IS 14234 (1996): Lubricants for Two-stroke Spark Ignition Air-cooled Gasoline Engines [PCD 3: Petroleum, Lubricants and their Related Products]

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भारतीय मानक

दो स्ट्रोक स्पार्क प्रज्वलन वायु-शीतित गैसोलीन इंजन के लिये स्नेहक — विशिष्टि

Indian Standard

LUBRICANTS FOR TWO-STROKE SPARK IGNITION AIR-COOLED GASOLINE ENGINES — SPECIFICATION

UDC 621.892.097.2

BUREAU OF INDIAN STANDARDS
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Price Group 13

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Lubricants and Related Products Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

The design of the two-stroke cycle gasoline engine offers unique operational and economic advantages for a wide range of different power applications. The two-stroke air-cooled engine applications are widely seen in (1) Mopeds, (2) Motor-cyles, (3) Scooters, (4) Chain saws, (5) Lawn movers, and (6) Portable small generators etc.

Proper lubrication of two-stroke engines is of primary importance for their satisfactory operation. Generally the following parameters constitute the basis for acceptability of lubricant for two-stroke engines:

a) Lubricity,
b) Deposits,
c) Ring sticking,
d) Spark plug fouling,
e) Exhaust port blocking,
f) Power loss,
g) Preignition,
h) Miscibility, and
j) Exhaust smoke.

Because of the many variations in design and the broad range of power applications, varying degrees of stresses are placed on the lubricants. The choice of a suitable lubricant is an especially difficult task in the absence of anv guide. Even internationally, no classification/specification is yet available although considerable progress has now been made on the joint classification proposed by CEC/SAE/API/ASTM and there is more towards global specification as a result of cooperation with JASO, Japan.

With the background information available on the proposed international specification and considering the lubricant requirements specific to Indian two-stroke engines, this specification has been proposed.

International engine tests have been retained till such time equivalent indigenous tests are developed and the correlation tests are run. Some engine test facilities for qualifying these oils are available in the country with Indian Institute of Petroleum (IIP), Dehradun ; Indian Oil Corporation (Research and Development Centre) [IOC (R&D)], Faridabad; and Lubrizol (India) Limited (LIL), Bombay. Facilities available in overseas laboratories can be utilized supplementing the facilities in the country.

Indigenous engine tests have been included in the specification as tentative methods and the correlation tests are currently being run.

The following table indicates the various indigenous engine tests which have been planned to be developed through the joint efforts of LIL, Bombay; IOC (R&D), Faridabad; IIP, Dehradun and the respective OEM's:

Performance Characteristics	*TSL-1*	*TSL-2*
Lubricity	Sunny 50 cc	Kinetic Honda KH 100
Detergency	Bajaj Chetak (Mod)	Bajaj Chetak (Mod)
Port blocking	Sunny 50 cc	—
Smoke	Sunny 50 cc	Sunny 50 cc
Preignition	Bajaj Chetak (Mod)	Bajaj Chetak (Mod)
Wear	To report as part of detergency test	To report as part of detergency test
Ring sticking	Covered in detergency test	Kinetic Honda KH 100

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

LUBRICANTS FOR TWO-STROKE SPARK IGNITION AIR-COOLED GASOLINE ENGINES — SPECIFICATION

1 SCOPE

1.1 This standard covers lubricants primarily intended for use in automotive, two-stroke cycle, spark ignition, air-cooled, gasoline engines such as mopeds, scooters, motor cycles, etc.

1.2 This standard prescribes the requirements and the engine tests for the two classes (*see* **4.1**) of lubricants as applicable to air cooled spark ignited two-stroke gasoline engines upto 350 cc capacity.

1.3 This standard covers two classes:

i) Conventional 2T-Lubricants intended for use in moderate output engines of old design having peak torque value less than and equal to 9.0×10^{-2}Nm/cc.

ii) High performance 2T-Lubricants intended for use in high output new generation two-stroke engines having peak torque value above 9.0×10^{-2}Nm/cc.

1.4 Oils meeting the requirements of this standard may also be specified by engine manufacturers for use in other types of two-stroke gasoline engines.

2 NORMATIVE REFERENCES

The following standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1447 : 1966	Methods of sampling of petroleum and its products
1448	Methods of test for petroleum and its product
2796 : 1971	Specification for motor gasoline
4639 : 1968	Glossary of petroleum terms
10000 (Part 4) : 1980	Methods of test for internal combustion engines : Part 4 Declaration of power, effeciency, fuel consumption and lubrication oil consumption (Amendment 1)

3 DEFINITIONS

3.1 For the purpose of this standard, the definition given in IS 4639 : 1968 and the following shall apply:

3.1.1 *Cold Sticking,* of piston rings, a condition in which the ring is free in its groove while the engine is running but stuck when the piston is cold, normally indicated by the absence of varnish or other deposits on the outer face of the ring and of signs of blowby on the piston skirt.

3.1.2 *Combustion Chamber,* in reciprocating internal combustion engines, the volume bounded by the piston crown and any portion of the cylinder walls extending above the piston crown when in the top dead center position, and the inner surface of the cylinder head including any spark plugs and other inserted components.

3.1.3 *Hot Sticking,* of piston rings, a condition in which the ring is stuck in its groove while the engine is running, normally indicated by varnish or other deposits on the outer face of the ring, by signs of blowby on the piston skirt, or both.

3.1.4 *Lubricity,* a qualitative term describing the ability of a lubricant to minimize damage to the surfaces in relative motion under load arising out of friction between the two surfaces.

3.1.5 *Preignition,* in a spark ignition engine ignition of the mixture of fuel and air due to hot deposits in the combustion chamber prior to the occurrence of the spark.

