1982 4th ASCOPE LABORATORIES TEST CORRELATION PROGRAMME ON C.F.R. ENGINE

By : Bustani Mustafa and E. Jasjfi

I. INTRODUCTION

Member countries taking part in this correlation programme are Indonesia as coordinator with seven laboratories participating, Malaysia with one laboratory, Thailand and the Philippine with two laboratories each.

The coordinator in this correlation programme is responsible in reparing the correlation samples and sending them by air to each participating laboratory.

Testing should be carried out at the same day and time specified by the programme coordinator. Testing should be carried out according to the same procedure (Bracketing Method).

The second part (4th correlation programme) was started by sending samples in March 1982. After being tested by the participating laboratories, the test results are to be sent to the coordinator for the determination of the standard deviation and other statistical data.

Based on the results, conclusion can be drawn about the deviation of laboratory test results and about outliers to be rejected. For better analysis of the results, for each of the samples for correlation it is also required to report physical and chemical tests such as specific gravity, RVP, distillation and lead (TEL) content in the receiving laboratories.

This necessary in order to take into account any possible changes in the sample properties which might have occured during transportation and storage. Also to be observed are ambient and engine operation condition during the correlation tests. The results of the analysis can then be used as a base for deviations the occurance of outliers and recomendation remidial steps to be taken.

The method used for testing the samples is the bracketing method, for rounding the value of the member found during the tests the ASA rules for rounding are used. The Grubb's rejection criteria with the use of "T" factors is used in evaluating the possible outliers.

II. CORRELATION PROGRAMME

A. *Correlation Sample*

Lemigas as coordinator, provided and prepared the correlation samples shown in Table 1.

Table 1
4th ASCOPE LABORATORY TEST CORRELATION PROGRAMME ON CFR ENGINES
Types and Codes of Sample

Type	Grade	Code
1. Commercial	Fuel High Grade	SC-01
2. Commercial	Fuel Low Grade	SC-02
3. Standardization	Toluene-Heptane	SC-03

The correlation samples were sent to participating laboratory. The amount of the correlation sample, was two liters for each grade, put into two one-liter cans; one liter cans were used in order to comply with IATA air transport regulations concerning the maximum fuel container volumes permitted for air transport of inflammable materials.

To facilitate and simplify the conduct of this programme, each sample was coded alpha-numerically according to sample type as follows; "SC number", where SC indicates sample code and number indicates sample type.

B. Participating Laboratories

The participating laboratories were similarly coded alpha-numerically as follows: "LC-number", where LC indicates laboratory code and participant's number in this correlation programme. The list of participating laboratories appears in Table 2.

Table 2
4th ASCOPE LABORATORY TEST CORRELATION PROGRAMME ON CFR ENGINES
List of Participating Laboratories

Country	Laboratory
Indonesia	1. Pertamina Refining Unit I Lab. Pangkalan Brandan
	2. Pertamina Refining Unit II Lab. Dumai
	3. Pertamina Refining Unit III Lab. Plaju
	4. Pertamina Refining Unit III Lab. Sungai Gerong
	5. Pertamina Refining Unit IV Lab. Cilacap
	6. Pertamina Refining Unit V Lab. Balikpapan
	7. Lemigas Research and Development Centre for Oil and Gas Technology P.O. Box 89/JKT Jakarta
Malaysia	1. ESSO Malaysia Berhad Port Dickson Att. : Mr. John J. Degouff Refinery Manager
Philippines	1. Bataan Refining Corporation (BRC) P.O. Box 1035 MCC Makati Metro Manila
	2. Petrophil Corporation Pandacan Laboratory P.O. Box 1031 MCC Makati Metro Manila
Thailand	1. Defence Energy Department Bangchak Refinery Laboratories Bangchak Bangkok
	2. Science Division Oil Distribution and Supply Petroleum Authority of Thailand Prakanong Bangkok

In order to facilitate communication, laboratories in each country were coordinated through a Country Coordinator.

