ASCOPE LABORATORY TEST CORRELATION PROGRAMME FOR OCTANE NUMBER MEASUREMENT IN 1992

by
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ABSTRACT

The ASCOPE Correlation Programme for octane number measurement obtains precision octane number data for gasoline using the CFR engine and the normally used method: ASTM 2699 and IP 237. The test results of the various participating laboratories are subjected to statistical analysis to determine average values, variance, standard deviation and to reject the outliers values. The Grubbs T-test is used for the statistical rejection of outliers. This method is used by both NEG and ASCOPE in their laboratory test correlation programme. The Grubb T-test appears to be quite satisfactory for ASCOPE purposes. The implementation of the Grubbs T-test assures inter-laboratory consistency and this in turn will give the buyer or seller of the gasoline confidence in the quality of the fuel.

I. INTRODUCTION

Many organisations worldwide share an interest in the precision of octane number testing. These organisations include those in fuel manufacturing, fuel marketing, research and in regulatory agencies. The CFR engine used to test the octane number of gasoline and cetane number of diesel fuel.

The quality of all gasolines sold and used must be assessed. We use the gasoline spesification to define the quality, durability, safety etc of the gasoline product brought and sold. Our interest as to the quality of gasoline will naturally be different depending on whether we are the buyers or the sellers.

It is very important, therefore, that the buyer and seller can agree on the method that will be used to determine the quality of the gasoline in question. Consequently there are a number of the CFR engine laboratories in existance with facilities available to undertake quality checks. It is however important that all these CFR engine laboratories use similar methods and achieve consistent results. It is for this reason that organizations are set up to test results and methodologies used by the various laboratories.

At this point would be a good idea to discuss the purpose and framework of the correlation programme for octane number test and at the same time show how the correlation programme participants benefit from sharing data and new ideas as to improve testing procedures and testing precision that may arise.

There is usually one or a combination of the following reasons for conducting a correlation programme for octane number testing:

- To test the soundness of the new test procedures any revisions made to existing procedures.
- To obtain precision data for standard method procedures.
- To allow laboratories to check their testing equipment and techniques to see that they are reliable and capable of providing good test results.

There are several groups that are devoted to the area of method testing and precision. Examples of such groups include; The National Exchange Group (NEG) in the USA; SAA in Australia; The ASEAN Council on Petroleum (ASCOPE) in ASEAN.

The ASCOPE Laboratory Test Correlation Programme for octane number was conducted in 1992 to obtain precision octane number data for gasoline using the CFR engine and the normally used method: ASTM

2699 and IP 237. The ASCOPE laboratory test correlation programme is a cooperative programme used by petroleum testing laboratories in ASEAN countries. The programme has been going on since 1979 and is currently composed of three sub programmes, namely for: (1) lubricating oil; (2) fuel; and (3) octane number measurement.

The program coordinator prepared the samples and sent them by air to each participating laboratory through the respective country coordinator. Member countries taking part in the laboratory test correlation programme for octane number measurement where Indonesia as coordinator with seven laboratories, Thailand with four laboratories, Malaysia with five laboratories, The Philippines and Singapore with two laboratories each and the Ethyl Corporation of the USA with one laboratory.

For correct analysis, the ambient operating conditions for the CFR engine during correlation tests must be recorded. Testing had to be carried out on a certain day at a certain time (local time) specified by programme coordinator. Testing had to be conducted using the same procedures, such as the bracketing and compression ratio methods. The test results had to be rounded according to the ASA procedure.

The test result of the various participating laboratories were subjected to statistical analysis to determine average values, variance, standard deviation and the outliers values. The results also enable us to determine which of the outliers that should be rejected.

The ASCOPE correlation programme execution consists of the following stages:

- sample preparation and shipment
- analyses and instrumentations
- test data analysis
- test results collection
- evaluation of procedure
- evaluation of results
- conclusion.

Since the first of these programmes, the ASCOPE laboratory group has been employing the Grubbs T-test for detection and the subsequent rejection of outliers. The ASTM standard practice for dealing whith outliers, allows the use of several methods of which Grubbs T-test, as practiced by ASCOPE, is one of the recommended methods. This method is also used by Ethyl Corporation and ASTM National Groups in USA for its octane number testing correlation programmes.

