Implementation of Lambda measurement in Pollution Under Control (PUC) certification programme in Delhi

EPCA Report No. 22 (July 2006)

In Response to the Hon'ble Supreme Court Order Dated May 05, 2006

(In the matter of W.P.(C) No.13029 of 1985; M.C. Mehta v/s UOI & others)

1. This report is in continuation of Report No. 20, May 2006. The report contains an assessment of the lambda data generated in the ongoing pilot programme to propose the lambda cut point for enforcement under PUC.

2. The report has examined the lambda specifications provided by the vehicle manufacturers. It has assessed the adequacy of the justifications provided by the car manufacturers for the lambda values that are at variance with the internationally accepted default lambda cut point of 1$\pm$ 0.03 that are applied in programmes in other countries.

3. It has assessed the performance of the in-use petrol cars with regard to internationally accepted cut point 1$\pm$ 0.03 which is also the default value to test cars in various I/M programmes.

4. The report discusses the concerns regarding the implementation of the lambda and suggests the way ahead.

Environment Pollution (Prevention & Control) Authority

for the National Capital Region

EPCA's mandate

The principal concern of the Hon'ble Supreme Court with regard to the implementation of the lambda test in the PUC programme has been to take the decision on the cut point for lambda value. The Hon'ble Court in its order of November 29, 2005 had given the following direction:

"At this stage, it is not in question that it is essential to implement the Lambda Test and, therefore, it is necessary to introduce the technology at the P.U.C. Centres so that they are in a position to undertake such a test. The question as to what shall be the cut-points, i.e, 0.03, 0.05, 0.07 or 0.09, would be examined after the technology has been installed at the P.U.C. Centres. Meanwhile, the pilot tests can also go on so that when the technology is introduced, this Court is also in a position to know the further results of the pilot tests and keep that also in consideration while fixing the cut-points."

To expedite the process the Hon'ble Supreme Court has also directed the Society for Indian Automobile Industry (SIAM) to submit the lambda specifications of the different car models of the vehicle manufacturers. The May 05, 2006 order directs:

"We have perused the Report No.20 regarding implementation of Lambda under P.U.C. programme in Delhi.

The learned counsel appearing for S.I.A.M. states that specifications for Lambda value of all vehicles will be supplied to E.P.C.A. within one week.
E.P.C.A. may give final report within three months. Society of Indian Automobile Manufacturers (S.I.A.M.) and Automotive Research Association of India (A.R.A.I.) will cooperate with E.P.C.A."

Following these court orders SIAM has submitted the manufacturers specifications to EPCA. In the meantime, the Delhi transport department has also submitted lambda data that were generated during the pilot lambda tests carried out in PUC centers in Delhi to EPCA.

The process initiated by EPCA

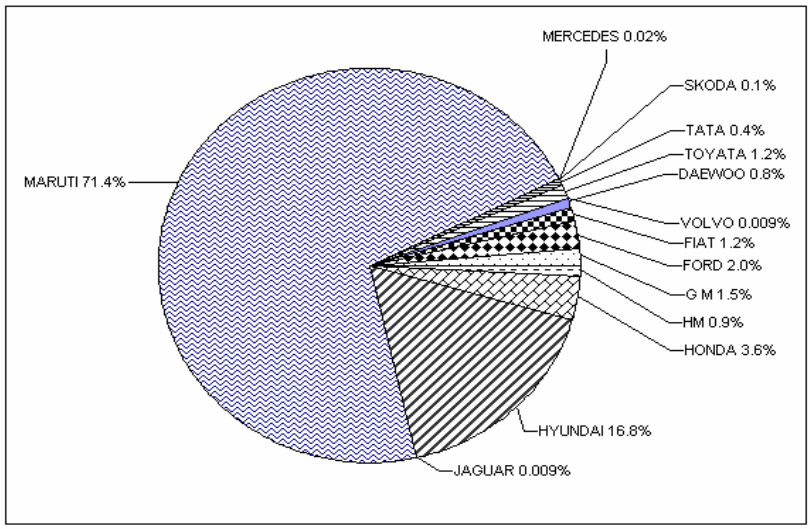
EPCA has carried out the following assessment to expedite the decision on lambda cut point:

I. Performance of the in-use vehicle fleet if the internationally accepted lambda value of 1$\pm$ 0.03 (in the range 0.97-1.03) for stoichiometric petrol cars fitted with three-way catalytic converters is applied.

