Appendix 4
Details of the cost effectiveness calculations

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1. Introduction

The objective of this appendix is to report the second iteration of calculating the cost effectiveness of various test options. The findings of these calculations are summarised in Chapter 6 of the main report. It is emphasised that the data presented here are a cost effectiveness analysis, calculating the cost (£) to achieve a reduction of 1 ktonne of pollutant from an in-service test given a number of stated assumptions. As agreed with the DfT it is not a cost benefit analysis. This would require further judgements of “damage cost factors” to convert a reduction in emissions (k tonnes of pollutant) to benefits to society (£). By providing cost effectiveness data the data is more robust and can be used for calculating cost benefit analyses at later dates using the most appropriate damage cost factors combined with geographic distributions of pollutants.

Two fundamental reviews of the methodology used for calculating cost effectiveness were undertaken around 18 months ago. The conclusions reached by these were used as the basis for the cost effectiveness analysis undertaken in Phase 2 of the Project on Low Emissions Diesels[1] and are relevant to this Phase 2 study also. A summary of the principal aspects of the methodology used is as follows:

Timescales

1) The cost effectiveness should be calculated on an annual basis, i.e. using annual emission savings for each year and annual cost (rather than over the vehicle or test equipment lifetime). This was to be done for representative years, e.g. 1998, 2005, 2010 and 2015.

Calculation of savings

1) Estimates of annual savings of pollutants should be based on
   a) NAEI forecasts
   b) an analysis of possible failure modes, their effect on emissions and their frequency.
2) Estimates of annual savings of pollutants should be broken down into the 2 vehicle types, passenger cars, light-duty vans (the number of SI engined HGVs and PSVs is negligible).
3) The fraction of the “savings potential” that would be realised from the estimated effectiveness of proposed I&M test programmes should be calculated.

Calculation of costs

1) Annual costs should be calculated (rather than costs over fleet lifetime).
2) Capital and setting up costs should be amortised over the period specified by the VI.
3) The discount rate to be used is currently 3.5% (standard DfT figure) although this does change periodically.
4) Vehicle testing time should be costed using a rate (£0.80/minute) obtained from the VI.
5) Cost of repair to be calculated, but kept as a separate cost component.
6) The costs calculated should be those incremental to the current test programme’s costs.

[1] Low emissions diesel research – Phase 2 report, J Norris, CP17/18/770, AEA Technology report AEAT/ENV/R/0629, June 2001.

2. Calculation of costs

2.1 INTRODUCTION AND GENERIC COST ANALYSIS

A first iteration of the cost effectiveness analysis was given in Chapter 7 and Appendix 5 of the Phase 1 report[2]. The structure of the project as a whole is such that Phase 1 considered the definition and identification of excess emitter vehicles at the annual test and Phase 2 is an assessment of alternative test procedures. Consequently, Phase 1 was neither expected to devise testing beyond what is currently undertaken, nor to cost unspecified options. In contrast, having discussed the options for alternative test instrumentation and procedures in this phase, the costings given here are a more detailed analysis of the alternative options.

The remainder of this appendix gives details regarding:
- the calculation of cost,
- the calculation of emissions savings potential and
- the resulting cost effectiveness of the I&M scenarios proposed.

The analysis is sub-divided into that for λ, CO and HC, i.e. covering the species currently tested, and NO_X, as a potential additional measurement.

With reference to the basis used for calculating labour costs – the figure used is that pertinent to 1998 in all cases, i.e. no assumptions or account has been made with regard to inflation. One reason for this approach is that it separates the effects of the different scenarios being costed and assumptions regarding inflation. If inflation were to be taken into account it would increase the cost of the labour components of the testing, discussed further below, by an amount dependent on the assumed inflation rate. If the annual inflation rate were 2.0% this would lead to an increase of 14.9% and 40.0% for 2007 and 2015, respectively. However, if the annual inflation rate were 3.5% this would lead to an larger increases of 27.2% and 79.5% for 2007 and 2015, respectively.

The generic costs of implementing a defined test regime can be itemised to include[3]:

1 Setting up costs
- 1.1 purchase of the meters that meet the specification
- 1.2 purchase of any vehicle testing equipment required to enable the specified procedure to be followed (this could range from none being required to the cost of a dynamometer)
- 1.3 installation costs of any vehicle testing equipment required
- 1.4 cost of training the testers on the use of new meters and undertaking a new procedure.