II. SAMPLE PREPARATION AND SHIPMENT

Test samples (SC-01) for the correlation programme were prepared by the programme coordinator who distributed them to the participating laboratories through their respective country coordinators. The amount of the correlation samples was two litres for each grade, this was placed in two one litre can. One litre can be used in order to comply with IATA (air transport regulations) concerning the maximum volume permitted for the air transport of flammable materials.

To facilitate and simplify the undertaking of this programme, each sample was coded alphanumerically as follows: "SC-Number", where SC means Sample Code and the number corresponds to the sample number in this correlation programme.

In order to facilitate communication, laboratories in each country were coordinated through a country coordinator. Each participating laboratory was coded with "LC-Number" where "LC" means Laboratory Code, and the number corresponds to the laboratory participating in this correlation programme.

In each case, the sample preparation consisted of five stages these were:

- Acquisition of suitable sample, preparative materials and equipments
- Blending of the samples
- Filling the containers with the samples
- Packing
- Dispatch

Each stage was undertaken with the upmost care under the supervision of the project coordinator in accordance with set routines.

III. TEST DATA ANALYSIS

The results were analysed using basic statistical methods. The data obtained by these methods includes; Average of the results, Average deviation; Variance; Standard deviations and Determinations of outliers. All which are basic to other statistical treatments such as trend, etc. Test results were rounded according to the ASA procedure.

The data thus obtained provides sufficient parameters for comparing like data from individual laboratories and groups of laboratories.

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

Average

Sum of test results = $X_1 + X_2 + X_3 ..... X_n = \sum_{i=1}^{n} X_i$

n = number of test results.

$$Average = \frac{sum\ of\ test\ results}{no\ of\ results}\ \frac{1}{n}\sum_{i=1}^{n}(X_i - \overline{X})$$

Average deviation

Average deviation is the average of all deviation from the set average taken without regard by algebraic sign

D = deviation = X_i - X

Xi = results

Average deviation =

$$\frac{sum\ of\ deviation}{no\ of\ results}\ \frac{1}{n}\sum_{i=1}^{n}(X_i - \overline{X})$$

X_i = results

Variance

Variance is a measure of a dispersion of a set of accepted results around the average. It is equal to the sum of the squares of the deviation.

D = deviation = X_i- X

Sum of squares of the deviation = $\sum_{i=1}^{n}(X_i - X)^2$

$$Variance = S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(X_i - X)^2$$

Standard deviation

Standard deviation is a measure of the dispersion of set of accepted results around their average, equal to the square root of the variance.

$$S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(X_i - \overline{X})^2}$$

Rejection of Outliers

$$\text{"T" factor X } \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(X_i - \overline{X})^2}$$

T factor from Table 1 of Grubbs rejection criteria.

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

IV. TEST RESULTS COLLECTION

The test results submitted by the participating laboratories were compiled and evaluated following the procedures described above. The results for sample SC-01 are listed in Table 1, this shows the ambient and engine conditions, calculated and individual test results reported by ASCOPE laboratory participants Tables 2 and 3.

These results are summarized and may be seen in Figure 1, 2 which plots the laboratory test results, standard deviation and rejection of outliers for sample SC-01.

Table 1
ASCOPE laboratory test correlation programme for octane number measurement (1992)

Test conditions for 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
Motor number		8	–	298669	1061150	251913	365616	207441	G-44004	1104652	G-49630	–
Total hours		2923	–	967.4	7326.4	2200.8	3367.5	2871.4	3105	7121.2	168.7	3945
Running hours after last overhaul/carbon blasting		170.7	863/147	448.8	296.1	48.9	215	125.1	75	299	New/ Engine	19.4
Use ice tower,	Yes/No	No	Yes	Yes	No	Yes	No	Yes	No	No	No	Yes
Intake air temperature,	°F	125	125	125	123	125	128	125	125	125	126	130
Ambient temperature,	°F	88	68	77	77	77	71.6	86	87	78	77	75
Barometric pressure, in Hg	29.9	29.9	29.95	29.8	29.9	30.14	29.9	29.9	29.92	29.97	30.3	
R. P. M.		596	600	600	600	600	600	600	600	600	601	600
Above sea level	m	3.65	–	28	–	4	2.8	4	0	41.8	6	–
Knockmeter sensitivity		20	26	20	14	17	12	18	20	–	17	–
Cylinder position	DC		718		731				728	–		723
	MS	0.498		0.487		0.485	0.496	0.497			0.491	

