A FUEL CONSUMPTION REVELATION

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'A FUEL CONSUMPTION REVELATION':

BTAC/IRTE COMMERCIAL VEHICLE FUEL TRIALS

1. *In my life-time as a practising Automotive Engineer I have been fascinated by fellow engineers, users and enthusiasts fuel consumption claims. Surely, I thought, given an engine's detailed specific consumption loop the vehicle's gearing, wheel and tyre size, aerodynamic co-efficient and rolling resistance for a given performance requirement and ambient and road conditions it should be a simple task to calculate the probable fuel consumption.*

   Indeed Cummins Engines Co. attempted this with their computerised Vehicle Mission Simulator Mark I. There were many variables not the least the driver (and a good driver could produce for example 8.5 mpg for a given route and speed conditions, whilst a poor driver or even an average driver could achieve 7.2 mpg). This 18% variation was far beyond the capability of the engine designer or the aerodynamic expert.

2. *My very practical career background included working with a very large petroleum conglomerate where time was spent determining engine octane requirements for the next generation of engines. More recently actually operating over 3000 commercial vehicles, 4200 cars and 1000 fork lift trucks. These experiences have demonstrated to me that there is a very large number of variables hell-bent on preventing courageous, innovative and credible fuel consumption forecasting that the Cummins Engine Co. attempted with their early Mission Simulator.*

The Cummins Mark I Mission Simulator began to lack credibility because it's forecasts were realistic and predictions did not compare favourably with the haulage contractor who was very optimistic over his Gardner Gin and Tonic anecdotes.

3. *On another front, improvement add-ons and fuel additives all tended in my experience to be more perceived than actual as did for that matter fuel consumption benefits as a result of repair and maintenance.*

I well recall an incident concerning a 1931 8 litre Bentley that I once owned and a daughter that I still have. The former would have been a very valuable asset had I retained it, the latter remains a continued revenue expense no matter how lovable.

4. *For those that cannot recall the 8 litre Bentley, it was an in-line 6 with an eccentric overhead cam drive fed by two 2" SU carburettors. Bentley claimed that even grossing 2½ tons it was capable of pulling from 5mph to 105mph in top gear.*

You must understand that one just does not maintain Vintage Bentleys - you just overhaul them every 20 years or so. But, with my Bentley' things had come to a head when my two year old toddler daughter was standing behind the car when I started it up. Her very white Sunday dress was transformed into a very black chimney-sweep-like overall, in fact she looked as though she had just crawled out of the very black 3" diameter exhaust tail pipe.

5. *The SU carburettors were attacked, the needle wear can best be described as astounding and new jets, washers and needles were acquired and assembled and much enjoyment resulted from the final tuning and balancing - a recommended party game for the family.*

6. *The point of this story is that fuel consumption prior to the SU overhaul with the black exhaust was 11mpg - after the overhaul of the carburettors which made them indistinguishable from the original and producing a very light grey exhaust pipe coating produced 11 mpg.*

7. *Then there was the dreaded H_2O bomb whose praises even Harry Ricardo had sung. This was claimed to improve volumetric efficiency and on a theoretical basis would appear to be foolproof and many more MPG were almost guaranteed from heaven.*

This I fitted to a 1926 3 litre 4 cylinder Bentley again this is a beautiful long stroke engine fed by two early Sloper bronze SU carburettors.

Incidentally, SU stands for Skinner Union and the name Skinner comes from Lilley and Skinner an early Victorian shoemaker and retailer.

The second generation of Skinners took interest in the automobile and produced the SU carburettor which originally used a leather diaphragm instead of the later bronze and then aluminium piston. The leather quickly deteriorated and it was Wm. Morris that increased the life of the leather by *impregnating it with petroleum resistant substance, and it was Wm Morris that we have to thank for the subsequent generations of constant volume carburettors.*

SU later became part of the Nuffield Group of Companies.