3.1.6 *Scuff, Scuffing,* damage caused by instantaneous localized welding between surfaces in relative motion which does not result in immobilization of the parts.

3.1.7 *Spark Plug Fouling,* deposition of essentially non-conducting material onto the electrodes of spark plug that may, but will not necessary prevent the plug from operating.

3.1.8 *Spark Plug Whiskering or Spark Plug Bridging,* a deposit between material on the spark plug electrodes, which tends to form a bridge between them, thus shorting out the plug.

3.1.9 *Benchmark Reference Oil*, an oil meeting the requirements of a test of this standard and whose performance on that test must be equalled or exceeded by that of the candidate oil within the specified tolerances (*see* Table 1).

3.1.10 *Major Pre-ignition*, Pre-ignition indicated by sudden increase in the combustion chamber of 30°C or more but over a period of less than a minute.

4 CLASSIFICATION

4.1 Types

The oils qualifying against this standard shall be classfied as two-stroke (TS) oils under one of the following two types:

TSL-1 : Conventional 2T oil for moderate output engines.

TSL-2 : High performance 2T oil for high output engines.

5 REQUIREMENTS

5.1 General

The oil shall be formulated using virgin or re-refined oil base stock blended with suitable additive material to meet the requirements of this standard. The use of synthetic base stocks is also permitted.

5.1.1 Blended base oil shall meet the requirements laid down in Table 2.

5.2 Physico Chemical Requirements

5.2.1 The oil shall be free from suspended matter, grit, water or any other impurities.

5.2.2 The oil shall comply with the physical and chemical requirements prescribed in Table 3.

5.3 ENGINE TEST REQUIREMENTS

5.3.1 Approved Engine Tests

The approved engine tests for performance evaluation of both the types TSL-1 and TSL-2 are summarised below (*see also* Annex A):

Sl No.	*Performance Characteristics*	*TSL-1*	*TSL-2*
i)	Lubricity	TVS XL-50[3]/ Yamaha CE 50/ Motobecane 50 cc	Bajaj[4] Super 05 Series
ii)	Detergency	Bajaj[1] Super 05 Series	Bajaj[1] Super 05 Series
iii)	Port blocking	Yamaha[5] CE 50S/ Motobecane 50 cc	—
iv)	Smoke	—	Bajaj[2] Super 05 Series
v)	Preignition	Bajaj[4] Super 05	Bajaj[4] Super 05 Series
vi)	Wear	Report as part of detergency test	Report as part of detergency test
vii)	Ring sticking	Covered in detergecy test	Rajdoot[4] 1A15 RD 350

1) Facility available at Lubrizol (India) Ltd, Bombay, Indian Institute of Petroleum, Dehradun and Indian Oil Corporation Ltd (R&D Centre), Faridabad.

2) Facility available at Indian Institute of Petroleum, Dehradun.

3) Facility available at IOC (R&D), Faridabad. Alternately Yamaha CE 50S or Motobecane 50 cc may be run.

4) Facility available at IOC (R&D), Faridabad. Alternatively, ASTM test on Yamaha RD 350 may be run.

5) Facility available at IFP, France; SWRI, USA.

6 PERFORMANCE CRITERIA IN ENGINE TEST FOR TSL-1 TYPE LUBRICANTS

6.1 Lubricity Sequence (TVS-XL 50 Engine)

The oil shall be able to provide adequate lubricity to avoid piston scuffing in all the vehicles less than 50 cc capacity. To assess this, the performance of the candidate oil in TVS-XL 50 engine test must be equal to, within the specified tolerance, or better than that of the bench mark reference oil when run under the test conditions specified in Annex B. The bench mark reference oil required by this standard is CEC Reference oil RL-09 or any indigenised reference oil.

6.2 Detergency Sequence (Bajaj Super 05 Series Engine Test)

The oil shall be able to provide overall good general performance with respect to piston deposits, ring sticking, spark plug fouling, powerloss due to port blockage etc. To assess this, the performance of the candidate oil must be equal to within the specified tolerances or better than that of the bench mark reference oil when run under the test conditions required by this standard. The bench mark reference oil to be used is CEC reference oil RL-7 or any indigenised reference oil. In case the performance of candidate oil exceeds the targets laid down in Table 4 it should be rated as 'pass' without the need for running a bench mark reference oil. Wear should also be reported in this test method.

6.3 Port Blocking Sequence (Yamaha CE 50S Engine)

The oil shall be able to keep piston and exhaust port clean in order to avoid any power loss due to blockage in moderate output conventional engine. To assess this, the performance of the candidate oil must be equal to, within the specified tolerance, or better than that of the bench mark reference oil when run under the test conditions required by this standard. The bench mark reference oil used when testing to this standard is CEC reference oil RL-10 or any indignenised reference oil. In case the drop in full throttle power with candidate oil is less than 20 percent and the exhaust system obstruction is less than 50 percent it should be rated as 'pass' without the need for running a bench mark reference oil.

Standard ASTM test procedure should be followed.

6.4 Pre-ignition Sequence (Bajaj Super 05 Series Engine Test)

The oil shall be able to avoid deposit induced preignition. Not more than one major preignition may occur when running the candidate oil under the test conditions specified in Annex C. The bench mark reference oil used when testing to this standard is CEC reference oil RL-05 or any indigenised reference oil.

7 PERFORMANCE CRITERIA IN ENGINE TEST FOR TSL-2 TYPE LUBRICANTS

7.1 Lubricity Sequence (Bajaj Super 05 Series Engine Test)

The oil shall be able to provide adequate lubricity to avoid piston scuffing in high load high output new generation two-stroke engines. To assess this, the performance of the candidate oil in test must be equal to, within the specified tolerances, or better than that of the bench mark reference oil when run under the test conditions specified in Annex D. The bench mark reference oil used when testing to this standard is CEC reference oil RL-56 or any indegenised reference oil.