Lab No.		LC-12	LC-13	LC-14	LC-15	LC-16	LC-17	LC-18	LC-19	LC-22	LC-23
Motor number		252382	G-49561	–	183549	308047	–	CFR F-1	–	400362	G-43559
Total hours		5770.1	1789	–	13982	4602.0	5973	648.9	2535.7	912.7	15630
Running hours after last overhaul/carbon blasting		480.9	225	–	96	242.0	5151	90	52	45.1	50
Use ice tower,	Yes/No	No	No	–	No	Yes	Yes	Yes	No	No	Yes
Intake air temperature,	°F	125	125	–	125	125	126	140	125	125	124.7
Ambient temperature,	°F	77	84	–	80	83.1	68	78	–	77.5	84
Barometric pressure, in Hg	29.9	29.92	–	29.8	29.97	30.0	29.84	29.9	29.9	29.9	
R. P. M.		600	602	–	600	600	595	600	–	602	600
Above sea level	m	4	Sea level	–	0	0	–	Sea level	–	Sea level	17
Knockmeter sensitivity		12	22	–	21	21.1	–	27	–	24	18
Cylinder position	DC		704	–	728		733	744	–	736	733
	MS	0.517				0.497					

V. EVALUATION OF PROCEDURE

From the test result conducted by the participating laboratories (see Table 1), and the evaluation of the test procedures, standard deviation and rejection outliers (see Tables 2, 3 and Figure 1, 2), the following conclusions can be drawn:

From table 1 it can be seen that some laboratories conducted the tests deviated from the test procedures established by the ASTM. Examples of non adherence to the procedures are as follows: Concerning sample SC-01, participating laboratory LC-18 carried out the test with the barometric pressure at 29,84 inHg with the intake air temperature at 140°F. According to the ASTM manual; for barometric pressure at 29,84 inHg, the intake air temperature has to be at 122° ± 2°F. Hence the test deviated from the test procedure establish by ASTM.

Beside this some participating laboratories carried out the test with too small a knockmeter sensitivity. This can cause an inaccuracies when interpolating the octane number. According to ASTM manual, the sensitivity should be 10 to 18 knockmeter divisions per octane number at the 90 octane level.