8. *In 1954 I was taking this 1926 Bentley to Monte Carlo - 2500 mile round trip. The car certainly was not as good as new. I certainly couldn't afford a rebore and I fitted the original pistons with high radial pressure Cord rings and the 525 x 21" tyres had been many times remoulded . The main point of the story is that the fuel consumption remained at a very constant 16 mpg whether the H_2O Harry Ricardo approved economising bomb was switched on or not.*

Later in my career a very detailed, enjoyable and enlightening extended induction course with the old Shell Mex and BP organisation, included a session at Sunbury on Thames where one laboratory's function was to determine the required octane rating of fuel needed to satisfy new and prototype engines.

This is now 30 years ago, but my memory recalls that the system was to take a manufacturer's engine directly from the production line and feed it with a mixture of ISO octane and normal heptane and run the engine until the threshold of audible knock was determined. The percentage ISO octane represented in the fuel was the octane requirement of that engine. However, in truth it was not quite that simple as the Shell Mex & BP technicians then went on to identify the most knock-prone cylinder and worked that cylinder to reduce the octane requirement. Then the next worst cylinder was *better engine was produced. What tended to happen was that manifolds were lined up and knock inducing burrs were polished from cylinder heads. The distributor cam was harmonised and a great deal of attention given to tappet clearance and ignition timing. All this produced a significantly lower octane requirement. But then the quite astonishing action: to then add 10% to the stated requirement and to this day I never did discover whether this was to compensate for engine manufacturers or the motor spirit production tolerances. Some doubt but probably a combination of the two.*

9. *In more recent years my present company was required to determine the cost penalty of operating cars with unleaded fuel, particularly as Mrs Bottomley had written to our Chairman advising that we were missing out on a huge cost savings.*

We took 2 Cavaliers - very popular in our fleet of 4200 cars - with some 20,000 miles recorded and consecutive chassis numbers, and subjected them to local Vauxhall distributors for service and the necessary ignition adjustment, and ran a back to back fuel trial to determine miles per gallon and fuel cost difference between leaded and unleaded.

This trial was carried out at MIRA very much in accord with BTAC/IRTE fuel consumption procedures that I will describe later.

We had allocated two days to this particular project. Three weeks later and two engines rebuilds later, we had reduced the leaded advantage from 19% to 3%. So maybe times have not changed very much in 30 years.

At about the same time because of less than acceptable fuel and performance results reported by our operators of newly delivered 16 ton trucks, we randomly selected a newly delivered truck chassis, removed the engine and asked MIRA to carry out an independent engine bench test and to record and report on fuel consumption and output performance. This 500 cubic 6 cylinder engine was 10% down against stated rated power and fuel was equally disappointing. MIRA were able to improve performance by adjustment to the fuel pump. The engine was stripped down and it was discovered that, unlike the Bentley and Gardner engines that had traditionally been so lovingly assembled by caring mechanics that they were proud enough to stamp their initials on their creations, the cylinder head gasket of our 6 cylinder 500cu.in. engine still supported the manufacturers wrapping paper and would you believe had been fitted with the incorrect fuel pump.

I might also mention that the oil sump pick-up pipe securing nut was only finger tight in spite of many months of reporting this recurring defect to the manufacturer.

11. *Could it now be that you are beginning to realise why BTAC hold Annual Commercial Vehicle Fuel Consumption Trials at MIRA to get a bit nearer the truth?*

12. *My company uses some 3m gallons of fuel per year. A 10% saving represents in broad terms the profit on sales of beer from 20 good pubs,(the pubs would be valued at something like £15m.). A 10% fuel consumption saving is what appears to be achievable if one selects the best engine and the best*

transmission according to our BTAC/IRTE Fuel Trials and by improving the performance of our worst driver to that of an average driver's performance which should be realistically achievable.

