

2nd Annual ASCOPE Laboratory Test Correlation Programme on CFR Engine (1981)

By:

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1. INTRODUCTION

The ASCOPE Work Programme for 1981 directed the Technical Committee to conduct the 2nd Annual Laboratory Test Correlation Programme for CFR Engines among petroleum laboratories in the ASCOPE member countries. Member countries taking part in this correlation programme are Indonesia with seven laboratories participating, Malaysia with two laboratories, Thailand and the Philippines with two laboratories each.

LEMIGAS Laboratory of Indonesia, as coordinator in this correlation programme, provided the samples to be sent to each participating laboratory. After being tested by the participating laboratories, the test results on these samples were to be sent to PPTMGB "LEMIGAS" in Jakarta for processing, including the determination of the standard deviation. Based on these results, conclusions can be drawn about the deviations of laboratory test results and about outliers to be rejected.

For proper analysis, the samples for correlation also require physical and chemical test such as specific gravity, RVP, distillation, and TEL content, in the receiving laboratories to take into account any possible changes in the sample properties which have occurred during transportation and storage.

Also important to be observed are ambient and engine operating conditions during the correlation tests.

The results of this analysis can then be used as a base for diagnosis of the probable causes of deviations, the occurrence of outliers and for recommendations of remedial steps to be taken.

The method used for testing the samples is the Bracketing Procedure System, while for rounding the values of the numbers found during the tests the ASA rules for rounding are used.

The Grubb's rejection criteria with the use of "T" factors are used in evaluating the possible outliers.

This article was first presented during a technical meeting on Laboratory Correlation, Oil Process and Application, held in Jakarta, from 9 up to 11 February 1982.

2. CORRELATION PROGRAMME EXECUTION

2.1 Sample Coding

LEMIGAS as coordinator, provided and prepared the correlation samples as shown in Table 1. The correlation samples were sent to each participating laboratory.

The amount of the correlation sample, was two liters for each grade, put into two one-litre cans. One litre 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.

2.2 Participating Laboratories

The participating laboratories were similarly coded alpha-numerically as follows:

LC number, where LC indicates laboratory code and number indicates the participants number in this correlation programme.

The list of participating laboratories appears in Table 2 (p.12).

In order to facilitate communication, laboratories in each country were coordinated through a country coordinator. The list of Country Coordinators and Programme Coordinator appears in Table 3 (p.13).

3. SAMPLE PREPARATION

The sample preparation consisted of five steps, 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 the coordinating laboratory (LEMIGAS)

4. ROUNDING RULES FOR TEST RESULTS

The ASA rules for rounding as they pertain 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 preceding the digit to be dropped is raised by one when the last digit is greater than 5.
- (3) When the digit to be dropped is exactly 5 and the digit preceding 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 preceding it is an odd digit, the digit preceding is raised by one.

Example:

	Number	Rounded	
		Nearest Hundredth	Nearest Tenth
1.	97.642	97.65	97.6
2.	97.237	97.24	97.2
3.	97.365	97.36	97.4
4.	97.985	97.98	98.0
5.	97.995	98.00	98.0

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

97.499	97.4
97.540	97.4
97.551	97.5
97.549	97.5
97.550	97.6

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

5. PROCEDURE FOR TEST DATA ANALYSIS

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

The data obtained by this procedure include: sample average, average deviation and standard deviation, 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 or groups of laboratories performing the same tests. The procedure is presented in a step-by-step number to standardize the procedure and to simplify the calculations and evaluation.

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

. Step I

Number of results = n

Results $X_1, X_2, X_3, \dots, X_n$

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

. Step II

$$\text{Average of results} = \frac{\sum_{i=1}^n X_i}{n} = \bar{X}$$

. Step III

$$\text{Deviation} = X_1 - \bar{X}$$

$$\text{Sum of deviation} = \sum_{i=1}^n X_i - \bar{X}$$

$$\text{Average deviation} = \frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n}$$

. Step IV

$$\text{Deviation squared} = (X_1 - \bar{X})^2$$

$$\text{Sum of deviation squared} = \frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n}$$

. Step V

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

. Step VI

$$\text{Standard deviation} = \sqrt{\text{variance}} = \sqrt{\frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n-1}}$$

. Step VII

Rejection of outliers

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

"T" factor is obtained from table of Grubb's rejection criteria.

6. TEST RESULTS

The results submitted by the participating laboratories were compiled and evaluated following the procedures described above.

Results for Sample SC-01 are listed in Tables 4, 5, 6, and 7 which show, respectively, the ambient and engine operating conditions, general properties of sample, deviation of general properties and calculations (see p. 16 through 22).

Results for Sample SC-02 are similarly listed in Tables 8, 9, 10, and 11. Similarly, the results for Sample SC-03 are shown in Tables 12, 13, 14, and 15 (see p. 23 through 36).

These results are summarized visually in Figures 1, 2, and 3 which plot the laboratory test results, the average octane number, standard deviations, and critical rejection of outliers for Samples SC-01, SC-02, and SC-03, respectively (see p. 37 through 39).

7. CONCLUSION

From the results of the tests conducted by all participating laboratories, and the evaluation of standard deviation/rejection of outliers (see Fig.1, Fig.2, and Fig.3), the following conclusions can be drawn.

7.1 Test Results

Concerning sample SC-01, 4 (four) test results exceed standard deviation viz, the test results coming from LC-05, LC-07, LC-9 and LC-12, which are however not be rejected as outliers being still within the permitted limits. Hence, all the list results from all the participating laboratories concerning sample SC-01 are satisfactory.

Concerning sample SC-02, only 1 (one) test results viz coming from LC-04 exceeds standard deviation, which however is still within the permitted limits and is not to be rejected as outlier. Hence also concerning sample SC-02 all the test results are satisfactory.

