprint will not always fall directly on the 1.8m line. It may be between lines 1 and 2. When making a mathematical calculation use the actual distance travelled, e.g 1.71m* if the tyre is midway between the two lines . (* i.e 1.80 metres less 9cm).

All photographs are taken with the front wheels within the white lines, irrespective of the speed of the vehicle. The system will also record the time in milliseconds between the last sensor being activated and the camera shutter activating to capture the photo. This time is shown on the data panel alongside the speed. Consequently it is possible to use the look-up table to check the speed that should be displayed with each millisecond time interval.

A mathematical check can also be made using the formula

Distance (1.8 metres) ÷ Time (secs) = Speed (as per the example below)

1.8 metres ÷ 0.060 secs x 2.237 conversion factor = 67.11 miles per hour.

0.060 secs is 60 milliseconds. Multiplying by 2.237 converts from metres per sec. to miles per hour.

Please note that all three software options, whether for a single photo, or two photos use the above secondary check in the first photo.

6.2 Single Rear Photo (Software Option 1)

On September 30th, 2005 the Home Office amended the type approval to permit the use of a single rear photo. This means that customers have a choice of using Truvelo rear photography with one or two photographs without any changes to the hardware or software in the Combi.

For a single rear photo simply operate the Combi using software option 1 (as you would do for front photography.)

Please note that 3 secondary check lines are required at the 1.8m mark in order to meet type approval requirements for a single rear photo.

6.3 Two Front or Rear Photos (Software Option 2)

This mode provides two front or rear photographs, the first at 1.8 metres and the second 20 metres later. The first photograph is taken as above with the axle on the single white line at the 1.8 m position. Whilst a millisecond time is imprinted on the photograph the type approval does not permit the use of a single 1.8m line secondary check.

The second photograph is delayed until the vehicle should have travelled 20m beyond the position of the first photograph. As the vehicle may be braking or accelerating as the first photograph was taken, or the driver reacts to the first flash, the second photograph may not always be exactly on the 20m white line. Therefore, lines would also be positioned at 19, 19.5, 20.5 and 21 metres in order to more accurately determine the distance travelled. See notes at end of "Option 2" tables regarding max. speed of 99mph for 20m secondary check. Higher speeds are possible with extra lines to provide distance information.

The secondary check is obtained by using the distance travelled and the time interval between the two photographs that is shown on the data block in photo 2 in place of the speed.

For example: -

$$20\text{m} \div 1.075 \text{ secs} \times 2.237 \text{ conversion factor} = 41.61 \text{ mph.}$$

6.4 Two Rear Photos (Software Option 3): LIKEGATSO

This mode provides two rear photographs, the first at 1.8 metres and the second ½ second later. Whilst a millisecond time is imprinted on the first photograph the type approval does not permit the use of a single 1.8m line secondary check.

The second photograph is taken ½ sec after the first one. Because the time is fixed and the speed is variable the distance travelled will depend on the speed of the vehicle. It is therefore necessary to have marks on the road starting at the 1.8m position in order to determine the distance travelled. Truvelo recommends that the check lines be at metre intervals, although some customers have chosen 5ft interval lines so as not to differ from other rear photography cameras.

The check lines should be at metre intervals starting from the 1.8 metre line going forwards and backwards so that lines appear under the rear of the vehicle. The intention is to gauge the distance travelled from rear of vehicle to rear of vehicle in the two photographs.

The same formula applies i.e.

$$\text{Dist (m)} \div \text{Time (}\frac{1}{2}\text{ sec)} \times 2.237 = \text{Speed.}$$

The time interval of $\frac{1}{2}$ sec is displayed on the data block as 500 milliseconds as confirmation of the interval between the two photographs.

Please note that a vehicle travelling at 90 mph will cover 20m in $\frac{1}{2}$ second. Therefore Option 2 above is best suited to very high speeds in excess of 90mph so as to reduce the distance between the two photographs.

Look-up tables for metre interval lines are included at the rear of this manual.

IMPORTANT: it is a strict type approval condition **that a magenta filter is used for front photography**. It is not required for rear photography. However, Truvelo recommends that the magenta filter is used for both front and rear photography so as to avoid any possibility that when changing the camera housing from rear facing to front facing the magenta filter is not replaced.

7.0 STATISTICS DEFINED

7.1 Average (x)

The average is calculated by dividing the total of all speed-readings taken during the session by the number of speed-readings. It is expressed in mph and assuming a normal distribution for the data, about 50% of the vehicles measured will exceed the average speed and 50 % of vehicles will be below the average.

7.2 Standard Deviation (σ)

This value is an expression of the spread of the speed readings around the average value and, is expressed in mph. Assuming a normal distribution, approximately 67% of all vehicles measured will fall within the range of the average value + or - 1 standard deviation. Hence, the higher the value of the standard deviation, the greater that range and the greater the likelihood of an accident happening, since the difference in speed between the fast and slow vehicles is greater.