7.2 Detergency Sequence (Bajaj Super 05 Series Engine Test)

The oil shall be able to provide overall good general performance with respect to piston deposits, ring sticking, spark plug fouling, powerloss due to port blockage etc. To assess this, the performance of the candidate oil must be equal to, within the specified tolerances, or better than that of the bench mark reference oil when run under the test condition specified in Annex E. The bench mark reference oil used when testing to this standard is CEC reference oil RL-7 or any indigenised reference oil. In case the performance of candidate oil exceeds the targets laid down in Table 4, it should be rated as 'pass' without the need for running a bench mark reference oil. Wear should be reported in this test method.

7.3 Pre-ignition Sequence (Bajaj Super 05 Series Engine Test)

The oils shall be able to avoid deposit induced preignition. Not more than one major preignition may occur when running the candiate oil under the test conditions specified in Annex C. The bench mark reference oil used when testing to this standard is CEC reference oil RL-05 or any indigenised reference oil.

7.4 Ring Sticking (Rajdoot 1A1.5 RD350 Engine Test)

The oil shall be able to avoid ring sticking high output new generation two-stroke engines. To assess this the performance of the candidate oil must be equal to, within the specified tolerances, or better than that of the bench mark reference oil when run under the conditions specified in Annex F. The bench mark reference oil used in this test is TSR-1.

7.5 Smoke Test (Bajaj Super 05 Series Engine)

The bench mark reference oil used in the test specified in Annex G is TSR-1[1] 2T-oil having synthetic base oil formulation or any other equivalent oil formulation may be used as high reference oil.

8 PASS FAIL CRITERIA IN ENGINE TESTS

8.1 For All Tests

8.1.1 As described above, the candidate oil may be rated as 'pass' without the need for runing a bench mark reference oil if the performance targets given in Table 4 are met. If the absolute targets laid down in Table 4 are not met the candidate oil must be compared with the bench mark reference oil. The performance of candidate oil must be as good as within the tolerance allowed or better than that of the bench mark reference oil.

8.1.2 The occurrence of the scuff or seizure mark in any part of the test engine shall require the test to be re-run. If scuff or seizure occurs again, the test shall be terminated as a failure unless it can be established that the failures are caused by some deficiency in the test bench. In this case, after correction, the test may be re-run.

8.1.3 The following criteria should be adopted to rate the candidate oil as 'pass' when compared to bench mark reference oils in various tests. These criteria basically constitute the tolerances specified on bench mark reference oils.

1) Made available from IOC (R&D) Centre. Faridabad.

a) *Ring sticking*
Rating of the individual rings of the candidate oil pistons shall be not more than 0.5 merit below that of the rings run on bench mark reference oils.

b) *Piston skirt varnish*
The average piston varnish rating of a candidate oil shall be not more than 0.5 merit number below that of the bench mark reference oil.

c) *Spark plug fouling*
Not more than two occurrences per test with the candidate oil than with the bench mark reference oil.

d) *Exhaust port blocking*
The percentage of the exhaust port area blocked by the deposits with candidate oil shall not be more than 10 percent greater than that for the bench mark reference oil.

e) *Preignition major preignition*
Not more than 1 major preignition with the candidate oil.

f) *Tightening*
The average torque drop observed for the candidate oil must be equal to or less than for the bench mark reference oil.

8.2 Pass Fail Criteria for Ring Sticking Sequence (Rajdoot 1A1 RD 350 Engine Test)

In this test two runs are normally made, exchanging the oils between cylinders after the first run, and the average mean of the ratings for the candidate and bench mark reference oils are compared; except that a pass may be given to the candidate without making the second run if the following conditions all exist:

8.2.1 *Early Pass Criteria*

a) Second ring sticking merit rating for the candidate oil is 9.0 or better.

b) The piston varnish rating for the candidate oil is absolutely without consideration of tolerance equal to or better than that for the bench mark reference oil.

c) There has been no incidence of preignition, major or minor.

d) Exhaust port blocking for the candidate oil is not more than 5 percent greater than for the bench mark reference oil.

e) There has been not more than one incidence of plug fouling with the candidate oil.

8.2.2 *Early Fail Criteria*

A candidate oil test must be rated as a failure, and may be terminated after the first run, if there has been any incidence in the candidate oil cylinder of hot sticking, major preignition, or exceessive port blockage as defined. Any such occurrence in the bench mark reference oil cylinder shall require the test to be re-run after the cause has been found and corrected. If this happens during the second run of a test, it is not necessary to repeat the test.

9 STABILITY AND COMPATIBILITY OF FINISHED LUBRICATING OILS

9.1 The finished blended oil shall have the additive elements uniformly distributed throughout the oil and shall show no evidence of instability at temperature specified in the homogenity and miscibility tests described in Annex H.

9.2 The oil shall be compatible with all other oils previously qualified under this standard as well as with reference oil TSR-1 as demonstrated by the homogeneity and miscibility test described in Annex H.