II. Assess the adequacy of the justifications provided by the car manufacturers for the lambda values that are at variance with the internationally accepted value.

III. Propose an action plan to address some operational issues with regard to lambda implementation especially those that may affect lambda values during operation as expressed by SIAM.

EPCA has analysed lambda data for a sample size of 10,767 petrol passenger vehicles that were tested during March – May 2006 in 79 PUC centers across Delhi. The data for 166 cars had to be removed due to high error level in calculated and indicated lambda. The data set reflects the vehicle models of 15 manufacturers. The make-wise distribution of cars indicates that the majority of cars are of Maruti Udyog Ltd (nearly 71 per cent), followed by Hyundai (17 per cent), Honda Siel (4 per cent) and Ford (2 per cent). These four manufactures constitute around 94 per cent of cars in the sample. This is broadly indicative of the size distribution of various makes and models of different manufacturers in the Delhi fleet.



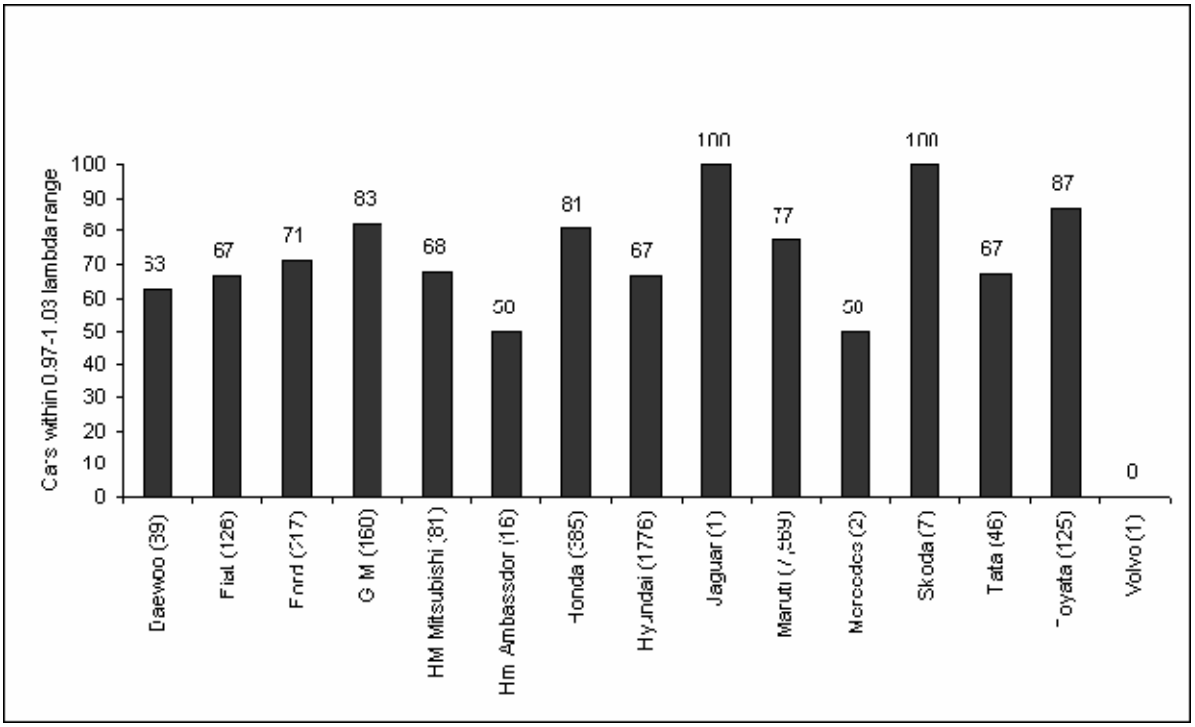
Key observations

i. Performance of the in-use fleet when the international default value of 0.97-1.03 is applied

The lambda value of the sample fleet was compared with the internationally accepted limit of 1± 0.03 for stoichiometric petrol engines fitted with closed loop system and three-way catalytic converters. Nearly 25 per cent of vehicles could not meet this limit.

There is variation in the performance across the makes and models of different manufacturers -- Maruti shows 77 per cent pass rate, Fiat, Tata Motors and Hyundai individually show a pass rate of 67 per cent, Toyota 87 per cent, General Motors 83 per cent, Honda 81 per cent and so on (See graph). In some cases available sample size is very small. Of the two Mercedes Benz cars shows a pass rate of 50 per cent.