Established by calculating the square root of the sum of the squared individual readings less the average speed-reading, divided by the total number of speed-readings.

7.3 85th Percentile

This is the average speed-reading plus one standard deviation and represents the maximum speed travelled by about 85% of the vehicles measured. This value should correlate with the speed limit for that road and, coupled with a variety of safety aspects for that road (i.e. accident figures) could be used to determine a speed limit for that road.

7.4 High

This is the highest speed-reading recorded during the session.

7.5 Low

This is the lowest speed-reading recorded during the session.

7.6 Peak Flow (vehicles per hour)

The peak flow is established by calculating the highest number of vehicles counted during a 15 minute interval, expressed in an hourly format (for a 1 hour interval) i.e. it is 4 times the number of vehicles counted during the busiest 15 minute period,

7.7 Average Flow (vehicles per hour)

Calculated by dividing the total number of vehicles counted during a session by the total time in hours.

7.8 Bar Graph

This is a histogram that displays the speed-readings in a graphical format whereby the individual speed-readings are sorted into cells of 5mph width, i.e. the processor counts the speed readings which fall into a cell starting at 0mph and ending at 5mph which is then displayed as a percentage of the total number of speed readings in a

vertical bar format. The same procedure is followed for the cell starting at just above 5mph up to 10mph etc. All cells are displayed next to each other.

8.0 FILM CASSETTES

- 8.1** The camera will normally be used with the Bulk Film Cassette supplied. This holds a 30 metre, 800 frame film. A metal NR 36 exposure cassette may also be used. Films of approximately 400 frames are also available. The loading methods for each are described in the Robot 36DCE Camera Operating Manual at the rear of this manual.

- 8.2** Film cassettes may become jammed or “sticky” due to dirt and particles of torn film. For cleaning and repairing of cassettes please contact our Service Department.

Option 1: TRUVELO SECONDARY CHECK

Single photo at 1.8m line (front or rear photography)

Time to 1.8m (ms)	Speed (mph)		Time to 1.8m (ms)	Speed (mph)
32	125.83		75	53.69
33	122.02		76	52.98
34	118.43		77	52.29
35	115.05		78	51.62
36	111.85		79	50.97
37	108.83		80	50.33
38	105.96		81	49.71
39	103.25		82	49.10
40	100.67		83	48.51
41	98.21		84	47.94
42	95.87		85	47.37
43	93.64		86	46.82
44	91.51		87	46.28
45	89.48		88	45.76
46	87.53		89	45.24
47	85.67		90	44.74
48	83.89		91	44.25
49	82.18		92	43.77
50	80.53		93	43.30
51	78.95		94	42.84
52	77.43		95	42.39
53	75.97		96	41.94
54	74.57		97	41.51
55	73.21		98	41.09
56	71.90		99	40.67
57	70.64		100	40.27
58	69.42		101	39.87
59	68.25		102	39.48
60	67.11		103	39.09
61	66.01		104	38.71
62	64.95		105	38.34
63	63.91		106	37.99
64	62.92		107	37.63
65	61.95		108	37.28
66	61.01		109	36.94
67	60.10		110	36.60
68	59.21		111	36.27
69	58.36		112	35.95
70	57.52		113	35.63
71	56.71		114	35.32
72	55.93		115	35.01
73	55.16	Formula: Dist(m) /Time(secs) x 2.237 =Speed (mph)		
74	54.41	NB: The Combi S is capable of measuring speeds up to 200mph. For Type Approval purposes it has been tested up to 140mph		
		The Truvelo Combi S Rounds down the measured speed		

Option 2: TRUVELO SECONDARY CHECK

Software OPTION 2, 1st photo at 1.8m, 2nd photo at 20m.