Concerning sample SC-03, five test results viz coming from LC-02, LC-04, LC-06, LC-09 and LC-12 exceed standard deviation, but none exceeding the permitted limits, they are all not to be rejected as outliers. This means that all the test results of sample SC-03 are satisfactory.

The above test result also agree with the test of the general properties of each sample as shown in the Table "General Properties of Sample", where it is shown that there are no significant deviations concerning the test results of Specific Gravity, RVP and Distillation.

7.2 Adherence to Test Procedure

Although, the test results of all the sample SC-01, SC-02, and SC-03 submitted by all the participating laboratories are satisfactory (none is rejected as outliers), from the data on ambient and engine operating conditions of sample, concerning SC-01, SC-02 and SC-03, however, it can be seen that some of the participating laboratories have not satisfied the conditions for the correlation of CFR engines. Some have even deviated from the test procedure established by the ASTM.

Examples of non-adherence to procedure are as follows:

(1) Concerning sample SC-01

- Participant laboratory LC-02 carried out the test with intake air temperature at 115°F. According to Table 4 "ASTM Manual", at barometric pressure 766,2 Hg (30,16 in Hg) LC-02 should have carried out the test with intake air temperature at 128 °F. Moreover the knock sensitivity (the difference pointed out by LC-02 during the test was 52). This is too large and can cause inaccuracies in acquiring the O.N. by interpolation. According to the "ASTM Manual" for octane numbers lower than 100 the knock sensitivity has to be about 30 or less.
- Participant laboratory LC-09 carried out the test with intake air temperature at 85 °F. According to Table 4 of the ASTM Manual, at barometric pressure 760 mm Hg (=29,92 in Hg), LC-09 should have carried out the test with intake air temperature at 125 °F. Moreover, LC-09 used the C.R Method in carrying out the test, while according to the conditions agreed for conducting the CFR Engine Correlation, the method used should be the Bracketing Method.
- Participant laboratory LC-13 carried out the test with a too large knock sensitivity i.e. 58. The proper knock sensitivity taken should have been about 30.

(2) Concerning sample SC-02

- Participant laboratory LC-02 (as in the testing of sample SC-01) carried out the test with intake air temperature 128° F.
- Participant laboratory LC-09 (as in the testing of sample SC-01) carried out the test with intake air temperature at 85 °F, which should have been carried out at 125 °F. The method used should have been the Bracketing Method, and not the C.R. Method.

(3) Concerning sample SC-03

- Participant laboratory LC-02 (as in the testing of SC-01 and SC-02) carried out the test with intake air temperature at 115 °F, which should have been carried out at 128 °F.
- Participant laboratory LC-09 (as in the testing of sample SC-07 and SC-02) carried out the test with intake air temperature at 85 °F, which should have been carried out at 125 °F. Also the method used should have been the Bracketing Method and not the C.R Method.

Table 1
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

Table 2

**2ND 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 Sungei Gerong
	(5) Pertamina Refining Unit IV Lab Cilacap
	(6) Pertamina Refining Unit V Lab Balikpapan
	(7) Lemigas Oil and Gas Technology Development Centre P.O. Box 89 JKT. Jakarta.
Malaysia	(1) ESSO Malaysia Berhad Port Dickson Attn : Mr. John J. Degouff Refinery Manager
	(2) Shell Refining Company (FOM) Port Dickson Attn : Mr. W.A. Pattison Operations 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
Bangohak Refinery Laboratories
Bangchak
Bangkok

(2) Science Division
Oil Distribution and Supply
Petroleum Authority of Thailand
Prakanong
Bangkok

Table 3

2ND ASCOPE LABORATORY TEST CORRELATION
PROGRAMME ON CFR ENGINES

List of Country Coordinators

Country	Coordinator
Indonesia	Mr. Bustami Mustafa PPTMGB "Lemigas" P.O. Box 89/JKT Jakarta
Malaysia	Mr. Ahmad Nordeen Salleh PNM Division. Petronas Kuala Lumpur
Philippines	Mr. J.N. Dulce Bataan Refining Corporation P.O. Box 1035 MCC Makati Metro Manila

Thailand
Mr. Sawaeng Boonyasuwat
Science Department
Oil Fuel Organization
Boonyavey
Plub Pla Chai Road
Bangkok

Programme Coordinator

Mr. E. Jasjfi
PPTMGB "Lemigas"
P.O. Box 89/JKT
Telex 47150
Jakarta
Indonesia

3. SAMPLE PREPARATION

The sample preparation consisted of five steps, 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 the coordinating laboratory (LEMIGAS).

Tabel 4

**2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)**

Test Conditions Sample No. SC - 01

Lab. No.:	IC-01	IC-02	IC-03	IC-04	IC-05	IC-06	IC-07	IC-08	IC-09
Motor Number	No. 4	1131197 4-62	E-815	-	F-1	724065	207441		-
Total Hours	-	9849.0	62520	-	789.5	7479.5	1201.5		-
Running Hours after Last Overhaul	145.2	155.4	722.7	300	46	418.5	94.2		167.7
Use Ice Tower, yes/no	N.	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Intake Air Temperature, °F	125	115	125	127	125	125	125		85
Ambient Temperature, °C	29.4	31.0	29.4	26	27	28	30		24
Barometric Pressure, mm Hg	758.5	766.2	760	764	763	755	759		760
RPM	600	600	600	600	600	600	600		600
Altitude, m	3.65	2.5	3.65	5	4.2	0.98	4		41
Knockmeter Sensitivity	17	52 Div. (3)	16	28	20	30	22		C.R. Method
Cylinder Position	DC				837 DC				
	MS	0.406	0.413	0.410	0.417	0.412	0.415		0.393

Table 4
2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)
 Test Conditions Sample No. SC - 01