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[2] An in-service emissions test for spark ignition petrol engines – Phase 1 report: Definition of an excess emitter and effectiveness of current annual test, J Norris, PPAD/9/107/09, AEA Technology report AEAT/ENV/R/0679, June 2001.

[3] This list is that generated and used in the cost effectiveness analysis given in the Phase 1 report.

These one-off costs should be depreciated over an appropriate term, enabling an annual cost of interest on capital expenditure and depreciation to be calculated.

2 Annual costs
   2.1 servicing of the meters
   2.2 servicing of any vehicle testing equipment used by the specified procedure
   2.3 cost of refresher training for the testers.
   2.4 insurance costs.

3 Costs per test
   3.1 time taken by tester to examine vehicle and report findings
   3.2 cost of repair of failed vehicles by owners.

2.2 NUMBER OF VEHICLES TO BE TESTED AND TEST STATIONS

Using fleet composition figures, based on vehicle licensing statistics from the DfT that form an input to the NAEI model, in 1998 the total number of passenger cars and light duty vehicles was 24.44 million. The NAO also estimated the number of tests carried out at garages on cars and light duty vehicles in 1998 as 23.00 million (Figure 14 of the NAO report[4]). They comment that this is higher than the number of eligible vehicles because some vehicles undergo more than one test before passing. However, the number of vehicles eligible for testing is less than the whole fleet because vehicles less than three years old are exempt from the test. **These figures give the rate of testing as 941 tests per thousand vehicles**.

If it is assumed that:
- the ratio of the number of tests to the number of eligible vehicles remains constant,
- the ratio of the number of eligible vehicles to the total number of gasoline vehicles in the fleet remains constant,
- the number of gasoline vehicles in the fleet is that given by the input data to the national atmospheric emissions inventory model[5],

then the number of vehicles to be tested can be calculated, see Table A4.1.

A further important aspect in the calculation of the cost of various testing scenarios is the number of pieces of equipment that may be required. This analysis assumes:
- there are 19,000 light-duty test stations (this is identical to the figure used in the Phase 1 report), and that
- only 1 set of equipment or cost (be it a meter, a dynamometer or setting up and training costs) is incurred by each test station.

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[4] National Audit Office report on Vehicle emissions testing, May 1999, HC 402
[5] Private communication with NETCEN Nov 2002

Table A4.1 Projected fleet numbers, and TWC tests required, (in thousands) for gasoline vehicles

	1998	2005	2010	2015
Total number of pass cars & light duty vans	24,440	27,441	29,424	31,091
Number of gasoline vehicles	20,373	20,740	21,957	23,152
Number of gasoline vehicles with TWCs	9,387	19,397	21,899	23,152
Number of tests of TWC vehicles	8,905	18,391	19,795	19,915
% of TWC gasoline vehicles that are passenger cars	99.1%	98.9%	98.8%	98.7%
% of TWC gasoline vehicles that are light-duty vans	0.9%	1.1%	1.2%	1.3%

2.3 COSTS OF I&M PROGRAMME FOR λ, CO AND HC

2.3.1 Scenarios

Scenario 1 Base case
The meters used to measure λ, CO and HC are already available, i.e. no additional test equipment is required. Whilst there may be minor changes to the test procedure the time taken is unaltered from that required at present. Consequently the costs for this base case are those of the current in-service test programme. The incremental cost of this scenario is £0.

Scenario 2 Extended unloaded test
The meters used to measure λ, CO and HC are already available, i.e. as for Scenario 1 no additional test equipment is required. The test procedure is extended such that it takes a further 3 minutes per test.

Scenario 3 Loaded test
Again it is assumed no change to the test meters is required. However, this test involves a simple dynamometer to load the vehicle. It is assumed that the **whole** cost of a low cost, air-cooled eddy dynamometer is carried by the tests. Further, because the dynamometer test is more complex than the unloaded test it is assumed that the additional test time is 9 minutes (making a total emissions test time of 12 – 15 minutes, and a maximum throughput of 4 – 5 vehicles/hour/dynamometer).