Table 3
4th ASCOPE LABORATORY TEST CORRELATION PROGRAMME ON CFR ENGINES
List of Country Coordinators

Country	Coordinator
Indonesia	Mr. Bustani Mustafa PPPTMGB "Lemigas" P.O. Box 89/JKT Jakarta
Malaysia	Mr. Jejakumar Thangarajah Refinery Project Department Processing and Manufacturing Division

	Petronas, P.O. Box 2444 Bangunan MIDF, 195 A, Jalan Pakeliling, Kuala Lumpur Telex : Petron MA 30839
Philippines	Mr. R.S. Bernardo Petrophil Corporation 7901 Makati Avenue Makati Metro Manila Telex : 22259 PNO PH, 45270 PNOC PM
Thailand	Mr. Sawaeng Boonyasuwat Science Departmen Office of Oil Distribution and Supply Petroleum Authority of Thailand Prakanong Bangkok Telex : 87940 NGOT TH
Programme Coordinator	Mr. E. Jasjfi PPPTMGB "Lemigas" P.O. Box 89/JKT Jakarta

III. SAMPLE PREPARATION

The 1982 Correlation Programme on CFR Engines consists of two parts i.e. 3rd and 4th CFR Correlation Programmes.

For each part of the programmes the test samples and distribute them to the participating laboratories through their respective country coordinators, samples for the first phase (3rd CFR Correlation Programme) were prepared and sent to the participating laboratories in January 1982, while for the second phase (4th CFR Correlation Programme) samples were prepared to be sent in March 1982.

In each care, sample preparation consists of five stages, viz :

1. Acquisition of substances for sample preparation, materials and equipment
2. Blending of sample
3. Filling of sample into containers
4. Packing
5. Dispatch.

Each of these steps was carried out in the routine manner, but with utmost care, by LEMIGAS as the coordinating laboratory.

IV. ROUNDING RULES FOR THE TEST RESULTS

The ASA rules for rounding as pertained to this procedure can be stated simply as follows :

1. The value of the number is unchanged when the last digit to be dropped is less than 5
2. The digit proceeding the digit to be dropped is raised by one when the last digit is greater than 5
3. When the last digit to be dropped is exactly 5 and the digit proceeding it is an even digit, the 5 is dropped without change to the number.
4. When the digit to be dropped is exactly 5 and the digit proceeding it is and odd digit, the digit proceeding is raised by one.

Example :

Number		Nearest Hundredth	Nearest Tenth
1.	97,642	97,64	97,6
2.	97,237	97,24	97,2
3.	97,355	97,36	97,4
4.	97,985	97,98	98,0

When rounding from three digits to one digit the last two digit to be dropped must be considered together and rule applies to values greater or less than 50.

97,449	97,4
97,540	97,5
97,551	97,6
97,549	97,5
97,550	97,6

V. PROCEDURE FOR TEST DATA ANALYSIS

The results are analysed according to the following procedure for calculating basic statistical data for analysis programme results.

The data obtained by this procedure include average of results, average of deviations, standard deviations, and rejection of outliers, which are basic to other statistical treatment such as trend etc.

The data thus obtained also provide sufficient parameters for comparing like data from individual laboratories or groups of laboratories performing the same test. The procedure is presented in a step by step manner to standardize procedure and to simplify the calculations and evaluation.

The following steps are taken to calculate the basic statistical data :

Step I Number of result = n

Results = $x_1, x_2, x_3, \ldots\ldots\ldots x_n$

Sum of results = $\sum_{i=1}^{n} x_i$

Step II Average of results = $\frac{\sum_{i=1}^{n} x_i}{n} = \bar{x}$

Step III Deviation = $x_i - \bar{x}$

Sum of deviation = $\sum_{i=1}^{n} x_i - \bar{x}$

Average deviation = $\frac{\sum_{i=1}^{n} x_i - \bar{x}}{n}$

Step IV Deviation squared = $(x_i - \bar{x})^2$

Step V Variance = $\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}$

Step VI Standard deviation = $\sqrt{\text{variance}} = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$

Step VII Rejection of Outliers

"T" factor times standard deviation =

$$T \times \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

"T" factor is obtained from Table of Grubb's rejection criterion.

In the computation of standard Deviation the use of (n-1) is statistically more than n.

VI. TEST RESULT

A. *4th ASCOPE CFR Engine Correlation Programme*

For the 4th CFR correlation programme

Results for sample SC-01 are listed in Table 4, 5, which show respectively the ambient temperature and engine operating conditions, general properties and calculation.

The results are sumarised visually in Figure 1, which plot the laboratory rest results.

The average Octane Number, standard deviations, and rejection of outliers for sample SC-01 respectively (see Table 6).

VII. CONCLUSION

A. *4th ASCOPE*

From the results of test conducted by all participating laboratories and the evaluation of standard deviation rejection of outliers (see Figure 1).