Lab. No.:	LC-10	LC-11	LC-12	LC-13				
Motor Number	G-37747/ 318810	178812 9-69	252382 9-73	CFR-48				
Total Hours	630.5	1431	1447	-				
Running Hours after Last Overhaul	624.2	248	186	30				
Use Ice Tower, yes/no	No	Yes	Yes	Yes				
Intake Air Temperature, °F	126	125	125	125				
Ambient Temperature, °C	28.5	25.6	30	30.6				
Barometric Pressure, mm Hg	763	759	755.5	760				
RPM	600	600	599	600				
Altitude, m	6	2.5	+ 4	0				
Knockmeter Sensitivity	18	25 (Time C3)	12	58				
Cylinder Position	DC			832 DC				
	MS	0.405	0.414	0.397				

Table 5

2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME FOR CFR ENGINES (1981)

Test Results Sample No. S.C - 01

Lab. No.:	LC-01	LC-02	LC-03	LC-04	LC-05	LC-06	LC-07	LC-08	LC-09
Motor Number	No. 4	1131197 4-62	E-1815	-	F-1	724065	207441		-
Knock Rating F-1 ASTM D-2699	97.3	97.3	97.4	97.3	96.8	97.0	96.9		98.2
Spec. Gravity 60/60 °F ASTM D-1298	0.7585	0.7579	0.7572	0.7563	0.7582	0.7576	0.7596		0.7571
KVP, psi	7.5	7.3	7.4	7.6	7.9	7.0	7.1		7.9
Distillation ASTM D-86									
IBP °C	38	36	41	35	39.5	42	50		36.5
10% °C	62	62	67	61	63	65	68.5		63.5
50% °C	101	102	103	102	102.5	99	103.0		100.0
90% °C	148	147	144	143	149.5	146	151.0		146.5
EP °C	182	190	176	180	179	179	183.5		181.0
Content, ml./USG ASTM D-526/IP-116	1.51	0.39	1.51	1.14	2.465	1.19	0.06		2.76

Table 5
**2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
 FOR CFR ENGINES (1981)**

Rest Results Sample No. S.C - 01

Lab. No.:	LC-10	LC-11	LC-12	LC-13	Average
Motor Number	G-37747/ 318810	178812 9-69	252382 9-73	CFR-48	
Knock Rating F-1 ASTM D-2699	97.3	97.7	98.0	97.4	97.4
Spec. Gravity 60/60 °F ASTM D-1298	0.7575	0.7583	0.7603	0.757	0.7580
RVP, psi	7.8	7.9	7.3	6.9	7.5
Distillation ASTM D-86					
IBP °C	38	41.0	39	-	39.6
10% °C	61	62.0	63	-	63.4
50% °C	101	102.0	102	-	101.6
90% °C	148	145.0	146	-	146.7
EP °C	178	187.0	179	-	181.3
Content, mL/USG ASTM D-526/IP-116	2.405	2.46	2.30	-	1.65

Table 6

**2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)**

Deviation of General Properties Sample (SC-01).

Determination	IC-01	IC-02	IC-03	IC-04	IC-05	IC-06	IC-07	IC-08	IC-09
Specific Gravity 60/60°F	+0.0005	-0.0001	-0.0008	-0.0017	+0.0002	-0.0004	+0.0016		-0.0009
R.V.P. psi	0.0	-0.2	-0.1	+0.1	+0.4	-0.5	-0.4		+0.4
Distillation									
I.B.P. °C	-1.6	-3.6	+1.4	-4.6	-0.1	+2.4	+10.4		-3.1
10% °C	-1.4	-1.4	+3.6	-2.4	-0.4	+1.6	+5.1		+0.1
50% °C	-0.6	+0.4	+1.4	+0.4	+0.9	-2.6	+1.4		-1.6
90% °C	+1.3	+0.3	-2.7	-3.7	+2.8	-0.7	+4.3		-0.2
E.P. °C	+0.7	+8.7	-5.3	-1.3	-2.3	-2.3	+2.2		-0.3
T.E.L. Content ml/USG	-0.14	-1.26	-0.14	-0.51	+0.815	-0.46	-1.59		+1.11

Table 6

2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)
Deviation of General Properties Sample (SC-01)

Determination	IC-10	IC-11	IC-12	IC-13				
Specific Gravity 60/60°F	-0.0005	+0.0003	+0.0023	-0.0010	+0.0005	-0.0004	+0.0076	-0.0003
R.V.P. psi	+0.3	+0.4	-0.2	-0.6				
Distillation								
I.B.P. °C	-1.6	+1.4	-0.6	-				
10% °C	-2.4	-1.4	-0.4	-				
50% °C	-0.6	+0.4	+0.4	-				
90% °C	+1.3	-1.7	-0.7	-				
E.P. °C	-3.3	+5.7	-2.3	-				
T.E.L. Content ml/USG	+0.755	+0.81	+0.65	-				

Table 7

**2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)**

Calculation SC-01

Col. A Laboratory	Motor Number F-1	Col. B Octane Number	Col. C Deviation of Average	Col. D Deviation Squared
LC-01	No. 4	97.3	-0.1	0.01
LC-02	4-62-1131197	97.3	-0.1	0.01
LC-03	E-1815	97.4	0.0	0.0
LC-04	-	97.3	-0.1	0.01
LC-05	F-1	96.8	-0.6	0.36
LC-06	724065	97.0	-0.4	-0.16
LC-07	207441	96.9	-0.5	0.25
LC-08				
LC-09	-	98.2	+0.8	0.64
LC-10	G-37747/318810	97.3	-0.1	0.01
LC-11	9-69-178812	97.7	+0.3	0.09
LC-12	9-73-252382	98.0	+0.6	0.36
LC-13	CFR-48	97.4	0.0	0.0
	SUM	1168.6	3.6	1.9
	No. of results (n)	12	12	12

Step 1 :

Average Octane Number : $\frac{\text{sum of results}}{\text{no. of result}} = \frac{1168.6}{12} = 97.38 = 97.4$

Step 2 :

Average Deviation : $\frac{\text{sum of deviation}}{\text{no. of deviation}} = \frac{3.6}{12} = 0.3$

Step 3 :

Variance : $\frac{\text{sum of dev. Squared}}{(\text{no. of dev. squared}-1)} = \frac{1.9}{12-1} = \frac{1.9}{11} = 0.17$

Step 4 : Standard Deviation : square root of variance = $\sqrt{\text{variance}} = \sqrt{0.17} = 0.41$

Step 5 :

Rejection of Outliers : "T" factor x std. deviation = $2.55 \times 0.41 = 1.05$

All results are not rejected.