Graph: Percentage of cars of different manufacturers meeting the international norm of lambda value of 1± 0.03



Note: The bracket with the makes name has the number of cars for which lambda data analysed

- EPCA would like to point out that the review of the international regulatory literature and practices show that in any inspection and maintenance programme the failure rate of 20-25 per cent is considered tolerable for enforcement. From that perspective, adoption of 1± 0.03 as the lambda cut point for enforcement will not create any undue pressure for repair or cause public outcry.

ii. Observations on the lambda specifications provided by the vehicle manufacturers

Some countries – as in those under European Commission – allow manufacturers to provide specification for lambda values unique to specific models only if it is technically justified. In such cases, the specific in-use models are tested against the limits proposed by manufacturers. SIAM in its submission of May 11, 2006 to the EPCA, has given specific lambda values of eleven manufacturers. It shows that vehicle models of six manufacturers (Ford, Honda, Hyundai, Mercedes Benz, Skoda, Toyota) already confirm to the internationally accepted range of 1± 0.03. Remaining manufacturers including Maruti Udyog Ltd, Tata Motors, General Motors, Fiat and Mahindra & Mahindra (M&M) have proposed the following specifications.

- Maruti has proposed 0.95 - 1.07, which is unusually wide and for the small cars considerably on the lean side.
- General Motors and Fiat have proposed a lax limit of 0.95 - 1.05.

- Tata Motors has proposed different specifications for BS III and BS II models -- 0.95 - 1.05 for BS III models and 0.93 -1.07 for BS II models. It is strange that Tata Motors has linked its lambda limits with mass emissions standards.
- Mahindra &Mahindra has proposed 0.93 - 1.07 for its petrol SUV model of Scorpio.

Table: Summary of Lambda specifications provided by manufacturers

Make	No. of models	Lambda specification						RPM	
		<-- Rich (Probability for high CO and HC)		Desired limit		Lean→ (Probability for high NOx)			
		0.93	0.95	**0.97**	**1.03**	1.05	1.07	Min.	Max.
1. Ford	4							NA	
2. Honda	8							2,250	2,750
3. Hyundai	All BSII & BSIII							2,400	2,600
4. Mercedes Benz	5							2,500	2,500
5. Skoda	3							2,850	2,900
6. Toyota	9							2,500	
7. General Motors	8							2,500	2,500
8. Maruti	11							2,000	2,500
9. Fiat	5							2,000	2,500
10. Tata Motors	2 BS III models							2,000	2,500
	1 BS III model							2,000	2,500
	2 BS II models							2,000	2,500
	1 BS II model							2,000	2,500
11. Mahindra & Mahindra	1							2,000	2,500

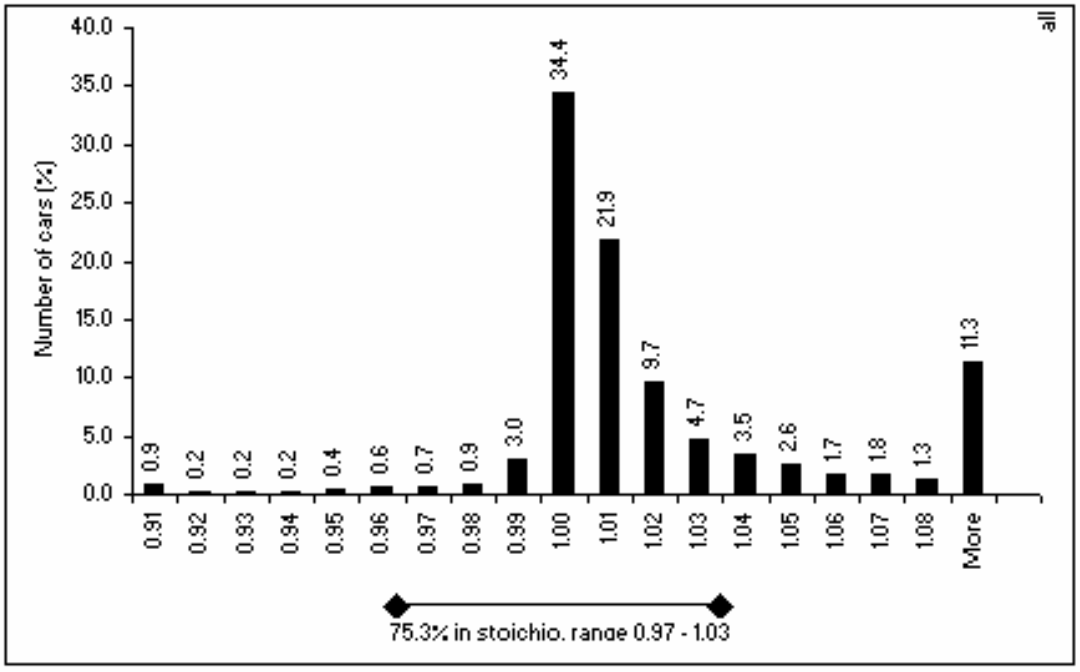
Among the manufacturers who have asked for lax limits, Maruti has sought relaxation asymmetrically -- more on the lean side, while Tata Motors, and Mahindra and Mahindra, have asked for a wider margin on both lean and rich side.