Table 4

4th ASCOPE Laboratory Test Correlation Programme
For CFR Engines

Test Conditions Sample No. SC-01

Lab. No.		LC-01	LC-02	LC-03	LC-04	LC-05	LC-06	LC-07	LC-08	LC-09	LC-10	LC-11	LC-12	LC-13
Motor Number		3	4-62 1131197	B-1815	1131181	F-1	752148/ 6718	207441	-	1104652	G-37747	9-69 178812	9-73 252382	CFR-48
Total Hours		3347.7	-	6732.7	5316	1094.3	3982.5	1251.7	-	314.6	1851.1	1705	1829	-
Running Hours after Last Overhaul		129.1	-	421.9	150	352	110.5	32.8	-	314.5	380.1	10	18	251
On Ice Tower, Yes/No		No	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	No	Yes	Yes	Yes
Intake Air Temperatur, °F		125	126	125	123	125	122	125	-	123	125	125	125	125
Ambient Temperature, °C		29.5	32	24	25	26	28.5	29	-	27	29	25	33	28
Barometric Pressure, mm Hg		762.2	762	758.9	760	762.4	754	761	-	757	760	760	760	759
RPM		600	600	600	600	600	600	600	-	598	600	600	600	600
Altitude, m		3.65	2.5	3.65	5	4.2	3.5	4	-	41	6	2.5	4	0
Knockmeter Sensitivity		21	31	22	30	19	30	24	-	11	22	32	20	36
Cylinder Position	DC								-					668
	MS	0.390	0.453	0.392	0.397	0.418	0.385	0.384	-	0.369	0.370	0.383	0.380	

Note : LC-13 : Barometric Pressure = 29.9 in Hg

$= 29.9 \times \frac{760}{29.92}$

= 759 mm Hg

Table 5

4th ASCOPE Laboratory Test Correlation Programme
For CFR Engines

Test Results Sample No. SC-01

Lab. No.		LC-01	LC-02	LC-03	LC-04	LC-05	LC-06	LC-07	LC-08	LC-09	LC-10	LC-11	LC-12	LC-13	Average
Motor Number		3	4-62 1131197	B-1815	1131181	F-1	752148/ 6718	207441	-	1104652	G-37747	9-69 178812	9-73 252382	CFR-48	
Knock Rating F-1 ASTM D-2699	ON	98.2	99.1	98.4	98.1	97.9	98.7	98.6	-	99.5	98.4	98.6	98.9	98.1	98.6
Spec. Gravity 60/60° ASTM D-1298	°F	0.7692	0.7694	0.7688	0.7682	0.7697	0.7696	0.7701	-	0.7699	0.7743	0.7694	0.7711	0.7686	0.7698
RVP, ASTM D-323	psi	7.2	7.9	7.4	7.6	7.35	7.1	7.5	-	8.2	7.6	7.3	7.4	7.3	7.5
Distillation ASTM D-86															
IBP	°C	35	37	38	36	39	42	36	-	37.8	43	39	44	42	39.0
10%	°C	61	62.5	61	61	64	63	61	-	63.3	66	60	68	65	63.0
50%	°C	105.5	107.5	106	104	109	110	108	-	107.8	109	105	108	109	107.4
90%	°C	146	148.5	145	147	150	151	144.5	-	150.0	149	143	147	148	147.4
EP	°C	179	186.0	182	182	186	182	203	-	180.0	185	183	185	185	184.5
TEL Content, ml/USG ASTM D-526/IP-116		2.0	2.20	1.95	0.44	2.04	1.09	1.50	-	-	2.12	2.38	1.70	2.22	1.78

1. The Results

Concerning sample SC-01, 3 (three) rating exceed standard deviation vis, the rating coming from LC-05, LC-07, LC-10 which are however not to be rejected as outliers being still within aceptable limits based on Grub's criterion for 99 percent probability.

Hence, the rating from all the participating laboratories concerning SC-01 are satisfactory.

Table 6

4th ASCOPE Laboratory Test Correlation Programme
For CFR Engines

Calculation Sample No. SC-01

Col. A Laboratory	Motor Number F-1	Col.B Octane Number	Col. C Deviation of Average	Col. D Deviation squared
LC-01	3	98.2	- 0.4	0.16
LC-02	4-62-1131197	99.1	+ 0.5	0.25
LC-03	E-1815	98.4	- 0.2	0.04
LC-04	1131181	98.1	- 0.5	0.25
LC-05	F-1	97.9	- 0.7	0.49
LC-06	752148/6718	98.7	+ 0.1	0.01
LC-07	207441	98.6	+ 0.0	0.0
LC-08	-	-	-	-
LC-09	1104652	99.5	+ 0.9	0.81
LC-10	G-37747	99.4	+ 0.8	0.64
LC-11	9-69-178812	98.6	0.0	0.0
LC-12	9-73-252382	98.9	+ 0.3	0.09
LC-13	CFR - 48	98.1	- 0.5	0.25
	Sum No. Of Results (n)	1183.5 12	4.9 12	2.99 12