10 QUALIFICATION APPROVAL

10.1 The oil shall be subjected to qualification approval in accordance with the details given in Annex J.

11 PRODUCT IDENTIFICATION

To ensure acceptance of only qualified products and for the purposes of product identification, tests may be carried out by the purchaser or his agency on the following characteristics of the oil and the test results shall be compared with the corresponding figures given in the product identification report. Permissible tolerances of test results are indicated against each of the characteristics:

Sl No.	*Characteristics*	*Method of Test Ref to IS 1448*	*Tolerence*
(1)	(2)	(3)	(4)
i)	Flash point (PMCC)	P:21	*Min*, as specified
ii)	Pour point	P:10	*Max*, as specified
iii)	Kinematic viscosity cSt, at 40°C	P:25	± 10 percent of the reported value
iv)	Viscosity index	P:56	*Min*, as specified
v)	Sulphated ash	P:4	
vi)	Calcium	P:77	
vii)	Magnesium	P:77	
viii)	Phosphorus	P:54	−10 to +20
ix)	Barium	P:77	percent of the
x)	Sulphur	P:33	reported
xi)	Nitrogen	[1]	value
xii)	Zinc	P:77	

[1] Under preparation. Till such time it is published ASTM D 3228-79 may be followed.

12 PACKING AND MARKING

12.1 Packing

The material shall be packed in metal containers or in any other suitable containers as agreed to between the purchaser and the supplier.

12.2 Marking

The container shall be securely closed and marked with the following:

i) Indication of the source of manufacture;
ii) Name, type and grade of the material;
iii) Net mass of the material;
iv) Recognized trade-mark, if any; and
v) Identification in code or otherwise to enable the lot of consignment or manufacture to be traced back from records.

12.2.1 All marking including batch number of lot of manufacture shall be made on one flat end when the material packed in barrels.

12.2.2 The containers may also be marked with the Standard Mark.

13 SAMPLING

13.1 Representative samples of the material shall be drawn as prescribed in IS 1447 : 1966.

13.2 Number of Tests

Tests for all the characteristics given in Table 2 shall be conducted on the composite sample.

13.3 Criteria for Conformity

The lot shall be declared as conforming to the requirements of the specification if all the test results on the composite sample satisfy the relevant specification requirements.

Table 1 Bench Mark Reference Oils
(*Clause* 3.1.9)

Sl No.	Characteristic	RL-09	RL-10	RL-55	RL-56	RL-07	RL-05	TSR-1	TSR-2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	K.viscosity @ 40°C	125	62.5	32.2	164.4	112.2	108	52.3	54.73
	@ 100°C	12.9	8.22	5.4	15.9	11.4	11.0	8.09	8.13
ii)	Viscosity index	104	108	114	110	96	96	125	118
iii)	Sulphated ash, percent by mass	0.73	0.25	0.16	0.16	0.12	—	0.14	0.24
iv)	Elemental analysis, percent by mass								
	Zinc	0	0	0	0	0	0.9	0	0
	Phosphorus	0	0	0	0	0	0.8	0	0
	Calcium	0.2	0.08	0.05	0.05	0	0	0.052	0.07
	Barium	0	0	0	0	0.07	0	0	0

NOTES

1 RL-09, RL-10, RL-55, RL-56, RL-07, RL-05 are CEC Standard Reference Oils and are therefore, available from CEC. In due course these CEC reference oils will be replaced by indigenous reference oils.

2 TSR-1, TSR-2 is available from IOC (R&D) Centre, Faridabad.

Table 2 Tests for Blended Base Oil Without Diluent and Without Additives (PIB or Any Other)
(*Clauses* 5.1.1 *and* 13.2)

Sl No.	Characteristic	Method of Test, Ref to IS 1448	Tolerence
(1)	(2)	(3)	(4)
i)	Density at 15°C, g/ml	P:16	To be reported
ii)	Viscosity index		
	a) Base oil up to 12.5 cSt at 100°C	P:56	95, *Min*
	b) Base oil above 12.5 cSt at 100°C	P:56	90, *Min*
iii)	Flash point (Cleveland open cup),°C	P:69	*Min* as specified for finished product (*see* Table 2)
iv)	Carbon residue (Conradson), percent by mass	P:122	0.4, *Max* for base oil upto 12.5 cSt 0.6, *Max* for base oil above 12.5 cSt
v)	Total acid number, mg KOH/g	P:1	0.05, *Max*
vi)	Strong acid number	P:1	Nil
vii)	Sulphur, percent by mass	P:33	20 percent of the reported value
viii)	Copper strip corrosion at 100°C for 3 hour	P:15	1, *Max*
ix)	Ash content, percent	P: 4	0.01, *Max*
x)	Water content, percent by volume	P:40	0.03, *Max*

Table 3 Physical and Chemical Requirements for Two-Stroke Engine Lubricating Oils TSL-1 and TSL-2

(*Clause* 5.2.2)

Sl No.	Characteristic	Requirement of Oil Type		Method of Test Ref to Annex IS 1448
		TSL-1	*TSL-2*	
(1)	(2)	(3)	(4)	(5)
i)	Kinematic viscosity, cSt,[1] 40°C, *Min*	45	45	P:25
ii)	Diluent, percent by mass, *Max*	20	15	2)
iii)	Sulphated ash, percent by mass, *Max*	0.2	0.25	P:4
iv)	Flash point °C, *Min* (PMCC)	65	65	P:21
v)	Pour point, °C, *Max*	−6	−6	P:10
vi)	Elemental analysis,[3] ppm, *Max*			
	a) Zinc	30	30	P:120
	b) Lead	Report	Report	P:80
	c) Phosphorus	5	5	P:54
	d) Silicon[1]	10	10	

[1] ASTM D 5185 : 1993 (ICAP) may be followed.

[2] ASTM D 1160 method may be followed.

[3] These are suggestions only. After monitoring over a year new guidelines will be laid.