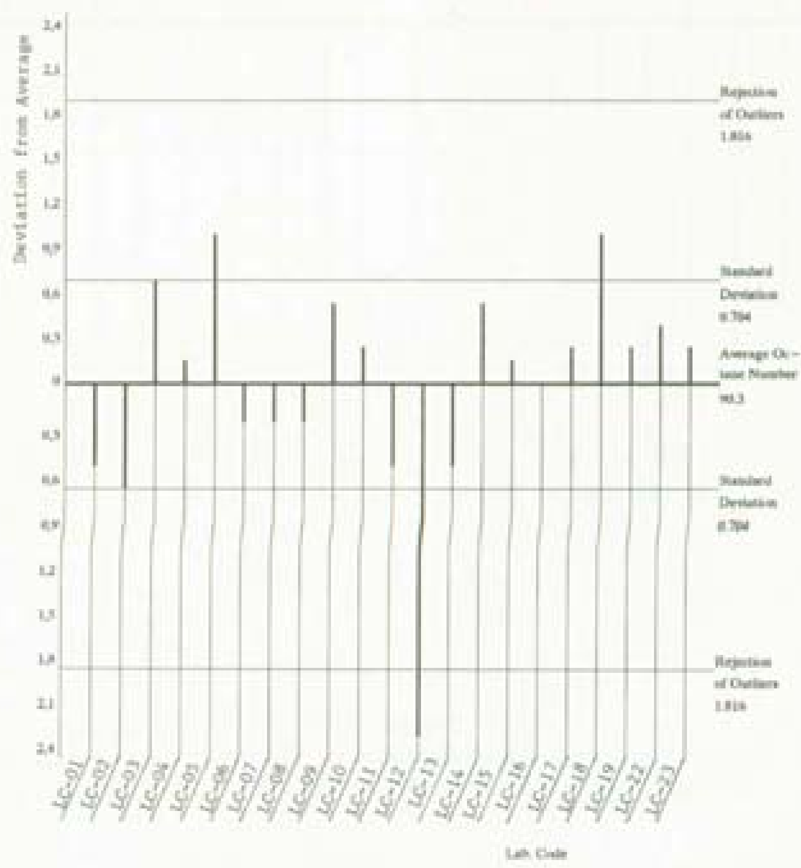

Figure 1
ASCOPE laboratory test correlation programme for octane number measurement (1992) deviation vs lab. code (sample-01) first calculation