Speed	Time (secs) to 20 m	Dist Travelled (metres)	Speed	Time (secs) to 20m	Dist Travelled (metres)
40	1.119	20 m	81	0.552	20m
41	1.091	20 m	82	0.546	20m
42	1.065	20 m	83	0.539	20m
43	1.040	20 m	84	0.533	20m
44	1.017	20 m	85	0.526	20m
45	0.994	20 m	86	0.520	20m
46	0.973	20 m	87	0.514	20m
47	0.952	20 m	88	0.508	20m
48	0.932	20 m	89	0.503	20m
49	0.913	20 m	90	0.497	20m
50	0.895	20 m	91	0.492	20m
51	0.877	20 m	92	0.486	20m
52	0.860	20 m	93	0.481	20m
53	0.844	20 m	94	0.476	20m
54	0.829	20 m	95	0.471	20m
55	0.813	20 m	96	0.466	20m
56	0.799	20 m	97	0.461	20m
57	0.785	20 m	98	0.457	20m
58	0.771	20 m	99	0.452	20m
59	0.758	20 m	100	450ms SEE	20.12
60	0.746	20 m	101	450ms NOTE	20.32
61	0.733	20 m	102	450ms AT	20.52
62	0.722	20 m	103	450ms END	20.72
63	0.710	20 m	104	450ms	20.92
64	0.699	20 m	105	450ms	21.12
65	0.688	20 m	106	450ms	21.32
66	0.678	20 m	107	450ms	21.52
67	0.668	20 m	108	450ms	21.72
68	0.658	20 m	109	450ms	21.93
69	0.648	20 m	110	450ms	22.13
70	0.639	20 m	111	450ms	22.33
71	0.630	20 m	112	450ms	22.53
72	0.621	20 m	113	450ms	22.73
73	0.613	20 m	114	450ms	22.93
74	0.605	20 m	115	450ms	23.13
75	0.597	20 m	116	450ms	23.33
76	0.589	20 m	117	450ms	23.53
77	0.581	20 m	118	450ms	23.74
78	0.574	20 m	119	450ms	23.94
79	0.566	20 m	120	450ms	24.14
80	0.559	20 m	121	450ms	24.34

Speed	Time (secs) to 20m	Dist Travelled (metres)	Speed	Time (secs) to 20m	Dist Travelled (metres)
122	450ms	24.54	132	450ms	26.55
123	450ms	24.74	133	450ms	26.75
124	450ms	24.94	134	450ms	26.95
125	450ms	25.14	135	450ms	27.16
126	450ms	25.34	136	450ms	27.36
127	450ms	25.55	137	450ms	27.56
128	450ms	25.75	138	450ms	27.76
129	450ms	25.95	139	450ms	27.96
130	450ms	26.15	140	450ms	28.16
131	450ms	26.35			

The Robot camera takes 2 photos per second. The minimum interval between two photos is 450 milliseconds. Therefore at speeds above 99 mph the time interval between the two photos will always be 450 milliseconds, it can not be less.

Consequently, the distance travelled by the vehicle at speeds above 99mph will be greater than 20 metres. Additional markings on the road will allow the distance travelled to be measured and the secondary speed calculation to be made. If speeds in excess of 120mph are expected then it would be necessary to move the camera post further back from the 20m mark.

The second photo is delayed until the vehicle should be on the 20m mark. Braking or accelerating during the 20m between photos will mean that the axle does not fall exactly on the white line. Therefore the distance used in the secondary speed calculation must be determined from the photo.

The Truvelo Combi Smc is capable of measuring speeds up to 200mph. For Type Approval purposes it has been tested up to 140mph.

Formula used above:

$$\text{Dist(m)} \times 2.237 \div \text{speed} = \text{time to 20m line}$$

$$\text{Mph} \times .447 (= \text{m per sec}) \times \text{secs} = \text{Dist travelled in metres}$$

NB: The first photo of the pair also provides a secondary check, at 1.8m.

Option 3: TRUVELO SECONDARY CHECK : REAR PHOTOGRAPHY: Metre check lines , 1/2 sec interval