Table 4 Performance Targets

(*Clauses* 6.2, 7.2 *and* 8.1)

Sl No.	Test	Targets	
		TSL-1	*TSL-2*
(1)	(2)	(3)	(4)
i)	Lubricity sequence	Performance of candidate oil better than or equal to bench mark reference oil RL-09 or indigenous reference oil	Performance of candiate oil better than or equal to bench mark, reference oil RL-56 or indigenous reference oil
ii)	Port blocking sequence		
	— Drop in full throttle power, percent	20, *Max*	—
	— Exhaust system obstruction, percent	50, *Max*	—
		Merit Rating	
iii)	Detergency sequence	*TSL-1*	*TSL-2*
	— Ring sticking (I Ring)	9/10, *Min*	9.5/10, *Min*
	(II Ring)	10/10, *Min*	10/10, *Min*
	— Piston skirt	8/10, *Min*	8.5/10, *Min*
	— Piston scuffing	10/10, *Min*	10/10, *Min*
	Exhaust port blocking, percent	5.0, *Max*	5.0, *Max*
	— Powerloss due to deposits, percent	5.0, *Max*	5.0, *Max*
iv)	Preignition sequence		
	— Incidence of major preignition	1, *Max*	0
v)	Ring sticking sequence	—	Performance of candidate oil better than or equal to bench mark reference oil, TSR-1.

ANNEX A

(*Clause* 5.3)

SUMMARY OF ENGINE TEST METHODS

A-1 LUBRICITY SEQUENCE (TVS XL-50 ENGIENE TEST)

This test sequence can be run in indigenous TVS XL-50 engine.

The TVS XL-50 engine test method has been standardized to evaluate the lubricity characteristics of oils under 'TSL-1' category. This procedure is a modification of CEC L-19-T-77. It is run in a TVS-50 engine, single cylinder air-cooled engine supplied with a 50:1 by volume fuel to oil mix. The engine is brought to equilibrium at 4 000 rpm wide open throttle (WOT), and the cooling air flow is adjusted to give a spark plug gasket temperature of 170± 3°C. Cooling air to the cylinder is then cut-off and the output torque recorded when the plug gasket temperature is 200°C and again when it reaches 300°C, then the cooling air flow is restored. The smaller the reduction in torque output at constant speed during this interval, the better the ability of the oil to lubricate the piston. This is normally a non-destructive test. Tests are run alternately on bench mark reference and candidate oils for their comparative evaluation.

A-2 PORT BLOCKING SEQUENCE (YAMAHA CE 50S ENGINE TEST)

The test sequence can be run in Yamaha CE 50S engine. The facility to run this test is available at 1FP, France and SWRI, USA. Method is run as per standard ASTM test procedure. The engine is run on a cycle approximating that of moped use and the test is terminated when the resistance to gas flow through the exhaust system has increased by 70 percent over that of a clean system. Or, a fixed duration (250 hours) test is run and the candidate oil data is compared with bench mark reference oil. Ring sticking and other deposit ratings are also done in this test.

NOTE — New planned test will be developed in indigenous Sunny 50 cc test engine.

A-3 LUBRICITY SEQUENCE (BAJAJ SUPER 05 SERIES ENGINE TEST)

The procedure is a modification of CEC L-21-T-77 Sequence I, for which the Vespa 180 cc test engines are no longer available. It is run in a Bajaj Super 150 cc single cylinder air cooled engine supplied with a 20 : 1 by volume fuel to oil mix. The engine is brought to equilibrium at 3 800 rpm and 3.1 KW output and after 1 hour of engine conditioning, the engine cooling is then cut off. The decrease in the engine torque and the time required for a spark plug temperature rise of 100°C are reported. It is a non-destructive test and tests are alternately run on low, high reference and candidate oils. Based on the torque drop and time data, a parameter, called percent Discriminating Index, is calculated to assess the oil quality.

A-4 DETERGENCY SEQUENCE (BAJAJ SUPER 05 SERIES ENGINE TEST)

The test procedure is a modification of CEC L-21-T-77 Sequence II, for which the Vespa 180 cc test engine are no longer available. It is run in a Bajaj Super 150 cc air cooled engine. The method consists of essentially a 56 h period of operation on 50 : 1 fuel oil ratio under cyclic operating conditions. At the end of the test piston is rated for ring sticking and deposits on the skirt, undercrown, ring land etc. Percent blockage of exhaust port and average power loss at WOT are also assessed.

A-5 PREIGNITION SEQUENCE (BAJAJ SUPER 05 SERIES ENGINE TEST)

This procedure is a modification of CEC L-21-7-77, Sequence III, for which the Vespa 180 cc engine are no longer available. It is run in a Bajaj Super 150 cc air cooled engine. The onset of preignition is accompanied by a sudden increase in the average cycle temperature as measured by a thermocouple in the combustion chamber together with a concurrent decrease in brake load. When the temperature increases and torque decreases, this is an indication of preignition.

A-6 RING STICKING SEQUENCE (RAJDOOT 1A1.5RD 350 ENGINE TEST)

This test sequence can be run using indigenous Rajdoot 350 engine. The test is run in a 347 cm^3 Yamaha RD 350B twin cylinder air cooled motor cycle engine for 20 h, set up with the number one cylinder supplied with a fuel mix containing the bench mark reference oil and number two cylinder with a fuel mix containing the candidate oil, both at 50:1 fuel to oil ratio by volume. The test is normally run twice, exchanging the oils between cylinders for the second run, unless the performance of the candidate oil exceeds that of the bench mark reference oil in which case the second run need not be made.

A-7 SMOKE SEQUENCE (BAJAJ SUPER 05 ENGINE)

This is smoke test run on Bajaj Chetak test bench engine and uses hartridges smoke meter for meas-

urement of smoke level with various oils. The test is carried out at 2 percent oil fuel ratio. No load acceleration test procedure is followed. 15 cycles are run, the average of last 5 cycles is taken as smoke level. Candidate oils are rated against a reference oil.