EPCA would like to reiterate the fact that for stoichiometric petrol engines the lambda value is approximately one. As the air-to fuel ratio becomes rich in fuel the lambda value becomes lower than one which increases carbon monoxide and hydrocarbon emissions. When lambda exceeds one the air to fuel ratio is lean which increases nitrogen oxide emissions. For a well tunes properly maintained vehicle the ideal lambda value should be 1±0.03 or in the range of 0.97 – 1.03 as per international norms and practices. In this range the emissions of all the three critical pollutants – CO, HC and NOx are optimally reduced.

EPCA would like to make special note of the fact that the analysis of the survey results shows that most of the cars are running on lean air to fuel mixture tuning (lambda value more than 1). (*See Graph: Distribution of lambda values of all cars*). In fact of all the cars that are outside the range of the internationally accepted lambda limit, as many as 88 per cent of these vehicles are on the lean side. Lean conditions in three-way cat equipped car can indicate high NOx emissions. It is quite possible that the cars in India are being tuned on the lean side to improve fuel efficiency but at the cost of high NOx emissions – as under lean conditions the three-way catalytic converter will not be as efficient in reducing the NOx in the exhaust emissions.

Graph: Distribution of lambda values of all cars

Majority of the cars failing to meet the international default limit are on the leaner side. This can be a contributory factor towards high NOx emissions



What difference would the manufacturers' specification make to the failure/pass rate?

EPCA has also assessed the performance of the fleet on the basis of the specifications provided by the vehicle manufacturers for their respective models. After applying the manufacturers specification to the respective company's makes and models in the sample EPCA has come to the conclusion that the improvement in the pass rate is not significant. Overall, the application of the manufacturers specifications improves the total compliance rate by around 7.7 per cent from the pass rate that would otherwise accrue on account of international default limit (With manufacturers' specification the pass rate improves from 75.37 per cent to 83.07 per cent). The performance in individual cases is as follow:

ii. The pass rate for Maruti cars improves from 77.26 per cent to 87.70 if their own specification is applied from that noted when the

international default lambda limit is applied (10.4 per cent improvement).

iii. The pass rate for GM cars improves from 82.5 per cent to 88.13 (an improvement of 5.63 per cent).

iv. For Fiat cars, the pass rate improves from 66.67 per cent to 75.40 (an improvement of 8.7 per cent).

v. For Tata Motors, the pass rate in BS II cars improves from 67.39 per cent to 80.43 (an improvement of 13.04 per cent). A few BSIII cars present in the sample are well within the international default limit.

How have manufacturers justified their specifications?

The five companies have given different reasons for seeking wide lambda window.

ii. Fiat India Ltd states that in the production stage they follow the default limit of 1± 0.03. But they still want to recommend 5 per cent variation from this range for enforcement (0.95 -1.05), as according to them, adulterated fuel, servicing of vehicles, and faulty lambda measurement may cause variation in lambda measurement.

iii. GM has also proposed 0.95-1.05 and has given similar reasons. According to them, the in-use vehicles may sometimes depict lambda value beyond the international default value of 1± 0.03 because of improper maintenance that may lead to minor leakage in the system, fuel adulteration that may make engine run on improper stoichiometric ratio causing variation in lambda value, improper calibration of PUC instruments and so on. GM has therefore proposed a lax lambda limit of 0.95 -1.05 and suggested subsequent review in the future vis a vis 0.97-1.03 (1± 0.03).