2.3.2 Costing for Scenario 1

This scenario involves **no incremental costs** beyond those already incurred.

For the current in-service test regime the estimate by DfT is that the average cost of the emissions test portion of the whole MOT test for a vehicle with a TWC is £7.30[6]. That being the case the cost of testing is simply the number of tests multiplied by the cost per test, see Table A4.2. The incremental costs, given in Table A4.3 are £0 for all years for this base case scenario.

2.3.3 Costing for Scenario 2

With reference to the list of generic costs in Section 2.1 above, the principal components to be included are 1.4 and 3.1.

Item 1.4 *Cost of training the testers on how to undertake the new procedure*
It is assumed that this can be achieved in half a day (4 hours) and that on average there are 2.5 testers per test station. This translates to a cost of £500 per test station. It is further assumed that this is recovered over 3 years. Applying a discount rate of 3.5%, this gives an additional cost of £178.50 per test station per year.

Item 3.1 *Cost of time taken by tester to examine vehicle and report findings*
For Scenario 1, the base case, this was taken as £7.30 per test. In this scenario, the time required per test is assumed to be 3 minutes longer. Using the figure of £0.80 per minute per test[7], this is a further cost of £2.40 per test, increasing the cost of each test to £9.70 per test.

2.3.4 Costing for Scenario 3

The big difference in this scenario is that dynamometers are required and that the **full cost of the dynamometers is borne by this test**. With reference to the list of generic costs, the principal costs arise from activities 1.2, 1.3, 1.4, 2.2 and 3.1.

Items 1.2 and 1.3, *purchase and installation of dynamometers that meet the specification*, and Item 2.2, *annual cost of the servicing and calibration of the dynamometers*
It was assumed that the number of dynamometers required was one for each test station.

It was also assumed that:
- the cost of purchasing and installing a dual axle light-duty dynamometer = £31,000
- the lifetime of dynamometers, used to calculate depreciation charges = 10 years
- the discount rate used = 3.5%
- the annual cost of servicing and calibrating the dynamometers = £1,500

These assumptions gave the depreciation to be recovered annually as £3,727.50.

Item 1.4 *Cost of training the testers how to test using a dynamometer and a new procedure*
This is assumed to be three times the £500 per test station figure used in Scenario 2 because of the significantly increased complexity of the training required to **safely** test vehicles using a dynamometer. Again it is assumed that this cost is recovered over 3 years. Applying a discount rate of 3.5%, this gives a £535.4 per test station per year.

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[6] Private communication with DTLR VSE2, August 2001.
[7] Private communication between the author and VI, November 2002

When added to the depreciation cost for the dynamometer, and the cost of servicing and calibrating the dynamometers, this gives an annual cost of ownership of £5,763 per test station.

Item 3.1 *cost of time taken by tester to examine vehicle and report findings*
Because of the higher level of complexity of the test, and based on figures given by Clayton Industries and the Oregon Vehicle Inspection Programme, it is assumed a further 9 minutes is required to test each vehicle relative to Scenario 1. This adds a further £7.20 to the cost of each test, taking the labour component up to £14.50 per test.

Therefore by summing together the components, the total cost of testing for λ, CO and HC assuming Scenario 3 is found, as given in Table A4.2 and an incremental cost relative to the current test programme as given in Table A4.3.

Table A4.2 The total cost of testing for λ, CO and HC for various scenarios

Year	1998	2005	2010	2015
Scenario 1	£64.5 M	£134.3 M	£144.5 M	£145.4 M
Scenario 2		£181.8 M	£195.4 M	£196.6 M
Scenario 3		£376.2 M	£396.5 M	£398.3 M

Table A4.3 The incremental cost of testing for λ, CO and HC for various scenarios

Year	1998	2005	2010	2015
Scenario 1	£0.0 M	£0.0 M	£0.0 M	£0.0 M
Scenario 2		£47.5 M	£50.9 M	£51.2 M
Scenario 3		£241.9 M	£252.0 M	£252.9 M

In addition to expressing the total costs either directly, Table A4.2, or expressed as incremental costs, Table A4.3, the costs can be expressed in terms of the cost per test. The data are presented in this format in Table A4.4

Table A4.4 The cost of testing for λ, CO and HC for various scenarios expressed as a cost per test

Year	1998	2005	2010	2015
Scenario 1	£7.30	£7.30	£7.30	£7.30
Scenario 2		£9.88	£9.87	£9.87
Scenario 3		£20.45	£20.03	£20.00

2.4 COSTS OF I&M PROGRAMME FOR NO_X

2.4.1 Scenarios

<u>Scenario 1 Base case</u>
Whilst there may be minor changes to the test procedure the time taken is unaltered from that required at present. However, unlike Scenario 1 for the measurement of λ, CO and HC currently there are **no** meters for measuring NO_X. Consequently this base case for NO_X measurement does require capital expenditure.