ANNEX B

(*Clause* 6.1)

DETERMINATION OF LUBRICITY FOR TSL-1 TYPE OF TWO-STROKE AIR-COOLED ENGINE LUBRICANTS (TVS-XL-50 LUBRICITY METHOD)

B-1 GENERAL

This test method evaluates the ability of lubricants to minimize piston and bore scuffing in two-stroke cycle spark ignition gasoline engines of upto 50 cc size.

B-2 SUMMARY OF TEST METHOD

The test has been developed to replace the CEC L-19-T-77 lubricity test, for which test engines are no longer available. It is run in a 49.9 cm^3 single cylinder air cooled two-stroke cycle engine operated at 4 000 rev/min wide open throttle (WOT) using 50 : 1 mixture of gasoline and oil by volume. After conditions have stabilized, the cooling air is cut off. The output torque is measured when the spark plug gasket temperature reaches 200°C and again when it reaches 300°C at which point the cooling air is restored. The corresponding time is also measured and the rate of torque drop *i.e.* $\Delta T \mid \Delta t$ is calculated. The smaller the reduction in the rate of torque drop during this period, the better the ability of the oil to lubricate the piston. This test is not normally damaging to the engine. Sets of five such tightenings are normally run using alternately a bench mark reference oil and the candidate oil for each set.

B-3 SIGNIFICANCE AND USE

The oil in a two-stroke cycle gasoline engine is either mixed with fuel prior to use or is metered into the fuel supply at or at some point prior to, its passage into the engine crankcase. The possibility of the amount of oil actually present in the engine being less than optimum always exists. Also, with some oil metering systems, short periods of operation with less oil than desirable can occur when the power increases suddenly. It has also been found that the incidence of piston scuff early in the life of the engine may be related to the lubricity of the oil used as defined by the test procedures of this type.

B-4 APPARATUS

B-4.1 Test Engine and Stand

B-4.1.1 *Test Engine Configuration*

A TVS-50 XL 50 cm^3 loop scavenged air cooled two-stroke cycle engine is used. This has 38.9 mm bore, 41.9 mm stroke with an alloy piston operating in a cast iron cylinder bore. Further details are given in B-14. For the purpose of this test the standard piston to bore clearance is increased as specified in B-4.1.2. Other parts are standard production. The engine is in current production and is commercially available.

B-4.1.2 *Adjustment of Piston Clearance*

For the purpose of this test method, the cylinder bore shall be honed to give a 0.08 to 0.09 mm. It is recommended that a number of cylinders be honed out as it is normally necessary to use new piston and also new cylinder for each test.

B-4.2 Test Stand

The dynamometer shall be able to absorb 2.5 KW at 4 000 rev/min with an inherent torque measurement accuracy rev/min of ±0.5 percent or better, and be capable of maintaining 4 000 ± 30 with varying power input. A direct shaft drive or a belt drive from the engine crankshaft may be used.

B-4.3 Cooling Blower

A variable blower with a free flow capacity of about 25m^3/min or air is required. The flow from the blower, shall be directed towards the exhaust side of the engine.

B-4.4 Fuel System

Quick disconnects or other means to facilitate rapid interchange of fuel supply shall be provided as near to the carburetor as practicable. In any case three fuel sources will be needed for a test, one for the candidate oil fuel mix, one for the reference oil fuel mix and one supplying test gasoline only with no oil. The temperature of the fuel entering the carburetor shall not exceed 25°C and this may require cooling in hot climates.

B-4.5 Instrumentation

B-4.5.1 *Measurement of Ambient Conditions*

It is assumed in this section that the engine draws ambient air from the test room. If it is supplied with air from a controlled source, reference to ambient temperature pressure and humidity apply to the air

from the controlled source. Continuous recording to the ambient conditions is recommended.

B-4.5.2 *Engine and System Temperatures*

B-4.5.2.1 *Spark plug gasket temperature*

The spark plug gasket may be fitted with thermocouples. A design that has been found satisfactory is described in **B-15**.

B-4.5.2.2 *Exhaust temperature*

A thermocouples is required in the exhaust elbow within approx 65 mm (2.5 in) from the cylinder exhaust port to monitor exhaust temperature. The thermocouple junction shall be located within ± 3 mm (0.12 in) of the centre of the pipe.

B-4.5.3 *Torque Measurement*

Measurement of torque values and spark plug temperature should be simultaneously done. A dual pen recorder may be used. This is an essential requirement because during the air cut off period both the data should be simultaneously available. Corresponding time is also recorded.

B-5 MATERIALS AND REAGENTS

B-5.1 Test Fuel

B-5.1.1 Reformate is the preferred test fuel.

B-5.1.2 If reformate is not available, use gasoline containing 0.013 g/l of lead. Any such alternative gasoline shall be tested by the procedure of **B-7.3** before it is adopted as a test fuel to ensure that adequate differentiation between reference oils can be obtained with such fuel.

B-5.1.3 About 16 litres of fuel are required for complete test including 10 litres for the break in.

B-5.2 Reference Oils

Servo 2T Supreme oil is used for running-in and as an assembly lubricant. RL-09 is specified as the bench mark reference oil. About 500 ml of bench mark reference oil and about 500 ml of Servo 2T Supreme for running-in is required.

B-5.3 Candidate Oil

About 200 ml is required for test. At least twice this amount should be provided in case the test is rerun.

B-6 PROCEDURE

B-6.1 Assembly of Engine

B-6.1.1 *Initial Build*

The test engine is initially built-in using a new piston, rings, cylinder (modified as specified in **B-4.1.2**) and cylinder base and head gaskets (*see* **B-16**).