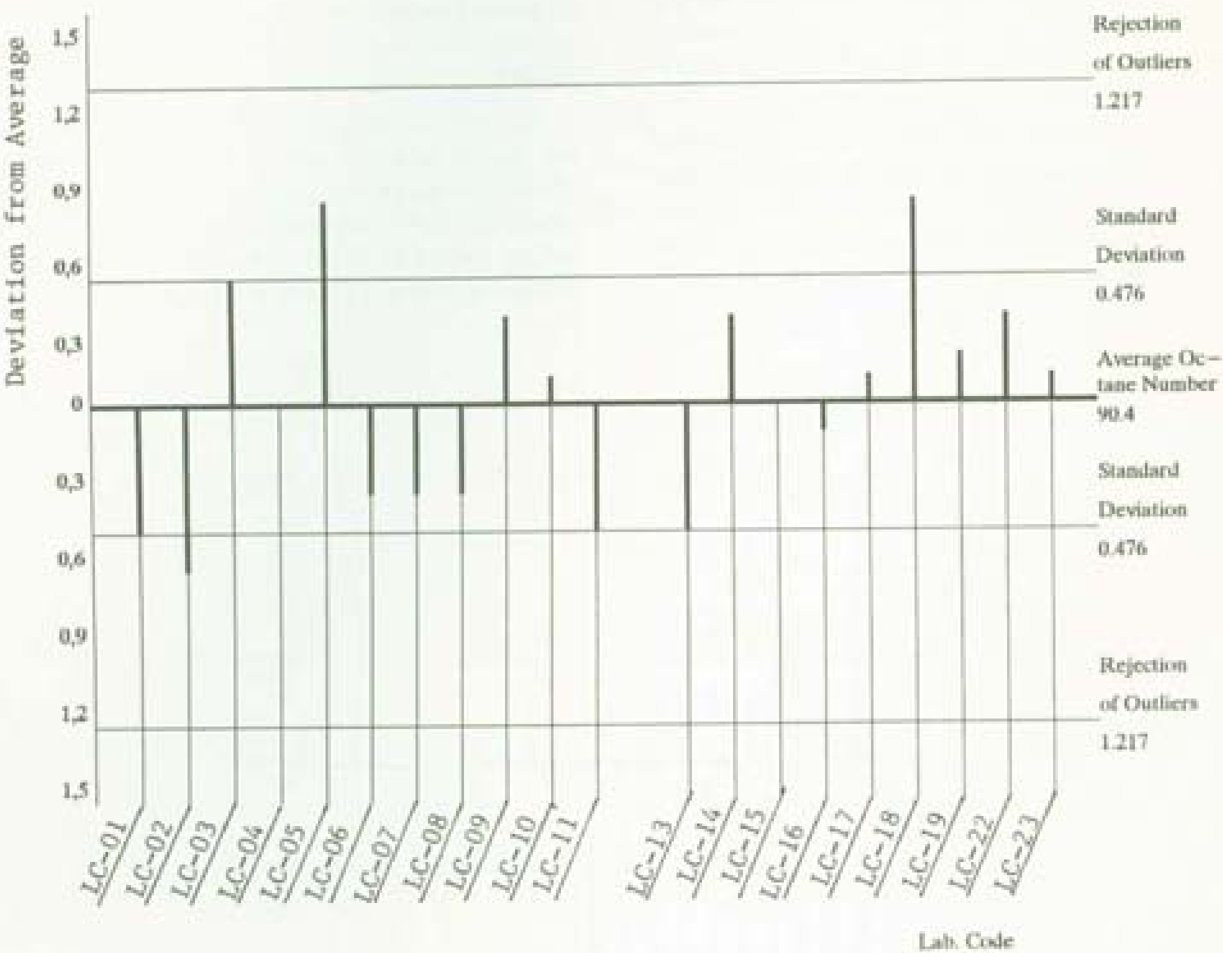

Figure 2
ASCOPE laboratory test correlation programme for octane number measurement (1992) deviation vs lab. code (sample-01) second calculation

Table 2
ASCOPE laboratory test correlation programme for octane number measurement (1992)
First calculation for SC-01

Col. A Laboratory	Motor number F. 1	Col. B Octane number	Col. C Deviation of average	Col. D Deviation squared
LC–01	8	89,8	–0,5	0,25
LC–02	–	89,7	–0,6	0,36
LC–03	298669	91,0	0,7	0,49
LC–04	1061150	90,4	0,1	0,01
LC–05	251913	91,3	1,0	1,00
LC–06	365616	90,1	-0,2	0,04
LC–07	207441	90,1	-0,2	0,04
LC–08	G–44004	90,1	-0,2	0,04
LC–09	1104652	90,8	0,5	0,25
LC–10	G–49630	90,5	0,2	0,04
LC–11	–	89,8	-0,5	0,25
LC–12	252382	88,0	-2,3	5,29
LC–13	G–49561	89,8	-0,5	0,25
LC–14	–	90,8	0,5	0,25
LC–15	183549	90,4	0,1	0,01
LC–16	380847	90,3	0,0	0,00
LC–17	–	90,5	0,2	0,04
LC–18	CFR F.1	91,3	1,0	1,00
LC–19	–	90,6	0,3	0,09
LC–22	400362	90,7	0,4	0,16
LC–23	G–43559	90,5	0,2	0,04
Sum		1.896,5	10,2	9,9
No. of results (n)		21,0	21	21,0

Step 1 : Average octane Number : $\frac{\textit{sum of results}}{\textit{no. of results}} = \frac{1.896,5}{21,0} = 90,31$

Step 2 : Average deviation : $\frac{\textit{sum of deviation}}{\textit{no. of deviation}} = \frac{10,2}{21,0} = 0,49$

Step 3 : Variance : $\frac{\textit{sum of dev. squared}}{(\textit{no. of dev. squared} - 1)} = \frac{9,9}{21, - 1} = \frac{9,9}{20} = 0,495$

Step 4 : Standard deviation : Square root of variance = variance = 0.70

Step 5 : Rejection of outliers : "T" factor x std. deviation = 2.580 x 0.704 = 1.816

Laboratory Code No. LC – 12 is rejected

VI. EVALUATION OF ANALYSIS

According to data in Table 2 and Figure 1, displayed 3 test results exceeding the standard deviation line defined from the test results coming from: LC-05, LC-18 and LC-12. These two results were not, however, rejected as outliers as they were within the Grubbs limits.

According to Figure 1 only one test results was rejected as outliers, it was not within the Grubbs limit. This was the test result coming from LC-12.

After the second calculation according to Table 3 and Figure 2 no test results were rejected as outliers. But 7 test results exceed the standard deviation, there are from the test results coming from LC-01, LC-02, LC-03, LC-05, LC-11, LC-13 and LC-18.

According to Table 4 all results that fall within minimum and maximum deviation.