Table 8
**2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
 FOR CFR ENGINES (1981)**
 Test Conditions Sample No. SC - 02

Lab. No.:	LC-01	LC-02	LC-03	LC-04	LC-05	LC-06	LC-07	LC-08	LC-09
Motor Number	No. 4	1131197 4-62	E-1815	-	F-1	724065	207441		-
Total Hours	-	9849.4	62517	-	790.5	,7481.5	12024		-
Running Hours after Last Overhaul	147.3	155.7	719.4	302	47	420	95.1		158.7
Use Ice Tower, yes/no	No	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Intake Air Temperature, °F	125	115	125	127	125	125	125		85
Ambient Temperature, °C	29.1	31.5	29.4	26	27	28.5	30		24
Barometric Pressure, mm Hg	757.6	766.4	760	764	764	755	759		760
RPM	600	600	600	600	600	595	600		600
Altitude, m	3.65	2.5	3.65	5	4.2	0.98	4		41
Knockmeter Sensitivity	14	30 Div (3)	20	28	20	20	19		C.R. Method
Cylinder Position	DC				681 DC				
	MS	0.521	0.534	0.530	0.524	0.526	0.523		0.523

Table 8

2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)

Test Results Sample No. S.C - 02

Lab. No.:	IC-10	IC-11	IC-12	IC-13				
Motor Number	G-37747/ 318810	178812 9-69	252382 9-73	CFR-48				
Total Hours	626.7	1431	1441	-				
Running Hours after Last Overhaul	620.4	248	100	31				
Use Ice Tower, yes/no	No	Yes	Yes	Yes				
Intake Air Temperature, °F	126	125	125	125				
Ambient Temperature, °C	28.5	25.6	30	30.6				
Barometric Pressure, mm Hg	763	759	755.5	760				
RPM	600	600	595	600				
Altitude, m	6	2.5	+ 4	0				
Knockmeter Sensitivity	18	14 (Time C3)	16	28				
Cylinder Position	DC			657 DC				
	MS	0.526	0.528	0.525				

Table 9
 2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
 FOR CFR ENGINES (1981)
 Test Result Sample No. S.C. - 02

Lab. No.:	LC-01	LC-02	LC-03	LC-04	LC-05	LC-06	LC-07	LC-08	LC-09
Motor Number	No. 4	1131197 4.62	E-1815	-	F-1	724065	207441		-
Knock Rating F-1 ASTM D-2699	87.5	88.2	87.2	86.7	86.8	86.9	87.2		87.3
Spec. Gravity 60/60 °F ASTM D-1298	0.7379	0.7377	0.7376	0.7370	0.7359	0.7370	0.7380		0.7408
KVP	7.3	7.6	7.0	7.4	7.85	6.7	6.9		7.8
Distillation ASTM D-86									
IBP	39	38	39	35	40.5	42	43.5		36.5
10%	64	64	64	61	64.5	65	63.5		62.0
50%	101	101	100	99	100.5	99	98.5		98.0
90%	144	143	142	142	146	141	146		144.5
EP	180	195	178	182	183	179	181		175.5
TEL Content, ml/USG ASTM D-526/IP-116	2.50	2.543	2.54	2.42	2.395	2.37	Nil		2.79

Table 9
2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)
Test Result Sample No. S.C. - 02

Lab. No.:	LC-10	LC-11	LC-12	LC-13	Average
Motor Number	G-37747/ 318810	178812 9-69	252382 9-73	CFR-48	
Knock Rating F-1 ASTM D-2699	87.3	86.9	87.0	87.1	87.2
Spec. Gravity 60/60 °F ASTM D-1298	0.7372	0.7366	0.7385	0.737	0.7376
RVP, psi	7.35	8.3	7.0	7.25	7.4
Distillation ASTM D-86					
ILP °C	38	44.0	37	-	39.3
10% °C	59.5	64.0	64	-	63.2
50% °C	97	100.0	99	-	99.4
90% °C	143.5	142.0	141	-	143.2
EP °C	178	192.0	175	-	181.7
TEL Content, ml/USG ASTM D-526/IP-116	2.525	2.43	2.52	-	2.3

Table 10
 2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
 FOR CFR ENGINES (1981)

Deviation of General Properties Sample (SC-02)

Determination	LC-01	LC-02	LC-03	LC-04	LC-05	LC-06	LC-07	LC-08	LC-09
Specific Gravity 60/60°F	+0.0003	+0.0001	0.0000	-0.0006	-0.0017	-0.0006	+0.0004		+0.0032
R.V.P. psi	-0.1	+0.2	-0.4	0.0	+0.4	-0.7	-0.5		+0.4
Distillation									
I.B.P. °C	-0.3	-1.3	-0.3	-4.3	+1.2	+2.7	+4.2		-2.8
10% °C	+0.8	+0.8	+0.8	-2.2	+1.3	+1.8	+0.3		-1.2
50% °C	+1.6	+1.6	+0.6	-0.4	+1.1	-0.4	-0.9		-1.4
90% °C	+0.8	-0.2	-1.2	-1.2	+2.8	-2.2	+2.8		+1.3
E.P. °C	-1.7	+13.3	-3.7	+0.3	+1.3	-2.7	-0.7		-6.2
T.E.L. Content ml/USG	+0.2	+0.243	+0.24	+0.12	+0.095	+0.07	-2.3		+0.49