Step 1 :
Average Octane Number : $\frac{\text{sum of results}}{\text{no. of results}} = \frac{1183.5}{12} = 98.6$

Step 2 :
Average Deviation : $\frac{\text{sum of deviation}}{\text{no. of deviation}} = \frac{4.9}{12} = 0.41$

Step 3 :
Variance : $\frac{\text{sum of dev. squared}}{(\text{no. of dev. squared} - 1)} = \frac{2.99}{12 - 1} = \frac{2.99}{11} = 0.27$

Step 4 :
Standard Deviation : square root of variance = $\sqrt{\text{variance}} = \sqrt{0.27} = 0.52$

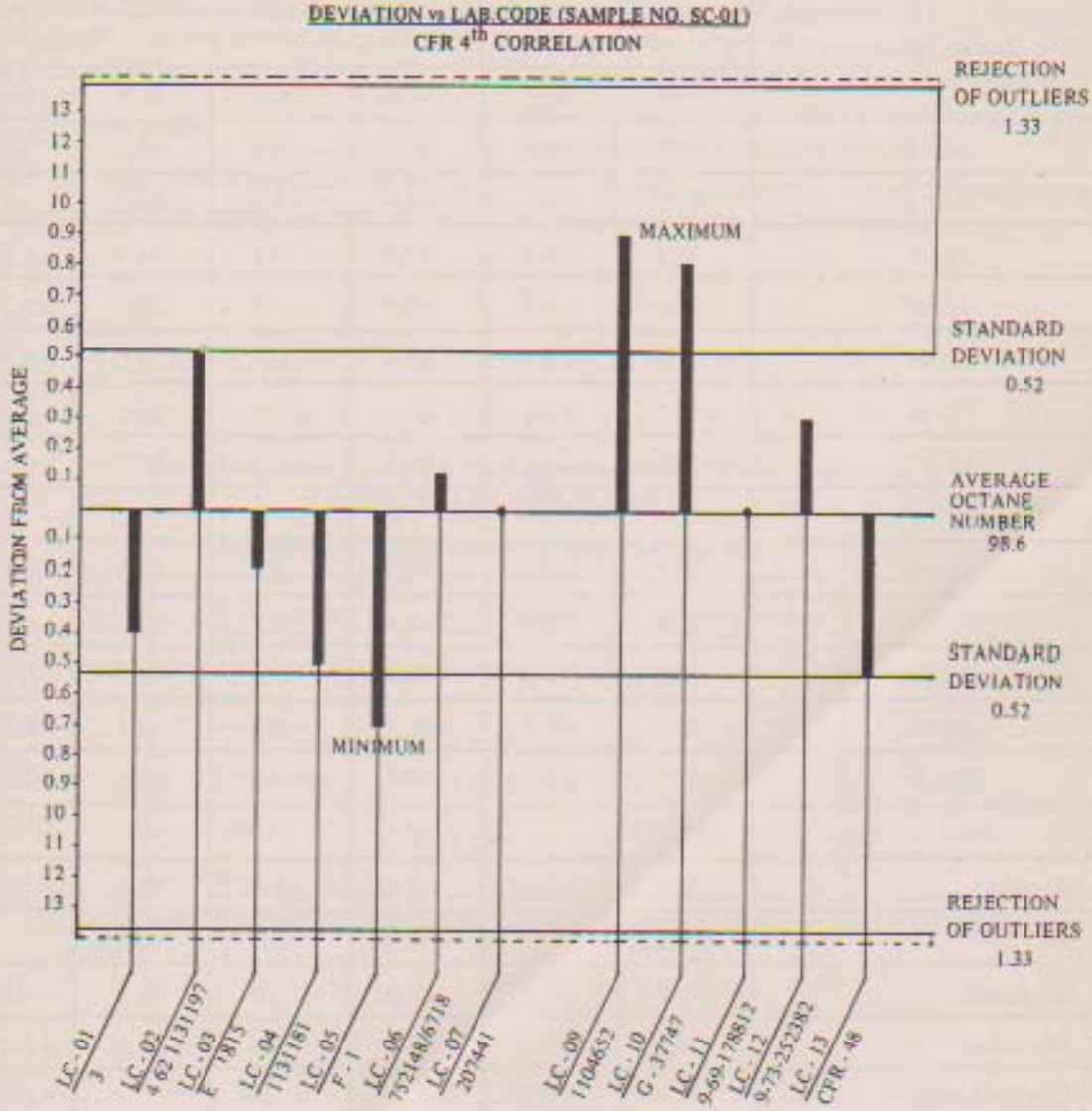
Step 5 :
Rejection of Outliers : "T" factor X std. deviation = 2.55 x 0.52 = 1.33

All results are not rejected.