<u>Scenario 2 Extended unloaded test</u>
This scenario is analogous to Scenario 2 for λ, CO and HC measurement, where the test procedure is extended such that it takes a further 3 minutes per test. In addition to the change in test time there is also the need to buy meters to measure NO_X

<u>Scenario 3 Loaded test</u>
As for Scenario 3 for λ, CO and HC measurement, this scenario assumes a simple dynamometer is required. It further assumes that the duration of the test procedure is increased by 9 minutes (making a total emissions test time of 12 – 15 minutes). There remains the additional need to buy the meters to measure NO_X.

2.4.2 Costing for Scenario 1

In addition to the costs of the current in-service test (costed at £7.30/test) this scenario requires the purchase of meters to measure NO_X. However, this is in the context of meters already being required to measure λ, CO and HC. Consequently the price is not that of a stand-alone NO_X meter but of adding NO_X measurement capability to the existing meters. Discussions with meter manufacturers have indicated a price of around £500/instrument would be a reasonable budgetary estimate for this upgrade.

When costing the measurement of NO_X for low emission diesels it was agreed that the capital costs of the meters should be annuitised over 5 years. Applying a discount rate of 3.5% this gives an annual depreciation cost of £110.70 per test station per year.

The total cost of an I&M programme based on this scenario, the incremental cost relative to the current programme, and the total cost expressed as a price per test are given in Table A4.5, Table A4.6 and Table A4.7, respectively.

2.4.3 Costing for Scenario 2

This scenario is that of Scenario 2 for λ, CO and HC **plus** the requirement for NO_X meters. Consequently the costs are identical to those for Scenario 2 as tabulated in Table A4.2 and Table A4.3 **plus** the additional cost associated with the NO_X meters, see Scenario 1 of Table A4.6.

2.4.4 Costing for Scenario 3

Like Scenario 2, above, this scenario is that of Scenario 3 for λ, CO and HC **plus** the requirement for NO_X meters. Consequently the costs are identical to those for Scenario 3 as tabulated in Table A4.2 and Table A4.3 **plus** the additional cost associated with the NO_X meters, see Scenario 1 of Table A4.6.

Table A4.5 The total cost of testing for NO_X for various scenarios

Year	2005	2010	2015
Scenario 1	£136.4 M	£146.6 M	£147.5 M
Scenario 2	£183.9 M	£197.5 M	£198.7 M
Scenario 3	£378.3 M	£398.6 M	£400.4 M

Table A4.6 The incremental cost of testing for NO_X for various scenarios

Year	2005	2010	2015
Scenario 1	£2.1 M	£2.1 M	£2.1 M
Scenario 2	£49.6 M	£53.0 M	£53.3 M
Scenario 3	£244.0 M	£254.1 M	£255.0 M

Table A4.7 The cost of testing for NO_X for various scenarios expressed as a cost per test

Year	2005	2010	2015
Scenario 1	£7.41	£7.41	£7.41
Scenario 2	£10.00	£9.98	£9.98
Scenario 3	£20.57	£20.14	£20.10

2.5 COSTS OF REPAIR

In Section 3.6 of the Phase 1 study (Reference 2) the frequency of the occurrence of faults was analysed. These data were used to apportion various repair options and costs to vehicles that failed the annual emissions test (see Table 2 of Appendix 5 in the Phase 1 report). It is assumed here that the proportion of the failed vehicles requiring each repair is unchanged.