iv. Maruti Udyog Limited has reasoned that as per European Commission's Directive 98/69/EEC, the manufacturers deduce the lambda values based on their field surveys within 24 months after the vehicle is type approved for lambda. However, based on a survey of 798 cars (after removing data of 67 cars in which cause of variation in lambda was identified but not disclosed) Maruti has proposed the limits as 0.95-1.07.

v. Tata Motors has proposed a wide limit of 1± 0.05 for BS III vehicles and 1± 0.07 for BS II vehicles. It is strange that the company has proposed lambda value according to mass emissions standards. The company has cited the following reasons to justify its claim: -- different emission control strategies, optimum combination in terms of emissions control unit (ECU), type and location of lambda sensor and catalytic converter size, precious metal loading and loading. The company states that its export of cars to Europe has started mainly with Euro III configuration and the volumes are very low and they will specify the similar lambda values for these applications. It has further informed that for its City Rover cars marketed in UK, the M/s M G Rover has specified specification in the range of 0.95-1.09. To justify their claim TATA has provided UK data for various car models that have been allowed wide lambda range. But they have not given the technical details on the basis of which these have been accepted as manufacturers specification in UK.

vi. Mahinda & Mahindra has given a wider limit of 0.93-1.07 for its Scorpio Petrol vehicles. They have justified it on the ground that they do not have prior data on the range of lambda before putting these vehicles to use in field as there is no need for measurement of lambda at the time of type approval. They have reiterated the

provision in the EU directive 98/69/EC on the need for manufacturer to confirm accuracy of the lambda value recorded at the time of type approval. So in the absence of such data collected for their vehicles in the filed they are not able to commit to the default lambda limit of 0.97-1.03. They propose to get some field data and study the level of variation and gradually reduce the window if required to 0.97-1.03. However, it is important to note that this model is now out of production and there are very few models in Delhi.

Addressing the issues raised by the manufacturers

EPCA would like to make the following observations regarding the justifications provided by the five companies for seeking lax lambda limit:

Justifications for lax lambda limit fall in two categories. Most manufacturers have cited extraneous reasons like fuel adulteration and poor maintenance of vehicles as the reason for seeking lax lambda limits. Maruti has proposed lambda window based on its own survey of cars and Tata Motors has mentioned some technical parameters as reasons for proposing lax lambda limit for their models but they have not given technical reasons for it.

i. Addressing technical justifications

Only Maruti has carried out field survey to arrive at a lambda value for their fleet. It is not clear why Maruti is proposing such a wide lambda range. EPCA has also reviewed the data for the same sample of cars provided by Maruti and has found that 98 per cent of cars (after excluding those in which assignable causes of lambda failure were identified by the company -- if these defaulting cars are included then it would be 10 per cent) already have lambda values within the international default lambda limit of 1 ± 0.03.

Only two percent cars appear to be the deciding factor in proposing such a lax range of 0.95-1.07. The company however, has not explained the reason for the two per cent cars not meeting the default limit of 0.97-1.03. But it is important to note that 98 per cent of their cars meet the internationally accepted limit. In that sense norms cannot be relaxed to make allowance for two per cent of cars that aim to pass nearly 100 per cent vehicles.

Tata Motors has cited some technical parameters and design of their vehicles as the reason for seeking more lax range. But adequate technical details are not available for assessment of the adequacy of the claims.

ii. Addressing extraneous reasons

Fuel adulteration cannot be the scapegoat: Among the five carmakers who proposed lax lambda limits most of them have raised the issue of fuel adulteration to justify lax lambda limit. There are no studies available to prove this in Delhi's car fleet and even the vehicle manufacturers have not given any estimation how the lambda values would get affected in case the fuel is adulterated. However, EPCA would like to observe that lambda is a calculated value, based on a formula in which values of CO, HC, CO_2, and O_2, are measured and the ratio of hydrogen to carbon and oxygen to carbon are taken as fixed values. These ratios can change if petrol is adulterated.

But EPCA would like to emphasise a larger issue. Fuel adulteration can not be used as a bogey to stop lambda implementation as fuel adulteration, if it is still a problem in Delhi would affect a whole range of engine and emissions parameters in the vehicles. It can corrode engine parts, clog injectors, affect emissions, destroy emissions control components among

others. In that case the implementation of the entire vehicle inspection programme will have to be scrapped. Solution does not lie in relaxing the limit of lambda but in ensuring that petrol does not get adulterated. Therefore, enforcement agencies and oil companies will have to be made responsible for checking this menace.