2. **Inspection Test**

The inspection test data can also point out probelms with the sample corelation (i.e. poorly mixed, light and loss, poor handling, leaking etc.). According to Table 5 there are no significant deviations in specific grafity, R.V.P. and TEL content. The means that all correlation samples are satisfactory.

Figure 1



B. Adhearance to The Procedure

Although, the test results of the sample SC-01, SC-02, SC-03 submited by all the participating laboratories (more is rejected as outliers), from the data on ambient and engine operation conditions.

During testing of SC-01, SC-02, SC-03, however can be sure one of participating laboratories has not satisfied the standard operating conditions for correlation of CFR engine.

One has even deviated from the test procedure

Table 7

4th ASCOPE Laboratory Test Correlation Programme
For CFR Engines

Individual Ratings Reported by ASCOPE Lab. Participant

Lab. No.	Research Method					
	SC-01		SC-02		SC-03	
	O.N.	Dev	O.N.	Dev	O.N.	Dev
LC-01	98.2	-0.4	87.9	-0.1	84.8	0.0
LC-02	99.1	+0.5	89.0	+1.0	84.7	0.1
LC-03	98.4	-0.2	87.9	-0.1	84.7	-0.1
LC-04	98.1	-0.5	87.0	-1.0	85.0	+0.2
LC-05	97.9	-0.7	87.8	-0.2	85.0	+0.2
LC-06	98.7	+0.1	87.5	-0.5	84.5	-0.3
LC-07	98.6	0.0	87.7	-0.3	85.2	+0.4
LC-08	-	-	-	-	-	-
LC-09	99.5	+0.9	87.5	-0.5	84.1	+0.7
LC-10	99.4	+0.8	88.1	+0.1	84.7	-0.1
LC-11	98.6	0.0	88.4	+0.4	84.7	-0.1
LC-12	98.9	+0.3	88.3	+0.3	85.1	-0.3
LC-13	98.1	-0.5	88.5	+0.5	84.6	-0.2
n	12		12		12	
Average	98.6	+0.41	88.0	+0.42	84.8	+0.22
Std. Dev.	0.52		0.54		0.30	
Minimum	97.9	-0.7	87.0	-1.0	84.1	-0.7
Maximum	99.5	+0.9	89.0	+1.0	85.2	+0.4
Grubbs' Limits		+1.33		+1.38		+0.76

* Rejected by Grubb's criterion for 99% probability. Results not included in computations.

Note : All ratings that fall within plus or minus two standar deviations of the group average are to be considered statistically equal, precision - wise. Any underlined values exceed two standar deviations but are within acceptable limits on the basis of Grubb's criterion for 99 percent probability. Such values are included in the computations. Rejected values, if any, are indicated by an asterisk (*) and are not included in computations.

established by the ASTM. Example of non adhearan ce to the procedure are as follows :

1. **Concerning Sample SC-01**

Participant laboratory LC-02 carried out the test with micrometer setting at 0,453 in (see table 4).

According to table 2 of the ASTM manual, for knock rating at 99,0 octane number, the micrometer has to be about 0,377 in.

C. *General Conclusion*

Is it can be observed from table 7 all the correlation samples and participating laboratories, it can be concluded that maximum and minimum deviations of all ratings are still within acceptable limits on the basis of Grubb's critirion for 99 percent probability. It means that none of the test results are rejected. According to table 8 concerning the evoluation of ratings axeeding standard deviation from 1st Programme (1980) to 4th programme (1982) for sample SC-01, SC-02, SC-03. The precentage of ratings exceeding standard deviation has decreased which show that the programme succesful in improving the performance of the participating laboratories.

Some participant however are still perishing in no adhearance to the ASTM procedure.

Table 8

Evaluation of the ASCOPE CFR Engine Correlation Programmes Conducted from 1980 to 1982

Percentage of ratings exceeding Standard Deviation

Sample Correlation	1th Programme (1980)/%	2rd Programme (1981)/%	3rd Programme (1982)/%	4th Programme (1983)/%
SC-01	30,8	33,7	25	25
SC-02	38,7	16,6	25	16,6
SC-03	38,7	25	25	16,6

Note : One of the causes unsatisfactory test results is non adherence to the test procedure established by ASTM.