13. *So the BTAC Fuel Trials comprise of running a vehicle of known specification, of known gross and tare weights, on known fuel quality, of known ambient temperature and humidity, of known wind speed and direction, around a known and identical track at a known and almost identical speed. To then record fuel consumption and to make meaningful comparisons and then draw sensible conclusions.*

14. *The test procedure quite simply requires a vehicle to be weighed on a very accurate weigh-bridge that can detect 7lb. difference. Typical permissible tolerances are as follows:-*

1.	7 tonne		± 40 kg.
2.	10 tonnes gross vehicle weight	)	
3.	16 tonne gross vehicle weight	)	± 50 kg.
4.	17 tonne gross vehicle weight	)	
5.	38 tonne gross vehicle weight.		± 200 kg.

Test fuel is contained in a detachable tank which is fitted with quick release connections.

Each vehicle has to have an up to date calibrated tachograph. Each vehicle has to be provided with a specific detailed build specification, sample copies attached.at Appendix A.

15. *The trials are carried out on what is quite seriously described and minuted as the first really wet weekend in September, and each vehicle is allocated a running time.*

16. *The vehicle is weighed in by officials at the MIRA "imperial" calibrated weigh-bridge where I must say it comes as quite a shock to have to convert imperial to metric tonnes.*

(Here a notice is displayed reminding the aged officials that you cannot have five quarters in a hundredweight.)

The tare weight of each vehicle is provided by the entrant. It has to be on a weight ticket recording the weight of the vehicle taken within the last 7 days as it is necessary to have this information to calculate the payload earning factor

17. *At the weigh-bridge the weights can be adjusted and here the typical brewers 14lb CO_2 cylinder comes in very handy. The vehicle is then scrutinised to ensure conformity with the stated specification before it is allowed to warm up, which also enables the driver and the observer to become familiar with the track and the trial regulations.*

18. *Before the actual trial the test tank is removed from the vehicle, filled, weighed and replaced. The vehicle is allowed to start when the time and distance details on the tachograph have been recorded. The trial comprises of 5 laps at 40, 50 and 60 mph on the high speed circuit at MIRA.*

19. On completion of this run it returns to the start/finish line where the distance, time and fuel consumed by weight is recorded.

20. This is part 1 of the test and is intended to simulate typical British motorway conditions.

21. Part 2 starts immediately after the fuel has been recorded by weighing and details of distance and time recorded.

22. Part 2 of the test attempts to simulate stops start delivery work and again at the end of this section the time, distance and fuel consumed by weight is recorded.

23. The most controversial part of the whole day occurs when the computerised results are posted on the notice board. It is not unknown for competitors to do more or less number of laps than required. Counting laps is not that straight-forward on the day and many ingenious devices are used to ensure that the correct number of laps are completed.

24. Ambient conditions can change and because of the popularity of the event it is necessary sometimes to start at 7 am and finish at 7 p.m. during which time humidity factors, windspeed and direction all play it's part, however, we have not found a way of operating 30 x 38 tonners on the 2.5 mile track at different speeds at one time. Nevertheless, you must realise that this method of fuel consumption testing is as near as you are going to get to perfect like for like conditions.

25. Over the last 10 years the following fuel advantages have been recognised and confirmed as a general order of things.

25.1. Temperature controlled cooling fan: 3.7 - 7.9% (Accepted).

25.2. Radial Tyres 3% (Accepted standard in UK.).

25.3. Synthetic lub. 3 - 4%. (Not generally accepted in UK although cost can be justified providing "driveline filled for life maintenance policy" is adopted).

25.4 Low drag trailers 2%

25.5. Low exhaust back pressure 2.4%

25.6 Low intake restriction 1.2%

25.7 Radiator shutter 1.8%

25.8 Tyre pressure 50% reduction in tyre pressure increases fuel consumption by 10%.

25.9 Reduction in speed from 65 mph to 50 mph improved 6.4 mpg to 8.4 mpg (31%). (USA have accepted this principle when they restricted maximum speeds to 55mpg during an earlier oil crises.

26. I suppose overall the conclusion is that it is speed that really consumes fuel, everything else being equal, and going back to basics, if you use more horsepower your consume more energy.