Role of maintenance and repair: Many manufacturers have stated that the customers may not follow manufacturer's recommended servicing schedule and may opt for roadside mechanics instead of dealers point for servicing. Poor maintenance will cause variation in lambda measurement. EPCA would like to note that the purpose of enforcing lambda measurement is to ensure disciplined maintenance, and to remedy problem of leakage and other maladies in the system. Therefore, enforcement of lambda will serve that purpose. For overall performance of the PUC programme Delhi government should license and authorize repair shops and garages and take action against unauthorized garages. Moreover, once lambda is brought within enforcement ARAI and automobile companies should carry out root cause analysis of common faults and review repair options in vehicles to expedite the process of implementation and create public awareness.

Variation in lambda due to improper measurement at the PUC center: Under directions of EPCA a joint audit team of ARAI, SIAM, CSE and Delhi transport department surveyed and audited around 20 PUC centers in Delhi in June. During the audit it was observed that the PUC centers are now well versed with the procedure of measuring of lambda. But the process of training must continue and automobile companies, Delhi transport department and instrument suppliers must play an active role to ensure that there is no deviation in the measurement protocol. For example, some PUC centers do not have proper extension pipes. Delhi transport department must ensure use of proper extension pipes and that there is no air entrainment while testing cars, which can affect lambda.

EPCA would like to emphasise further that six other manufacturers including Ford, Honda, Hyundai, Mercedes Benz, Skoda, and Toyota who already adhere to the internationally accepted limit value have not given these extraneous reasons.

Final Observations EPCA

i. It is important to note that the Delhi government has already initiated a pilot scheme of a massive scale to build the facilities for lambda testing in all the PUC centers to smoothen the process of lambda implementation. Accordingly, instrument certification and deployment of instrument in all PUC centers have been carried out by the all concerned agencies – PUC operators, instrument manufacturers and certification bodies. Delhi is now ready to implement the legal provision in the Central Motor Vehicles Rules on lambda testing for Euro II and post Euro II cars fitted with three way catalytic converters. The pilot project, which has been going on for over last one year, has generated sufficient lambda data for characterization of the fleet and has given the opportunity to learn the operational issues. The city has gained considerable experience to begin lambda testing for enforcement.

ii. EPCA believes that adding lambda test in a vehicle inspection programme will help in a variety of ways. This is an important strategy that is available to keep an eye on the performance of the catalytic converters, one of the most important emissions control technologies in the vehicles. The optimal lambda value indicates that the conditions are conducive for the optimal functioning of the cat converters. Low CO and HC emissions but a disturbed lambda recorded during a PUC test is a reason enough to suspect that the closed loop system is not working properly. It is also possible that the closed loop system is okay

but there is a leakage in the exhaust pipe. Lambda test also ensures that the PUC tests have been carried out properly. If the vehicle is in the lean mode NOx emissions can be high.

It is also important to note that currently, there is no in-use compliance requirement for the vehicle manufacturers to ensure that they meet the durability requirements during the useful life of the vehicles. As a result of these there is no pressure on the manufacturers to pay attention to the quality of the emissions control systems to make them last. Therefore, strengthening of the in-use emissions regulations will compel manufacturers to make qualitative improvements.

iii. The only impediment to the enforcement of lambda in the PUC programme that now remains is the decision on the cut point for the lambda limit to be used for enforcement. In this regard EPCA would like to make the following recommendations based on its own assessment of the performance of the vehicles fleet during the pilot project and the various submissions made by the industry and other agencies:

Recommendations

1. Adopt the international default lambda limit of 0.97-1.03:

Dilution of the internationally accepted lambda limit of 0.97-1.03, applied widely in vehicle inspection programme in other countries, is not needed for enforcement of lambda in the PUC programme in Delhi. EPCA is convinced from the results of the pilot study in Delhi that the lambda value of 0.97-1.03 can be adopted for enforcement. Already 75 per cent of cars are in compliance. About 25 per cent failure rate has been noted which is considered tolerable for any I/M programme.