Distance travelled (metres)	Conversion factor	Speed (miles per hour)	Distance travelled (metres)	Conversion factor	Speed (miles per hour)
6.75	0.22352	30.20	19.00	0.22352	85.00
7.00	0.22352	31.32	19.25	0.22352	86.12
7.25	0.22352	32.44	19.50	0.22352	87.24
7.50	0.22352	33.55	19.75	0.22352	88.36
7.75	0.22352	34.67	20.00	0.22352	89.48
8.00	0.22352	35.79	20.25	0.22352	90.60
8.25	0.22352	36.91	20.50	0.22352	91.71
8.50	0.22352	38.03	20.75	0.22352	92.83
8.75	0.22352	39.15	21.00	0.22352	93.95
9.00	0.22352	40.26	21.25	0.22352	95.07
9.25	0.22352	41.38	21.50	0.22352	96.19
9.50	0.22352	42.50	21.75	0.22352	97.31
9.75	0.22352	43.62	22.00	0.22352	98.43
10.00	0.22352	44.74	22.25	0.22352	99.54
10.25	0.22352	45.86	22.50	0.22352	100.66
10.50	0.22352	46.98	22.75	0.22352	101.78
10.75	0.22352	48.09	23.00	0.22352	102.90
11.00	0.22352	49.21	23.25	0.22352	104.02
11.25	0.22352	50.33	23.50	0.22352	105.14
11.50	0.22352	51.45	23.75	0.22352	106.25
11.75	0.22352	52.57	24.00	0.22352	107.37
12.00	0.22352	53.69	24.25	0.22352	108.49
12.25	0.22352	54.80	24.50	0.22352	109.61
12.50	0.22352	55.92	24.75	0.22352	110.73
12.75	0.22352	57.04	25.00	0.22352	111.85
13.00	0.22352	58.16	25.25	0.22352	112.97
13.25	0.22352	59.28	25.50	0.22352	114.08
13.50	0.22352	60.40	25.75	0.22352	115.20
13.75	0.22352	61.52	26.00	0.22352	116.32
14.00	0.22352	62.63	26.25	0.22352	117.44
14.25	0.22352	63.75	26.50	0.22352	118.56
14.50	0.22352	64.87	26.75	0.22352	119.68
14.75	0.22352	65.99	27.00	0.22352	120.79
15.00	0.22352	67.11	27.25	0.22352	121.91
15.25	0.22352	68.23	27.50	0.22352	123.03
15.50	0.22352	69.35	27.75	0.22352	124.15
15.75	0.22352	70.46	28.00	0.22352	125.27
16.00	0.22352	71.58	28.25	0.22352	126.39
16.25	0.22352	72.70	28.50	0.22352	127.51
16.50	0.22352	73.82	28.75	0.22352	128.62
16.75	0.22352	74.94	29.00	0.22352	129.74
17.00	0.22352	76.06	29.25	0.22352	130.86
17.25	0.22352	77.17	29.50	0.22352	131.98
17.50	0.22352	78.29	29.75	0.22352	133.10
17.75	0.22352	79.41	30.00	0.22352	134.22
18.00	0.22352	80.53	30.25	0.22352	135.33
18.25	0.22352	81.65	30.50	0.22352	136.45
18.50	0.22352	82.77	30.75	0.22352	137.57
18.75	0.22352	83.89	31.00	0.22352	138.69

1 mph = 0.22352 metres travelled in 1/2 a second. Metres per sec to mph conversion factor is x 2.237

The above table is designed to provide the speed for a given distance travelled. Distances in 0.25 m increments.

To calculate speed use formula :- Distance (metres) divided by time (0.5 secs) x 2.237 = Speed in mph.

NB If the data panel shows 499 ms use 0.499 secs as the time.

Option 3:TRUVELO SECONDARY CHECK: REAR PHOTOGRAPHY: 5 ft interval lines 1/2 sec interval

Speed (Mph)	Mph to Fps	Distance Travelled (ft)	Speed		Dist Travelled (ft)
Speed (Mph)	Conversion			Speed (Mph)	
27	0.7333333	20	76	0.7333333	56
28	0.7333333	21	77	0.7333333	56
29	0.7333333	21	78	0.7333333	57
30	0.7333333	22	79	0.7333333	58
31	0.7333333	23	80	0.7333333	59
32	0.7333333	23	81	0.7333333	59
33	0.7333333	24	82	0.7333333	60
34	0.7333333	25	83	0.7333333	61
35	0.7333333	26	84	0.7333333	62
36	0.7333333	26	85	0.7333333	62
37	0.7333333	27	86	0.7333333	63
38	0.7333333	28	87	0.7333333	64
39	0.7333333	29	88	0.7333333	65
40	0.7333333	29	89	0.7333333	65
41	0.7333333	30	90	0.7333333	66
42	0.7333333	31	91	0.7333333	67
43	0.7333333	32	92	0.7333333	67
44	0.7333333	32	93	0.7333333	68
45	0.7333333	33	94	0.7333333	69
46	0.7333333	34	95	0.7333333	70
47	0.7333333	34	96	0.7333333	70
48	0.7333333	35	97	0.7333333	71
49	0.7333333	36	98	0.7333333	72
50	0.7333333	37	99	0.7333333	73
51	0.7333333	37	100	0.7333333	73
52	0.7333333	38	101	0.7333333	74
53	0.7333333	39	102	0.7333333	75
54	0.7333333	40	103	0.7333333	76
55	0.7333333	40	104	0.7333333	76
56	0.7333333	41	105	0.7333333	77
57	0.7333333	42	106	0.7333333	78
58	0.7333333	43	107	0.7333333	78
59	0.7333333	43	108	0.7333333	79
60	0.7333333	44	109	0.7333333	80
61	0.7333333	45	110	0.7333333	81
62	0.7333333	45	111	0.7333333	81
63	0.7333333	46	112	0.7333333	82
64	0.7333333	47	113	0.7333333	83
65	0.7333333	48	114	0.7333333	84
66	0.7333333	48	115	0.7333333	84
67	0.7333333	49	116	0.7333333	85
68	0.7333333	50	117	0.7333333	86
69	0.7333333	51	118	0.7333333	87
70	0.7333333	51	119	0.7333333	87
71	0.7333333	52	120	0.7333333	88
72	0.7333333	53			
73	0.7333333	54			
74	0.7333333	54			
75	0.7333333	55			