Table 10
 2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
 FOR CFR ENGINES (1981)

Deviation of General Properties Sample (SC-02)

Determination	LC-01	LC-02	LC-03	LC-04	LC-05	LC-06	LC-07	LC-08	LC-09
Specific Gravity 60/60°F	+0.0003	+0.0001	0.0000	-0.0006	-0.0017	-0.0006	+0.0004		+0.0032
R.V.P. psi	-0.1	+0.2	-0.4	0.0	+0.4	-0.7	-0.5		+0.4
Distillation									
I.B.P. °C	-0.3	-1.3	-0.3	-4.3	+1.2	+2.7	+4.2		-2.8
10% °C	+0.8	+0.8	+0.8	-2.2	+1.3	+1.8	+0.3		-1.2
50% °C	+1.6	+1.6	+0.6	-0.4	+1.1	-0.4	-0.9		-1.4
90% °C	+0.8	-0.2	-1.2	-1.2	+2.8	-2.2	+2.8		+1.3
E.P. °C	-1.7	+13.3	-3.7	+0.3	+1.3	-2.7	-0.7		-6.2
T.E.L. Content mL/USG	+0.2	+0.243	+0.24	+0.12	+0.095	+0.07	-2.3		+0.49

Table 11
**2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
 FOR CFR ENGINES (1981)**
 Deviation of General Properties Sample (SC-02)

Col. A Laboratory	Motor Number F-1	Col. B Octane Number	Col. C Deviation of Average	Col. D Deviation Squared
LC-01	No.4	87.5	+0.3	0.09
LC-02	4-62-1131197	88.2	+1.0	1.0
LC-03	E-1815	87.2	0.0	0.0
LC-04	-	86.7	-0.5	0.25
LC-05	F-1	86.8	-0.4	0.16
LC-06	724065	86.9	-0.3	-0.09
LC-07	207441	87.2	0.0	0.0
LC-08				
LC-09	-	87.3	+0.1	0.01
LC-10	G-37747/318810	87.3	+0.1	0.01
LC-11	9-69-178812	86.9	-0.3	0.09
LC-12	9-73-252382	87.0	-0.2	0.04
LC-13	CFR-48	87.1	-0.1	0.01
	SUM	1046.1	3.3	1.75
	No. of results (n)	12	12	12

Step 1 :
 Average Octane Number : $\frac{\text{sum of results}}{\text{no. of results}} = \frac{1046.1}{12} = 87.18 = 87.2$

Step 2 :
 Average Deviation : $\frac{\text{sum of deviation}}{\text{no. of deviation}} = \frac{3.3}{12} = 0.28$

Step 3 :
 Variance : $\frac{\text{sum of dev. squared}}{(\text{no. of dev. squared} - 1)} = \frac{1.75}{12-1} = \frac{1.75}{11} = 0.16$

Step 4 :
 Standard Deviation : squared root of variance = $\sqrt{\text{variance}} = \sqrt{0.16} = 0.40$

Step 5 :
 Rejection of Outliers : "T" factor x std. deviation = $2.55 \times 0.40 = 1.02$
 All results are not ree rejected.

Table 12
2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)
 Test Conditions Sample No. SC-03

Lab. No.:	LC-01	LC-02	LC-03	LC-04	LC-05	LC-06	LC-07	LC-08	LC-09
Motor Number	No. 4	1131197 4-62	E-1815	-	F-1	/24065	207441		-
Total Hours	-	9850.1	62519	-	791.4	7483	1203.5		-
Running Hours after Last Overhaul	153.1	156.4	721.6	304	47.9	421.5	96.2		168.2
Use Ice Tower, yes/no	No	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Intake Air Temperature, °F	125	115	125	127	125	125	125		85
Ambient Temperature, °C	29.2	31.5	29.4	26	27	28	30		24
Barometric Pressure, mm Hg	757.0	766.2	760	764	764	755	759		760
RPM	600	600	600	600	600	595	600		600
Altitude	3.65	2.5	3.65	5	4.2	0.98	4		41
Knockmeter Sensitivity	14	25 Div (3)	17	28	22	20	18		C.R. Method
Cylinder Position	DC				663 DC				
	MS	0.548	0.546	0.538	0.550	0.540			0.540

Table 12
 2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
 FOR CFR ENGINES (1981)
 Test Conditions Sample No. SC-03

Lab. No.:	IC-10	IC-11	IC-12	IC-13	IC-14	IC-15	IC-16	IC-17	IC-18
Motor Number	G-37747/ 318810	178812 9-69	252382 9-73	CFR-48					
Total Hours	625.8	1431	1449	-					
Running Hours after Last Overhaul	619.5	248	108	32					
Use Ice Tower, yes/no	No	Yes	Yes	Yes					
Intake Air Temperature, °F	126	125	125	125					
Ambient Temperature, °C	28.5	25.6	30	30.6					
Barometric Pressure, mm Hg	763	759	755.5	760					
RPM	600	600	599	600					
Altitude, m	6	2.5	+ 4	0					
Knockmeter Sensitivity	16	²⁶ (Time C3)	19	25					
Cylinder Position	DC			627 DC					
	MS	0.543	0.556	0.549					

Table 13

2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME FOR CFR ENGINES (1981)