B-6.1.2 *Rebuilt After Test*

It is not necessary to use new parts in each test other than gaskets, a new piston, new piston rings, a new cylinder (modified dimensions) and a new or reconditioned muffler, provided that all parts are clean and within specification with no sign of damage. Engine rebuild procedure as given in **B-16** may be followed.

B-7 OPERATING INSTRUCTIONS

B-7.1 Running-in Procedure

A new engine assembly after proper tuning is run-in using 4:100 oil/fuel ratio. Oil recommended for running-in is Servo 2T Supreme. The running-in procedure is given in **B-17**. After completion of II Phase of running-in schedule, engine is dismantled and engine parts such as cylinder block, piston and piston rings are visually inspected for scoring marks, if any. If scoring marks are evident, the assembly is rejected; otherwise after decarbonising, the components are assembled back and III Phase of running-in schedule is completed and a full throttle power curve is taken. If the engine develops more than 90 percent of rated power, the engine is ready for lubricity test. On completion of running-in, run for 5 min at 4 000 rpm at no load using oil free test gasoline.

B-7.2 Lubricity Test Procedure

In lubricity test, the engine is run at 4 000 rpm and full throttle (1.9 HP) output. Air cooling is controlled in such a way that the spark plug seat temperature is 170 °C ± 3°C.

The engine is run for 30 min for stabilization. The cooling air is then cut off and the recorder for spark plug temperature and torque measurement is switched on simultaneously. Measurement of time and torque drop between 200 to 300°C spark plug temperature is accounted for calculation. As soon as temperature reaches 300°C, power output is reduced and cooling is restored. Five consistent readings are taken on one oil and then test is carried out on another oil. Before switching over to next oil, the engine is stopped by running the carburetor dry on previous oil and is then restarted to run for 5 min without any oil in the fuel before the next test is taken up. The engine is then run for 30 min stabilization period before measuring torque drop by cutting off cooling air.

All the tests are conducted at 2:100 oil to fuel ratio.

B-7.3 Selective Assembly for Lubricity Test

After running-in has been satisfactorily completed, it is necessary to check whether the given assembly

is able to discriminate between high and low reference oils. This parameter known as Engine Selectivity Index (ESI) is calculated as follows:

$$\text{Engine selectivity index} = \frac{\Delta C_2 - \Delta C_1}{\Delta C_1} \times 100$$

where

ΔC_1 = Rate of torque drop for low ref oil (RL 79)—Average for 5 runs

ΔC_2 = Rate of torque drop for high ref oil (RL-09)—Average for 5 runs

For an engine assembly to be declared fit for carrying out lubricity tests, engine selectivity index must be less than–50.

The ESI should also be worked out at least after 10 tests or 30 operating days whichever comes first. ESI should also be worked out if the test bench has been idle for a month or more days.

B-7.4 Sequence of Oil Testing

Once the assembly has passed the criteria of selectivity as indicated above, it is ready for lubricity test. the following sequence may be run.

Oil	*Run No.*	*Set No.*
Bench mark reference oil	1-6	1
Candidate oil	7-12	2
Bench mark reference oil	13-18	3
Candidate oil	19-24	4

The first test in each series that is 1, 7, 13, 19 are not taken into account when interpreting the results. Bench mark reference oil is RL-09.

Each set shall be run without interruption and the interval between sets shall not exceed 2 h. If the test is interruppted for any longer period the entire test shall be rerun as set-to-set comparisons are not then reliable.

B-7.5 Elimination of Maverick Results Within a Series

It may happen that one of the torque loss data, does not seem to be in accordance with the others in the series. If this happens, apply the Hawkins and Perold method described in **B-18** to a maximum significance of 0.10.

B-7.6 Change Over Engine Flush

After completing each set, run the carburetor dry and top the engine as it runs out of fuel. Run it again for two minutes on pure gasoline at 4 000 rpm at half load. Run the carburetor dry and stop the engine as it runs out of fuel. Run it again for one minute with new fuel at 4 000 rpm at full load. Run the carburetor dry and stop the engine as it runs out of fuel. Run it for 15 min with new fuel at 4 000 rpm at full load. Test bench is now ready to begin the new series of tightening tests.

B-7.7 Spark Plug Malfunctions

Malfunctioning spark plugs are replaced and the test continues. Repeat any set of tightenings during which it occurs.

B-7.8 Calculations

The mean (average) value of the rate of the torque drop are calculated separately for the reference and the candidate oil. These values are used to determine whether there is a significant difference between the results obtained with the two oils. A sample calculation is shwon in **B-19.**

B-8 PASS FAIL CRITERION

If the average torque drop obtained with the candidate oil is equal to or less than that obtained with bench mark reference oil as calculated by the procedures specified in **B-19** the candidate oil is declared 'PASS'.

B-9 REPORT

A detailed report should be prepared including the identification of candidate oil, engine selectivity data, dates of test run and other relevant details.

B-10 RETENTION OF PARTS AND RECORDS

The testing laboratory shall retain for a minimum of 1 year the log sheets, recordings and other test records for both candidate and reference oil tests. one litre sample of candidate oil, each batch of reference oil and each batch of fuel used should be retained for a minimum of one year.

B-11 PRECISION AND BIAS

B-11.1 Precision

No precision statement can be made as this test determines only that the lubricity of a candidate oil is or not equal to or greater than that of a reference oil.

B-11.2 Bias

the procedure of this test method has no bias because lubricity is defined only in terms of this test method.