Across all countries wherever lambda is part of the in-use inspection programme, the governments use this limit value of 0.97-1.03 for implementation along with other emissions tests, unless manufacturers provide specification for any specific model (See annexure 1). This value is drawn from the principle that technically all stoichiometric petrol vehicles that are fitted with three-way catalyst and equipped with closed loop control need to have this lambda window to minimize the emissions of CO, HC and NOx simultaneously and efficiently. In fact EPCA notes with concern that nearly 88 per cent of cars that are outside this limit of 0.97-1.03 are on the leaner side, which can be a contributory factor towards high NOx emissions.

The car manufacturers were given the opportunity to submit the manufacturers specifications and also justify them. The submissions of 6 car manufacturers – Ford, Honda, Hyundai, Mercedes Benz, Skoda, and Toyota -- to the EPCA show that they already adhere to the internationally accepted value of 0.97-1.03.

Five manufacturers – Maruti Udyog Ltd, Tata Motors, General Motors, Fiat, and Mahindra & Mahindra, -- have deviated from the default value and have proposed more lax limit. But the majority of them have justified their claims on the grounds of extraneous factors like poor maintenance practices, fuel adulteration and the problem of inaccurate tests in PUC centers.

EPCA is of the view that the limit 0.97-1.03 cannot be diluted on these grounds. If fuel adulteration is still a problem in Delhi it can affect a wide range of engine and

emissions parameters and not just lambda. Therefore, if fuel adulteration is considered as the deciding factor then the vehicle inspection programme would have to be scrapped. The solution lies not in blocking adoption of lambda but in controlling the problem of adulteration. Moreover, the car manufacturers who are already adhering to the limit value of 0.97-1.03 have not considered these factors to be a hurdle.

It is important to note that the enforcement of lambda is targeted to improve the overall maintenance and repair regime. Therefore, a wide range of factors that can make lambda go off spec -- leakage in exhaust pipes, faulty closed loop system, poor quality sensors among others etc, are expected to get addressed if lambda test is enforced. Therefore, the overall the programme will benefit from lambda implementation as part of the overall in-use emissions tests.

Specifically with regard to the justification for wide lambda limit provided by Maruti Udyog Ltd based on its own field survey, EPCA has found it curious that the company should seek such a wide margin to accommodate only two-percent cars (after excluding those in which assignable causes of lambda failure have been identified – if these are included then it is 10 per cent). This means that the proposal for 0.95-1.07 is targeted to pass almost the entire fleet. This is not acceptable for a norm setting process. Moreover, EPCA's independent survey and analysis of PUC data for Maruti cars shows 23 per cent failure rate if the default limit is considered. This is acceptable as a normal failure rate in a vehicle inspection programme.

EPCA has taken note of the technical factors that have been cited by Tata Motors for a wider lambda window, such as emissions control strategies, ECU, type and location of lambda sensor etc, but these have not been explained adequately to justify a wide range.

EPCA therefore recommends the limit value of 0.97-1.03 for implementation. This is considered optimal value for stoichiometric petrol vehicles that are fitted with three-way catalyst and equipped with closed loop control to minimize the emissions of CO, HC and NOx simultaneously and efficiently.

2. The government of national capital territory of Delhi be directed to enforce lambda as a regulatory measure from October 1, 2006:

Delhi government should implement lambda as part of the PUC programme from October 1, 2006. Lambda test should be enforced along with two-speed idle tests for emissions. Currently, emissions of CO and HC are tested at low idle speed and lambda at high idle speed. But this is not adequate. CO emissions should also be tested on high idle speed. The internationally accepted limit for high idle CO is 0.3 per cent. The measurement of CO and HC at high idle is more effective in indicating whether the catalytic converter is functioning or not.

Moreover, testing of CO emissions at the high speed idle can also act as a safeguard against fraud in which the emission measurement probe can be adjusted for getting the right emissions values during the low idle test by diluting the exhaust and a right lambda value separately obtained at high idle speed.

3. Periodic review:

EPCA will continue to oversee this programme and review it from time to time. Vehicle manufacturers should inform EPCA about their observations and experience in the operationalisation of the lambda regime in the city.