Test Results Sample No. S.c. -03

Lab. No.:	IC-10	IC-11	IC-12	IC-13	Average
Motor Number	G-37747/ 318810	178812 9-69	252382 9-73	CFR-48	
Knock Rating F-1 ON ASIM D-2699	85.1	85.0	84.0	84.6	84.9
Spec. Gravity 60/60 °F ASIM D-1298	0.8060	0.8067	0.8090	0.806	0.8072
RVP, psi	1.4	-	2.1	1	1.4
Distillation ASIM D-86					
IBP °C	100	100.0	98	-	99.5
10% °C	102	100.0	103	-	102.1
50% °C	104	105.0	105	-	104.1
90% °C	107	107.0	108	-	107.3
EP °C	114.5	130.0	131	-	121.4
TEL Content, ml/USG ASIM D-526/IP-116	0.04	0.09	Nil	-	0.02

Table 13
 2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
 FOR CFR ENGINES (1981)

Test Results Sample No. S.C. - 03

Lab. No.:	IC-01	IC-02	IC-03	IC-04	IC-05	IC-06	IC-07	IC-08	IC-09
Motor Number	No. 4	113 1197 4.62	E-1815	-	F-1	724065	207441		-
Knock Rating F-1 ASTM D-2699	84.8	85.3	84.8	85.4	85.0	84.0	85.2		85.3
Spec. Gravity 60/60 °F ASTM D-1298	0.8071	0.8081	0.8067	0.8081	0.8071	0.8072	0.8065		0.8076
KVP, psi	1.3	1.4	1:1	1.6	1.65	1.0	1.5		1.6
Distillation ASTM D-86									
IBP °C	100	100	98	100	99.5	98	101		100.0
10% °C	102	103	102	102.2	102	102.5	103.5		101.0
50% °C	103.5	104	103.5	104.2	104	104	104.5		103.5
90% °C	107	108	106	108.0	107.5	107	108.0		107.0
EP °C	114	140	118	110.8	121.5	128	118		109.5
TEL Content, ml/USG ASTM D-526/IP-116	0.02	Nil	0.01	0.02	Nil	Nil	0.01		Nil

Table 14

**2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)**

Deviation of General Properties Sample (SC-03)

Determination	IC-01	IC-02	IC-03	IC-04	IC-05	IC-06	IC-07	IC-08	IC-09
Specific Gravity 60/60°F	-0.0001	+0.0009	-0.0005	+0.0009	-0.0001	0.0	-0.0007		+0.0004
R.V.P. psi	-0.1	0.0	-0.3	+0.2	+0.25	-0.4	+0.1		+0.2
Distillation									
I.B.P. °C	+0.5	+0.5	-1.5	+0.5	0.0	-1.5	+1.5		+0.5
10% °C	-0.1	+0.9	-0.1	+0.1	-0.1	+0.4	+1.4		-1.1
50% °C	-0.6	-0.1	-0.6	+0.1	-0.1	-0.1	+0.4		-0.6
90% °C	-0.3	+0.7	-1.3	+0.7	+0.2	-0.3	+0.7		-0.3
E.P. °C	-7.4	+18.6	-3.4	-10.6	+0.1	+6.6	-3.4		-11.9
T.E.L. Content ml/USG	0.0	-0.02	-0.01	0.0	-0.02	-0.02	-0.01		-0.02

Table 14

2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)

Deviation of General Properties Sample (SC-03)

Determination	LC-10	LC-11	LC-12	LC-13
Specific Gravity 60/60°F	-0.0012	-0.0005	+0.0018	-0.0012
R.V.P. psi	0.0	-	+0.7	-0.4
Distillation				
I.B.P. °C	+0.5	+0.5	-1.5	-
10% °C	-0.1	-2.1	+0.9	-
50% °C	-0.1	+0.9	+0.9	-
90% °C	-0.3	-0.3	+0.7	-
E.P. °C	-6.9	+8.6	+9.6	-
T.E.L. Content mL/USG	+0.02	+0.07	-0.02	-

Table 15

**2ND ANNUAL ASCOPE LABORATORY TEST CORRELATION PROGRAMME
FOR CFR ENGINES (1981)**

Calculation SC-03

Col. A Laboratory	Motor Number F-1	Col. B Octane Number	Col. C Deviation of Average	Col. D Deviation Squared
LC-01	No. 4	84.8	-0.1	0.01
LC-02	4-62-1131197	85.3	+0.4	0.16
LC-03	E-1815	84.8	-0.1	0.01
LC-04	-	85.4	+0.5	0.25
LC-05	F-1	85.0	+0.1	0.01
LC-06	724065	84.0	-0.9	0.81
LC-07	207441	85.2	+0.3	0.09
LC-08				
LC-09	-	85.3	+0.4	0.16
LC-10	G-37747/318810	85.1	+0.2	0.04
LC-11	9-69-178812	85.0	+0.1	0.01
LC-12	9-73-252382	84.0	=0.9	0.81
LC-13	CFR-48	84.6	-0.3	0.09
	SUM	1018.5	4.3	2.45
	No. of results (n)	12	12	12

Step 1 :
Average Octane Number : $\frac{\text{sum of results}}{\text{no. of results}} = \frac{1018.5}{12} = 84.88 = 84.9$

Step 2 :
Average Deviation : $\frac{\text{sum of deviation}}{\text{no. of deviation}} = \frac{4.3}{12} = 0.36$

Step 3 :
Variance : $\frac{\text{sum of dev. squared}}{(\text{no. of dve. squared} - 1)} = \frac{2.45}{12.1} = \frac{2.45}{11} = 0.22$

Step 4 :
Standard Deviation : Square root of variance = $\sqrt{\text{variance}} = \sqrt{0.22} = 0.47$

Step 5 :
Rejection of Outliers : "T" factor x std. deviation = 1.20

All results are not rejected.