The Phase 1 study assumed 5.0% of the vehicles tested failed on emissions, based on a 1998 TRL report[8]. Data from the DfT's 28th edition of Transport Statistics of Great Britain (Table 3.13) gives the total number of petrol passenger cars failing the emissions part of the MOT test as around 6.5% for 1998. The lower figure reported by TRL almost certainly arises because that study considered exclusively vehicles fitted with TWCs, where as the 6.5% DfT figure is for all petrol cars. Therefore the 5% figure appears correct for that date.

[8] An analysis of emissions data from the MOT test, TJ Barlow, RS Bartlett and ICP Simmons, S140C/VB, Transport Research Laboratory report PR/SE/474/98, August 1998.

The data for 2001/2 gives a failure rate of 3.1%. Again it is probable that the frequency of failure of the older, pre-Euro I vehicles will be higher than for vehicles fitted with TWCs. However, the passing of time means that the pre-Euro I proportion of the fleet has diminished significantly, from just over 50% to between 20 and 25%. Therefore in this cost effectiveness analysis it is assumed that 3.0% of vehicles fail the in-service test on emissions, and it is the repair of this proportion of the fleet that is calculated here.

Using the same approach as was used in the Phase 1 study, but with these updated failure statistics, the average repair bill, and the projected cost of repairing petrol vehicles which fail the annual emissions test are given in Table A4.8 and Table A4.9, respectively.

Table A4.8 Costs of repairing gasoline vehicles, which fail the annual emissions, test

% of failures	Repair	Cost	Weighted cost
20%	minor adjustments or repair,	£0	£0.00
35%	new λ sensor	£150	£52.50
25%	new exhaust system	£250	£62.50
15%	new catalyst	£300	£45.00
5%	new ECU	£700	£35.00
	Average repair bill		**£195**

Table A4.9 Projected annual costs of repairing gasoline vehicles which fail the annual emissions test

	1998	2005	2010	2015
Number of tests (1000s)	8,905	18,391	19,795	19,915
Number of vehicles failing test (1000s)	267.15	551.73	593.86	597.46
Cost of repairing vehicles	£52.1 M	£107.6 M	£115.8 M	£116.5 M

These figures are 0.80 times the cost of the testing. (For 100 vehicles tested at a £730 cost, 3% fail and require an average £195 spending to repair them, i.e. £585, which is 0.80 times the cost of the testing.)

3. Effectiveness calculations

3.1 INTRODUCTION

The effectiveness analysis presented in the Phase 1 report estimated the emissions savings that were realised for 1997/8 based on a TRL study of almost 2,200 MOT tests. The report also forecast the emissions savings potential of a "perfect" test for the years 2005, 2010, and 2015 based on estimates for the distribution profile of the vehicle fleet (derived from JCS data) and the NAEI forecasts on emissions (i.e. the integral under distribution function summed for a whole year).

The findings of this analysis remain valid in most respects. In terms of the NAEI forecasts there have been no significant changes in either the emissions factors used for the species considered or in the vehicle/emissions technology/miles driven forecasts.

One area where the original analysis has been revised is with regard to the effectiveness of the current test in reducing NO_X emissions. This is because the EPA data, and our own experience, indicates that repair and maintenance is more effective at reducing NO_X emissions than the JCS report indicated. Consequently, this analysis of effectiveness summarises the findings of the Phase 1 report, revising where appropriate with a justification for the revisions made.

3.2 EMISSIONS SAVINGS FOR 1997/8

The effectiveness of the **existing** in-service emissions test (as distinct from the potential that exists for savings) for petrol vehicles was estimated. The foundation of the analysis was the TRL study of nearly 2,200 MOT tests for cars fitted with TWCs. This found:

- 2.8% of vehicles tested failed because CO > 0.3% at high idle, and
- 2.3% of vehicles tested failed because λ was outside its prescribed limits.

The CO emissions saved by the test was estimated. The calculation was based on the following assumptions.

- The maintenance of vehicles which failed the test with high CO readings does lead to a reduction in their on-the-road CO emissions, but the maintenance of vehicles with high λ does not.
- Vehicles whose high idle CO concentrations are above 0.3% are rectified such that on retest their CO concentration equals 0.3%.
- The extent to which the high idle CO concentration is above 0.3% is equal to the excess emissions for the vehicle on-the-road.