Annexure 1

Table: An overview of Lambda specification in I/M Programmes in some countries

Country		Test Mode	Limits
Austria	No cat:	IDLE	CO 3.5%
	3-Way cat:	FAST IDLE	CO 0.3% Lambda 1+/-0.03 + Lambda circuit check
European Commission	3 way cat + lambda-probe controlled[1]	IDLE	CO 0,5 % vol. & 0,3 % vol.[2]
		FAST IDLE	CO 0,3 % vol. & 0,2 % vol.[3] Lambda: 1± 0,03 Or in accordance with MS.
UK	Exhaust Emissions S.I, All vehicles used on or after Sept 1, 2002	CAT test as per Vehicle specific limits[4] Or CAT test by using default limits:	
		FAST IDLE 2500 – 3000 RPM Min oil temp 60^{o}C	CO <= 0.2% HC <= 200 ppm Lambda 0.97 – 1.03
		IDLE 450 – 1500 RPM	CO <= 0.3%
Hong Kong	On or after January 1, 1992	IDLE	CO 0.5%
		FAST IDLE	CO 0.3% and Lambda 1+/-0.03
Philippines	New vehicles registered on or after January 1, 2003	IDLE	CO 0.5% HC 100 ppm
		FAST IDLE	CO 0.3% Lambda 1 +/- 0.03
Finland	Low emission vehicles	IDLE+FAST IDLE	CO 0.3%

			HC 100 ppm Lambda 1 +/- 0.03
Germany	No cat: 3-way cat:	IDLE	CO 3.5% CO 0.5%
	3-way cat:	FAST IDLE	CO 0.3% Lambda MS +/- 2% Or 1 +/- 0.03 + Lambda circuit check
Greece	3 way cat:	IDLE	CO 0.5% HC 120 ppm
		FAST IDLE	CO 0.3% HC 100 ppm Lambda 1 +/- 0.03
India	Bharat Stage II compliant petrol/CNG/LPG 4 wheelers	IDLE	CO 0.5% HC 750ppm

Notes:

MS = manufacturer's specification, NA = Not applicable

1. The maximum permissible CO content in the exhaust gases is that stated by the vehicle manufacturer. Where this information is not available the CO content must not exceed these limits

2. For vehicles that have been type-approved according to the limit values shown in row A or row B of the table in section 5.3.1.4. of Annex I to Directive 70/220/EEC, as amended by Directive 98/69/EC (**) or later amendments the maximum CO content must not exceed 0,3 % vol. Where identification to Directive 70/220/EEC, as amended by Directive 98/69/EC is not possible then the above shall apply to vehicles registered or first put into service after 1 July 2002.

3. Measurement at high idle speed (no load), engine speed to be at least 2 000 min-1:
CO content: maximum 0,3 % vol. and for vehicles that have been type-approved according to the limit values shown in row A or row B of the table in section 5.3.1.4. of Annex I to Directive 70/220/EEC, as amended by Directive 98/69/EC or later amendments the maximum CO content must not exceed 0,2 % vol. Where identification to Directive 70/220/EEC, as amended by Directive 98/69/EC is not possible then the above shall apply to vehicles registered or first put into service after 1 July 2002.

4. If tester finds an exact match in the analyzer database on in the in-service emissions book. Exact Match: To find an exact match in the current emissions data book, you will need the make, model and other data such as engine size, model code, engine code, VIN code or serial number.

If after normal cleaning and/or scraping processes a particular code is unreadable or inaccessible, carry on as if no exact match can be found. Test to default limits, carry out that test, but use the less demanding of either the default limits or the specific limits for any vehicle which is an exact match in everything but an unreadable code

Reference:

- *For European Union:* Anon 2003, 'Commission Directive 2003/27/EC of 3 April 2003 on adapting to technical progress Council Directive 96/96/EC as regards the testing of exhaust emissions from motor vehicles', Official Journal of the European Union, L 90/41, April, p 2.
- *For Hong Kong*: 'Exhaust Emission Test for Petrol and LPG vehicles', Environment Protection Department, Hong Kong Special Administrative Region Government, HK
- *For Philippines*: Anon 2000, 'The motor vehicle inspection program of the Philippines', Carlines, Virginia, USA, Issue 2000-4, July, p 22.
- *For UK*: 'Exhaust Emissions - Spark Ignition –All vehicles used on or after 1 September 2002', Vehicle and Operator Services Agency, An executive agency of department of transport, UK
- *For Austria, Finland, Greece, Germany*: Zissis Samaras et al 1995, 'The Inspection of In-Use Cars in Order to Attain Minimum Emissions of Pollutants and Optimum Energy Efficiency', Aristotle University, Thessaloniki, Greece, A Project funded by EC, p 31