FIG. 1
 DEVIATION vs LAB. CODE (SC - 01)

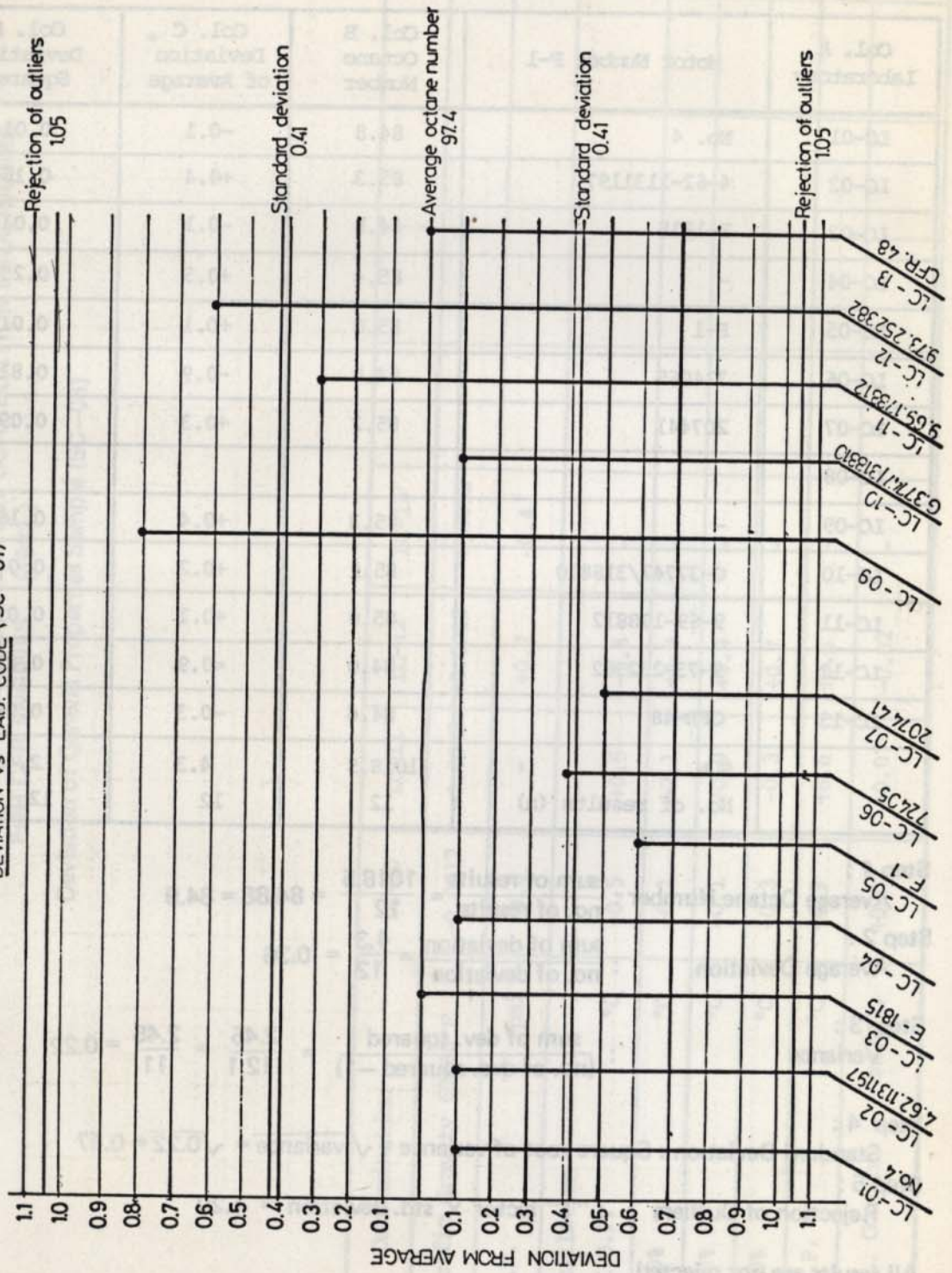


FIG. 2
DEVIATION vs LAB. CODE
 (SC - 02)