27. The trial is by no means driver proof but goes a long way to eliminating the 18% driver variation influence mentioned earlier in this paper when reference was made to the Cummins Mission Simulator Mark I. The driver that is skilled and knowledgeable and practiced on the BTAC Fuel Consumption

produces an ideal tachograph disc like the one that will be illustrated is likely to be beaten. His fuel consumption is likely to be bettered by somebody that does not hit a 50mph requirement exactly on time.

28. *Overall in spite of problems, disputes, variations in climatic conditions that are outside the control of BTAC/IRTE and even the I.Mech. E the trials have gained credibility and the operator can monitor the order of improvements as a result of new generation engines and energy reduction devices. The user and manufacturer can use these trials as a heaven sent low expense opportunity to determine the cost effectiveness of methods of reducing fuel consumption.*

29. *In addition, whilst the trials are very competitive on the day, they are carried out in a very pro-active, warm and friendly spirit which in addition provides an opportunity for all to gain far more knowledge of industry happenings and technical development than just the mpg achieved on the day.*

30. *Selected results from the 1986 and 1989 trials are attached and can be discussed.*

31. *I would like to acknowledge and thank the enthusiastic BTAC and IRTE members, the long suffering and helpful MIRA staff, participating brewery, petroleum, Royal Mail and haulage companies, I must not forget the equally long suffering Fletcher Computer Services who have computer analysed and posted the results over the years, and last but by no means least the very supportive European and American motor and component manufacturers.*

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IRTE/BTAC FUEL TRIALS

1989 SAMPLE/TEST RESULTS

No	Item tested	Vehicle	GVW	Result	Comment
1	*Synthetic versus Mineral lubricant*	*Volvo FL614*	*14T*	*Synth. 13.46* *Min. 13.06*	*Mobil synthetic showed a 3.06% improvement in mpg. This is in line with previous trials and manufacturers/users claims.*
2	*New Premium Diesel Fuel v. Standard DERV*	*Seddon Atk.Strato 6 x 2 Cummins E365*	*38T*	*Premium 6.85* *Stand. 6.97*	*Standard showed almost 2% better than Premium. Again this is typical of so called advanced products from Petroleum Companies. Could be that the Standard product had already been up-spec'd.*
3.	*Iveco Ford Cargo 1615 versus Volvo F616*	*Both dropframe vehicles.*	*17T*	*Ford 12.316* *Volvo 11.741*	*Ford Cargo 4.9% more economical than the Volvo in line with users' experience.*
4.	*Cat.3306B ATAAC v Cummins LTA 10-290.*	*Foden S104Cat v Foden S104Cummins*	*38T*	*Cat. 6.814* *Cummins 6.931*	*Cummins 1.72% more economic. This was a surprise and contrary to impression gained from vehicle manufacturer.*
5.	*Twin tyres versus Super singles*	*Trailers*	*24T*	*Twins 8.035* *Singles 8.091*	*Negligible difference (0.7%) in favour of single tyre. This is contrary to tyre manufacturer's rep's claim of 3% +.*
6.	*Aerodynamic Aids v Standard veh.*	*Volvo FL10*	*38T*	*With Aer.7.07* *W/out " 7.09*	*Air management systems are usually expected to show fuel savings of c3%. Wind speed 10mpg with gusts up to 20. The trial with the air management system was carried out first and therefore the vehicle would have been warmer for the second part of the trial with the air management system removed.*
7.	*Comparison of 17 tonne rigid vehicles.*	*Steyr 17.S18* *ERF ES6* *Steyr 17.S21* *Sed.At.* *L DAF Cruiser 1718* *Volvo FL617* *L DAF 1900DNS*	*17T* *+|-* *50* *kgms*	*Av.Spd.* *11.91 35.43* *11.65 34.85* *11.47 34.29* *11.32 33.75* *11.06 33.22* *11.06 33.22* *10.65 33.8*	*Trials show 12% variation between best and worst which at that time with fuel at £1.60/gal represented some £800/yr at 50,000 miles/yr. The Steyr was an outstanding vehicle in that not only did it achieve the best fuel consumption but did so at a significantly higher speed.*