The justification for using these assumptions is discussed in Appendix 5 of the Phase 1 report (page 5 and onwards). The conclusion of the analysis was that repairing the high CO emitters "led to an emissions reduction of 44.5% of the original cumulative CO emissions total". In the context of the NAEI it was concluded “ the 44.5% reduction corresponds to 1,070 ktonnes of CO”.

The reduction in hydrocarbon (including benzene and 1,3 butadiene) and NO_X emissions generated by the existing test could not be calculated directly because these species were not measured directly. Instead they were estimated from the CO emissions using the methodology:

1. The emissions savings generated from maintenance for CO, HC (generically) and NO_X as reported in the JCS study were used to define a CO:HC:NO_X ratio.
2. These emission savings were scaled to a 44.5% CO reduction (the figure calculated from the TRL study).
3. The HC and NO_X savings reductions, calculated above, were then applied to the NAEI emissions for non-methane volatile organic compounds (NMVOCs), benzene, 1,3 butadiene and NO_X.

The data for steps 1 and 2 above are given in Table A4.10 using both the JCS data (as in the Phase 1 report) and US EPA data (as discussed in Appendix 3 of this report).

Table A4.10 Calculation of HC and NO_X reductions

	CO	HC	NO_X
JCS emissions before maintenance	100%	100%	100%
JCS emissions after maintenance	60.9%	73.9%	95.7%
Savings relative to the maintained fleet for JCS data	64.2%	35.3%	4.5%
Savings relative to the maintained TRL data	44.5%	24.5%	3.1%
EPA emissions before maintenance	100%	100%	100%
EPA emissions after maintenance	41.7%	58.5%	66.2%
Savings relative to the maintained fleet for EPA data	140.0%	70.9%	51.1%
Savings relative to the maintained TRL data	44.5%	22.6%	16.3%

The CO data are scaled to be that calculated above from the TRL data. The hydrocarbon savings predicted are similar (24.5% from JCS data and 22.6% from EPA data). However the NO_X savings are distinctly different (3.1% from JCS data and 16.2% from EPA data). In Appendix 3, and Chapter 4, it was concluded that the JCS conclusion that NO_X emissions are principally unaffected by maintenance are too pessimistic. Therefore instead of the very modest 3.1% reduction used in the Phase 1 report, the figure used here is 15%.

This leads to a revised inventory for the reduction in emissions achieved by testing in 1998 as shown in Table A4.11.

Table A4.11 Emissions inventory and reduction of emissions achieved for 1998

Species	NMVOCs	Benzene	1,3 butadiene	NO_X
1998 inventory for TWC petrol vehicles (k tonnes)[9]	98.7	5.8	1.0	146
Savings for the maintained fleet from TRL data	24.5%	24.5%	24.5%	15.0%
Reduction in emissions achieved (TRL data)	32.0 kt	1.88 kt	0.33 kt	25.76 kt

3.3 EMISSIONS SAVINGS POTENTIAL FOR 2005, 2010 AND 2015

The methodology for calculating the emissions savings potential for each pollutant was:

1. to select the model's parameters (possibly to fit some data)
2. to select the pass/fail criterion
3. to compute the fraction of vehicles above and below the emissions pass/fail criterion
4. to compute the fraction of the total emissions from the vehicles above and below the emissions pass/fail criterion
5. to compute a new revised total of emissions if all failing vehicles (those above the threshold) emitted at a lower rate (e.g. the pass/fail level)
6. to express the emissions reduction in terms of the percentage increase to the revised total of emissions for rectified vehicles
7. to find the NAEI prediction for the selected pollutant for each selected year
8. to multiply the NAEI figure by the emission reduction from 6 above, to convert from percentage of a normalised whole to ktonnes/year.

The first four steps of the analysis used the model and the resulting numbers of excess emitters as developed in Chapters 3 and 4 of the Phase 1 report. Step 5 requires the setting of an emissions level for the rectified vehicles. This was taken as 67% of the pass/fail limit, one of the values used in the sensitivity analysis presented in the Phase 1 report.

This leads to emissions savings potentials, expressed as a percentage of the cumulative emissions as shown in Table A4.12. The overall resulting emissions savings potentials in k tonnes are given in Table A4.13 (these are the same values as were given in Table 6 of Appendix 5 of the Phase 1 report).