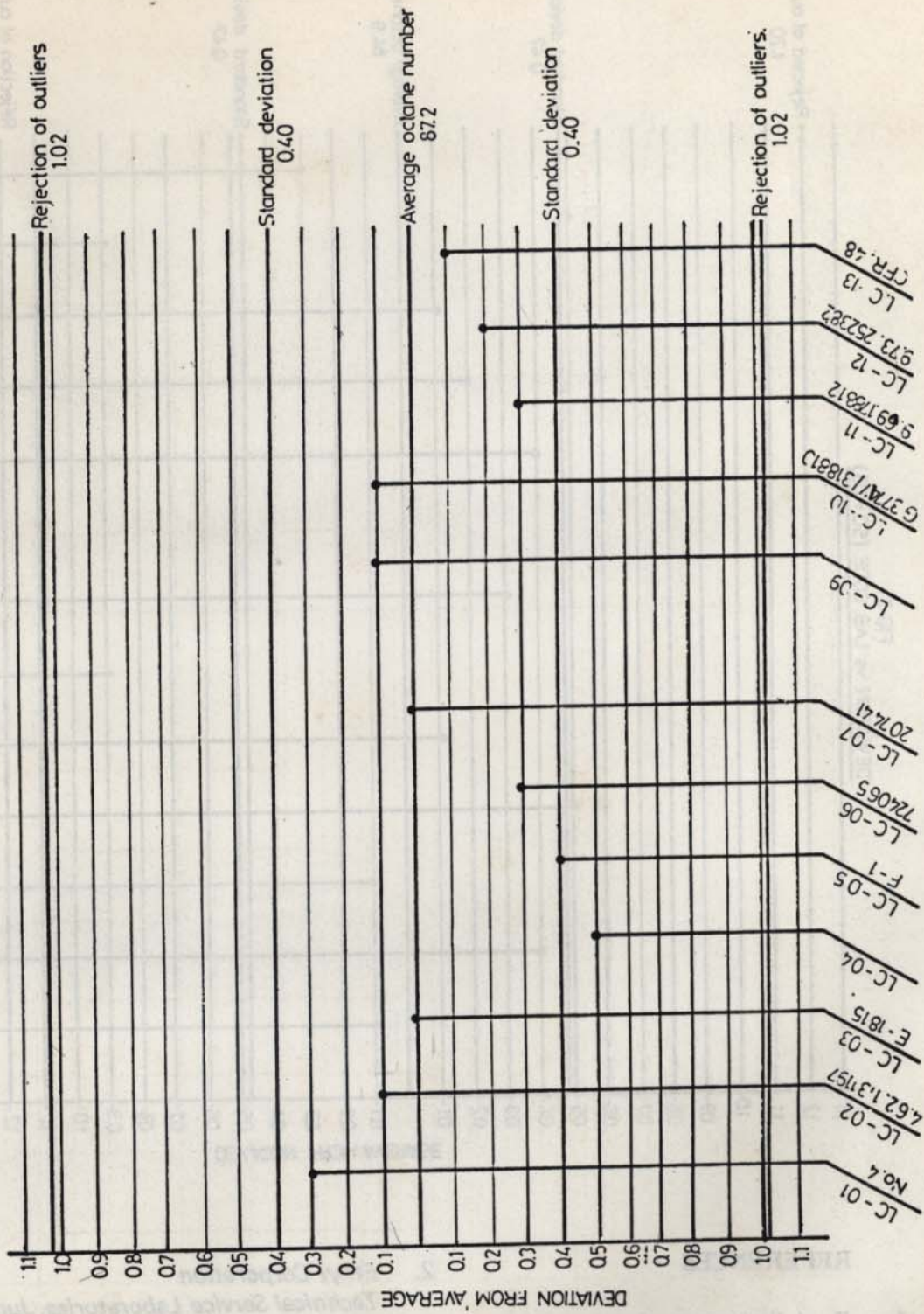
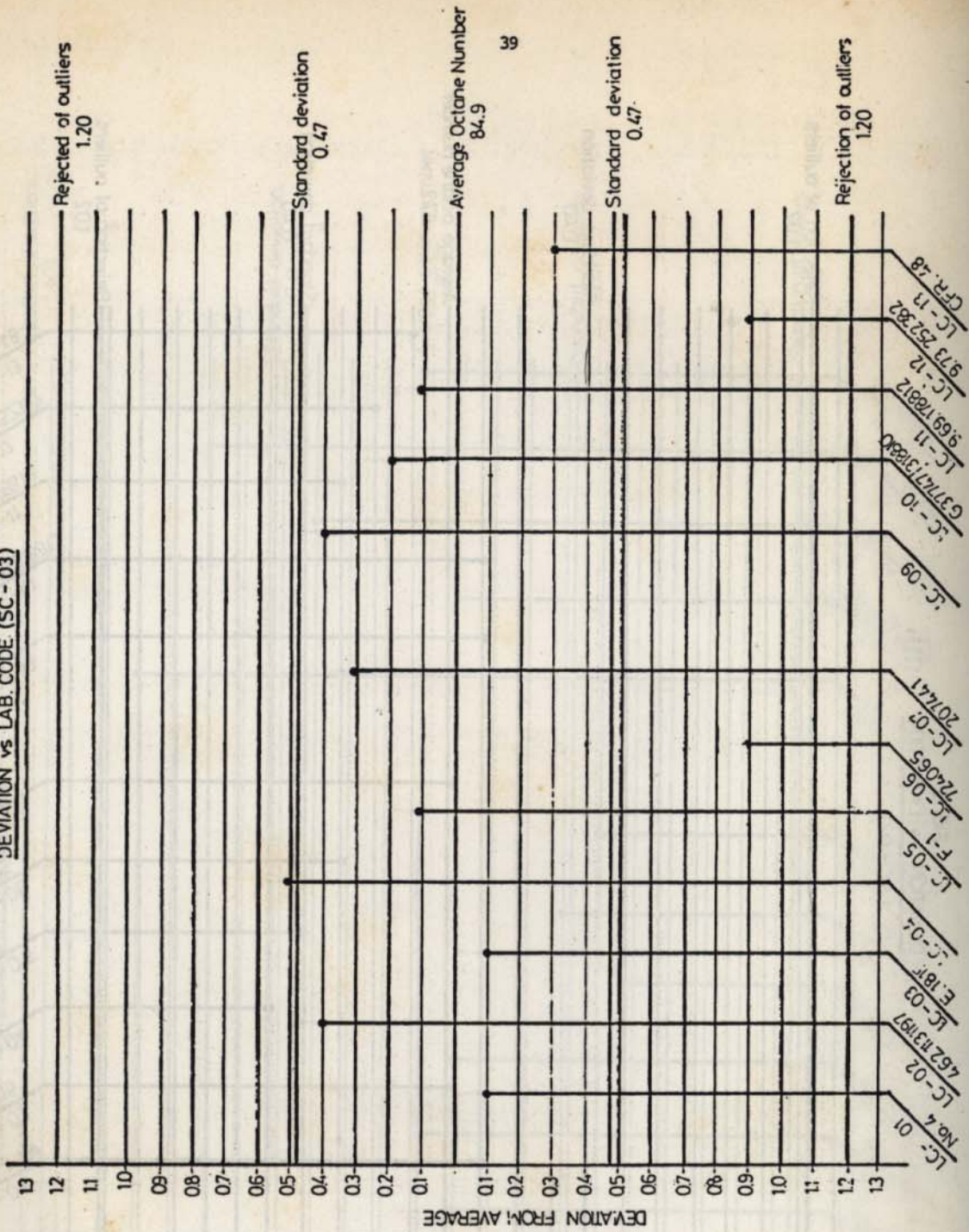


FIG. 3
DEVIATION vs LAB. CODE (SC - 03)



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