1986 Results

TRUCK TYPES	H.p.	Engine revs Per mile	Non-stop m.p.g.	Urban m.p.g.	Overall m.p.g.	Av. m.p.h.	P.E.F. **	Entrant
7.5 TONNE								
Leyland Roadrunner van, Cu 300 5.9	115	2446	18.68	23.05	19.99			
van 698, 5.7	115	2642	17.55	19.21	18.09			
van 698, 5.7	115	2446	17.55	18.44	17.85			
Ford Cargo curtain, 6.2	114	2791	17.55	17.07	17.38			
MAN-VW curtain, 5.7	136	3307	16.39	17.39	16.72			
15 TONNE								
Bedford TL curtain 8.2 turbo	173	2303	0.09	10.59	9.56			
16 TON								
Ford Cargo curtain 6.0 turbo	150	2689	13.68	12.62	13.29			
MAN: curtain 5.7 turbo	170	2444	13.16	12.80	13.03			
Volvo FL6 curtain, 5.5 turbo	201	2687	13.16	12.29	12.84			
Volvo FL6 curtain, 5.5 turbo	201	3002	12.87	12.45	12.72			
Ford Cargo curtain 6.0 turbo	150	2689	12.77	12.29	12.60			
curtain 6.0 turbo	150	2689	12.50	12.45	12.48			
Bedford artic dray Perk. 5.9 turbo	160	2872	11.28	12.62	11.71			
artic dray Cu. 5.9 turbo	170	3856	11.21	11.38	11.26			
curtain 8.2 turbo	173	2687	10.53	10.59	10.55			
artic dray 8.2 turbo	130	2965	9.7	11.24	10.19			
24 TONNE								
Leyland dray, 400 6.5 turbo	172	2446	11.98	8.23	10.34			
32 TON								
Foden S104 reefer Cu. 10 turbo 2+2	236	1861	8.15	6.02	7.26			
Seddon Atki reefer Cu.10 turbo 2+2	241	1876	7.89	6.18	7.20			

continued:

38 TONNE								
Volvo FL7 curtain. 6.7 turbo/int.,2+3	245	1995	9.24	7.31	8.47	29.3	6197	Volvo
ERF E10 curtain, Cu.10 turbo/int,2+3	275	1534	9.39	7.03	8.41	28.0	6041	ERF
*Scania P92, curtain 8.5 turbo/int.2+3	275	1837	8.86	7.32	8.26	29.8	6241	Scania
ERF C. curtain Cu.10 t/int.2+3	275	1898	8.82	6.68	7.93	29.38	6052	Whitbread
Seddon Atki 301, curtain. Cu.10t/int.3+2	273	1876	8.12	7.55	7.91	30.68	6063	Econocruise
ERF C.curtain.CU10 t/int.2+3	275	1913	9.00	6.44	7.91	30.00	6197	Whitbread
Betac Volvo, curtain Cu.10 t/int.2+3	275	1708	8.64	6.72	7.86	30.68	6468	BTAC
Scania P112, curtain, 11 t/int.2+3	333	1701	8.47	6.68	7.75	31.61	6057	Scania
* Ford Cargo, curtain Cu.10 t/int.(o'd)2+3	279	1618	8.35	6.98	7.82	29.8	6081	Whitbread
Ford Cargo curtain, Cu.10 t/int.2+3	279	2074	8.47	6.63	7.73	30.46	5930	Iveco Ford
ERF C.curtain. Cu.10 t/int.2+3	275	1852	8.31	6.44	7.55	30.60	5990	Britvic
Bedford TM curtain, Cu.10 turbo 2+3	241	1969	8.12	6.31	7.38	31.6	6110	Bedford
MAN 20.331,van,12 t/int, 3+3	325	1594	8.19	6.10	7.32	30.68	5804	MAN
ERF C.curtain Cu.10 t/int 2+3	275	1852	8.15	6.14	7.32	30.0	5905	Britvic
Volvo F10,curtain, 9.6 t/int.2+3	286	1912	8.35	5.87	7.28	32.1	6053	Bass
Foden S104,curtain Cu.10 t/int,2+3	276	1898	8.04	5.83	7.11	30.24	5617	Whitbread
ERF E10,hopper,Cu.10 t/int 2+3	275	1852	7.55	6.18	7.01	30.06	5990	Bass
Seddon Atki.tanker Cu.14 turbo 2+3	277	1861	7.93	5.39	6.81	30.09	5295	Esso
Volvo F10 curtain, 9.6 t/int. 2+3	286	1912	7.79	5.45	6.78	31.00	6080	Bass Ireland
ERF C.tanker Cu.10 t/int. 2+3	275	2062	7.55	5.62	6.75	30.09	5295	Esso
Foden S106 tanker, Royce 12 t/int. 3+2	276	1856	7.55	5.58	6.73	29.59	5108	Shell