Table A4.12 Emissions savings potentials, expressed as %

	Repaired value = 0.67x pass/fail limit
NO_X	48.50%
Hydrocarbons	26.20%
CO "Total" sample	119.40%
CO "Random" sample	9.80%

[9] Emissions data in this Appendix on Cost Effectiveness are taken from the 1999 NAEI Road Transport Emissions Projections. This is the most recent data available, and is used in preference to slightly older data given in Appendix 3 of the report.

Table A4.13 Emissions savings potentials, expressed as k tonnes

	NAEI emissions inventory projections (k tonnes)			Emissions savings potential (k tonnes)		
Year	2005	2010	2015	2005	2010	2015
NO_X	170.7	126.2	106.0	82.8	61.2	51.4
NMVOCs	132.0	117.7	110.9	34.6	30.9	29.0
Benzene	6.51	5.53	5.10	1.71	1.45	1.34
1,3 butadiene	1.37	1.06	0.93	0.36	0.28	0.24
CO Total sample	1,708	1,389	1,171	2,039	1,658	1,398
CO Random sample	1,708	1,389	1,171	167	136	115

4. Cost effectiveness calculations

In preceding sections of this appendix the costs of various scenarios and the emissions savings potential were calculated for the years 2005, 2010 and 2015. From these the cost effectiveness can be calculated.

An important difference is a change in the units of cost effectiveness used in this report, relative to those used in the previous report. This report uses **£ that need to be spent per tonne saved**, as opposed to grams saved per £ spent. Therefore the cost effectiveness values given in this report are reciprocally, rather than directly, related with those of the Phase 1 report.

A further important consequence of this change is that care should be excercised when interpreting relative changes. A cost effectiveness of £200 /tonne is **larger** than £50 /tonne. However, environmentally the **larger** cost effectiveness figure is the **less** desirable.

Further factors to be remembered are that:

- The cost effectiveness values given are not exclusive because the cost of, for example, £100,000 to save 1 tonne of benzene for the current test is **not the sole benefit**. The test also leads to savings for 1,3 butadiene, other hydrocarbons, CO and NO_X.
- The cost effectiveness presented in Table A4.14 is calculated from the emissions savings potentials, i.e. represent the maximum possible for a “perfect” in-service test.

Given the caveats above regarding the interpretation of the data, the maximum cost effectiveness of the various test scenarios are given in Table A4.14.

Table A4.14 Resulting maximum cost effectiveness of emissions testing

2005	Scenario 1	Scenario 2	Scenario 3
CO Total sample (£/tonne)	66	89	184
CO Random sample (£/tonne)	804	1,089	2,252
NMVOCs (£/tonne)	3,880	5,254	10,872
benzene (£1000s/tonne)	78.5	106.3	220.0
1,3 butadiene (£1000s/tonne)	372.9	505.0	1,044.9
NO_X costs from λ, CO HC test (£/tonne)	1,621	2,195	4,543
NO_X costs from NO_X test (£/tonne)	1,647	2,221	4,568
2010	Scenario 1	Scenario 2	Scenario 3
CO Total sample (£/tonne)	87	118	239
CO Random sample (£/tonne)	1,063	1,437	2,916
NMVOCs (£/tonne)	4,677	6,324	12,833
benzene (£1000s/tonne)	99.7	134.8	273.5
1,3 butadiene (£1000s/tonne)	516.1	697.9	1,416.2
NO_X costs from λ, CO HC test (£/tonne)	2,361	3,193	6,479
NO_X costs from NO_X test (£/tonne)	2,396	3,227	6,514
2015	Scenario 1	Scenario 2	Scenario 3
CO Total sample (£/tonne)	104	141	285
CO Random sample (£/tonne)	1,264	1,709	3,463
NMVOCs (£/tonne)	5,013	6,778	13,733
benzene (£1000s/tonne)	108.5	146.7	297.2
1,3 butadiene (£1000s/tonne)	605.8	819.0	1,659.5
NO_X costs from λ, CO HC test (£/tonne)	2,828	3,824	7,748
NO_X costs from NO_X test (£/tonne)	2,869	3,865	7,789

(If the data for Scenario 1 for the three chosen years is converted from £/tonne to units of grams saved per £ spent, the data in the table above is very similar to that given in the Phase 1 report, i.e. Table 5 of Appendix 5.)