Tabel 3
ASCOPE laboratory test correlation programme for octane number measurement (1992)
Second calculation for SC-01

Col. A Laboratory	Motor number F. 1	Col. B Octane number	Col. C Deviation of average	Col. D Deviation squared
LC-01	8	89,8	-0,6	0,36
LC-02	-	89,7	-0,7	0,49
LC-03	298669	91,0	0,6	0,36
LC-04	1061150	90,4	0,0	0,00
LC-05	251913	91,3	0,9	1,81
LC-06	365616	90,1	-0,3	0,09
LC-07	207441	90,1	-0,3	0,09
LC-08	G-44004	90,1	-0,3	0,09
LC-09	1104652	90,8	0,4	0,16
LC-10	G-49630	90,5	0,1	0,01
LC-11	-	89,8	-0,6	0,36
*	*	*	*	*
LC-13	G-49561	89,8	-0,6	0,36
LC-14	-	90,8	0,4	0,16
LC-15	183549	90,4	0,0	0,00
LC-16	380847	90,3	-0,1	0,01
LC-17	-	90,5	0,1	0,01
LC-18	CFR F.1	91,3	0,9	1,81
LC-19	-	90,6	0,2	0,04
LC-22	400362	90,7	0,3	0,09
LC-23	G-43559	90,5	0,1	0,01
Sum		1.808,5	7,5	4,31
No. of Results (n)		20,0	20,0	20,0

Step 1 : Average octane number : $\frac{\text{sum of results}}{\text{no. of results}} = \frac{1.808,5}{20,0} = 90,43$

Step 2 : Average deviation : $\frac{\text{sum of deviation}}{\text{no. of deviation}} = \frac{7,5}{20,0} = 0,38$

Step 3 : Variance : $\frac{\text{sum of dev. squared}}{(\text{no. of dev. squared} - 1)} = \frac{4,31}{20-1} = \frac{4,31}{19} = 0,2268$

Step 4 : Standard deviation : Square root of variance = variance = 0.47

Step 5 : Rejection of outliers : "T" factor x std. deviation = 2.5557 x 0.476 = 1.217

All result are not rejected

Tabel 4
ASCOPE laboratory test correlation programme for octane number measurement (1992)
Individual rating reported by ASCOPE lab participant

Lab No.	Research method SC – 01	
	O.N.	Dev.
8	89.8	–0.6
–	89.7	–0.7
298669	91.0	0.6
1061150	90.4	0.0
251913	91.3	0.9
365616	90.1	–0.3
207441	90.1	–0.3
G–44004	90.1	–0.3
1104652	90.8	0.4
G–49630	90.5	0.1
–	89.8	–0.6
252382	*	*
G–49561	89.8	–0.6
–	90.8	0.4
183549	90.4	0.0
380847	90.3	–0.1
–	90.5	0.1
CFR F.1	91.3	0.9
–	90.6	0.2
400362	90.7	0.3
G–43559	90.5	0.1
n	20	
Average	90.4	±0.38
Standard deviation		±0.476
Minimum	89.7	–0.7
Maximum	91.3	+0.9
Grubbs' limits		+1.217

* *Rejected by Grubbs' criterian for 95% probability*
Results not included in computation

Note : All ratings that fall within plus or minus two standard deviation the group average are to be considered statistically equal, precision-wise. Any underlined values exced two standar deviations but are within acceptable limits on the basis of Grubbs' criterian for 95 percent probability. Such values are included in the computations. Rejected values, if any, are indicated by an asterik (*) and are not included in computations.

VII. CONCLUSIONS

1. As can be observed from analysis and evaluation, all test results of the ASCOPE participating laboratories for each sample were still within acceptable limits on the basic of Grubbs criteria for 95 percent probability. It means that none of the test results were rejected. The Labs are all working property, customers and sellers can be sure of the product.
2. The grubbs T-Test appears to be quite satisfactory for ASCOPE correlation programme for octane number measurement testing. Although the results in generals seen quite good, some laboratories are still required to pay more attention to the conduct of their tests, particularly as regards adherence to the ASTM procedure.
3. These correlation programmes enable each participating laboratory to monitor its own performance and to take corrective action when and if necessary. Only in this way we can improve the precision of octane number measurement by CFR engine laboratory testing.

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