Note: * These vehicles did not attain stipulated speed between stops on the urban mpg test and had to be disqualified in the competition.

** PEF = Payload Earning Factor = Tonnes x mph x mpg: Slowest v Fastest 14.00%
Best - Worst 26%

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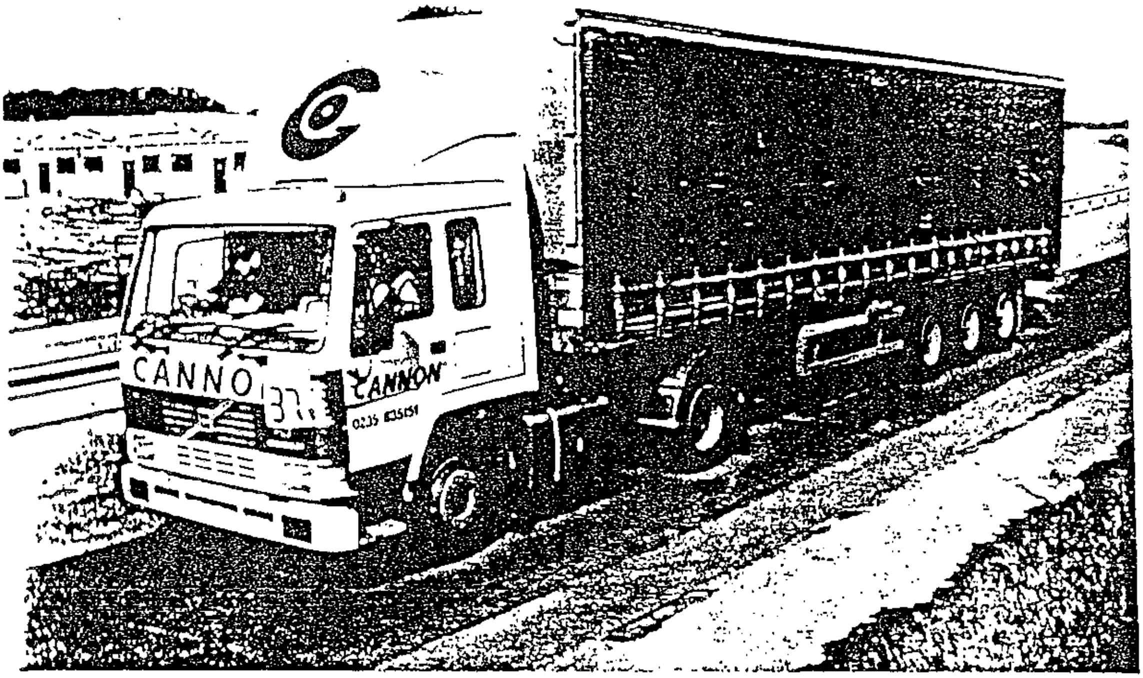
Non integrated combination
Green indicates areas requiring attention



JRD should note we have some in house knowledge when it comes to its fuel consumption. [illegible]


B.T.A.C. PROJECT VEHICLE
HAA 859T