B-12 TECHNICAL SPECIFICATION OF THE TEST ENGINE

Name of Engine : TVS-50 XL

ENGINE DATA

Engine type,
scavenging type : Schnurle

No. of cylinder, No.: 1 (One)

Bore, mm : 38.9 mm

Swept vol. cc	:	49.9 cc
Comp. ratio	:	8.0
Max power @ rpm	:	1.40 kW at 5 000 rpm
Max torque @ rpm	:	3.2 Nm at 3 250 rpm
Spark plug	:	W 175 Z1
Spark plug gap mm	:	0.5 mm
Ignition timing, BTDC or mm	:	2.4 mm BTDC
CB point gap, mm	:	0.4 mm
Carburetor	:	Spaco 13/11 SHA
Main jet size, mm	:	52, 0.52 mm
Idle jet size, mm	:	NA
Idle rpm	:	1 300 rpm - 1 500 rpm
Idle CO set %	:	4.5% with by pass device
Intake	:	NA

Port timing CA or mm

Exhaust	:	118° CA
Transfer	:	134° CA

Port areas

Intake	:	NA
Exhaust	:	(25 × 9.6) mm^2
Transfer	:	(18 × 6) mm^2 × 2

Material

Cylinder	:	CI Grade 25
Cylinder head	:	Aluminium
Piston	:	AL Alloy — Mahle 224
Rings	:	CI Top chrome plated ring
Lubrication	:	Petroil

B-13 SPARK PLUG GASKET THERMOCOUPLE (*see* **Fig. 3**)

B-14 TVS 50 ENGINE REBUILD PROCEDURE

Inspection of a new TVS-50XL test engine prior to test and the inspection and parts replacement required for rebuild of engine between tests is summarized below. For details other than those summarized here refer to the TVS-50 service manual.

B-14.1 Disassembly

B-14.1.1 *Cylinder and Piston*

Pullout H.T. Cap and the spark plug. Loosen the four cylinder head nuts uniformly by diagonal selection to avoid warping of the cylinder head by using 10 mm box/tubler spanner. Carefully push out the cylinder block from the studs along with the cylinder head gasket. Remove the base gasket by scrapping if necessary. Take care not to damage the crankcase. Remove the piston pin locks using suitable pliers. Gently tap or press out the piston pin using a piloted driver.

B-14.1.2 *Crankcase*

It is not necessary to disassemble the crankcase after completing 6 test run or 500 operation whichever is earlier. Refer to TVS-50 service manual for cleaning and reuse.

B-14.2 Inspection of Parts

B-14.2.1 *Cylinder Head*

Remove carbon from cylinder head with blunt tool. Check spark plug threads and gasket surface for flatness, replace if found damaged.

B-14.2.2 *Connecting Rod and Crank Pin Bearing*

Prior to piston assembly measure the side clearance between connecting rod and the crankthrow face. If this exceeds 0.5 mm or if there is any sign of bearing distress either repair/replace the crank shaft, rod and associated bearings and seals or discard if overhauling already done once.

B-14.2.3 *Clutch*

Clutch facing should be checked for cracks and thickness. Replace if cracks are found and thickness is reduced to 3.0 mm.

B-14.2.4 *Pressure Plate*

Check for distortion and if it exceeds 0.2 mm, discard.

B-14.2.5 *Induction System*

Check for flatness, check for the insulator/adopter on the carburetor fitting snugly in the induction pipe, replace adopter/insulator or induction pipe, if required.

B-14.2.6 *Reed Valve*

It is necessary to inspect after 250 h run. Refer to service manual for cleaning and check.

B-14.2.7 *Other Components*

Make a general inspection of air filter, carburetor and ignition wiring. Cleaning repairing or replacing as necessary may be carried out.

B-14.3 Replacement Part for Each Test

Following original spare parts shall be used for each test.

i) New cylinder block,
ii) New piston,
iii) New ring sets,
iv) C.B. point,
v) Small end bearing,
vi) Gaskets, and
vii) Spark plugs.

Measurement shall be done before assembly.

Piston at the rate of 3, 20, 40 mm from the bottom.

Cylinder block at the rate of 20, 38, 55, 70 mm from the bottom.

— Ring end gap

— Ring side clearance

— Ring weight

B-14.4 Recommended Clearance for Rebuild

	Min, mm	*Max,* mm
Cylinder piston clearance[1)]	0.08	0.09
Ring gap 1st	0.02	0.35
Ring gap 2nd	0.22	0.35
Ring side clearance		
1st	0.05	0.1
2nd	0.05	0.1

B-14.5 Other Settings

C.B Point end gap : 0.35 - 0.455 mm

Ignition timing : 21 ± 1° BTDC/23-2.5 mm

Spark plug : MICO W 175 Z1

Spark plug gap : 0.5 mm

Idle CO : 3.5 % V

B-14.6 Miscellaneous

B-14.6.1 Thermocouple and dynamometer shall be calibrated for each test.

B-14.6.2 Tightening torque as per service manual.

B-14.6.3 Reconditioned silencer can be used.

B-15 RUNNING IN PROCEDURE

PHASE-I

Sl No.	*rpm*	*Load %* (hp)	*Temperature Max,* °C	*Duration* h
i)	3 000	25% (0.5)	125	2
ii)	3 500	50% (1.05)	125	2
iii)	4 200	75% (1.6)	140	2
iv)	4 800	Full load 90% (1.82)	160	2

On completion of running-in the engine mounting bolts were checked for tightening and tightened as per manufacturer's specification.

[1)]Bore dimension is to be checked on a plane normal to the gudgeon pin axis. Piston dimension is to be checked 3 mm from the bottom of the piston.

PHASE-II

Sl No.	*rpm*	*Load %* (hp)	*Temperature Max,* °C	*Duration* h
i)	3 000	Full (1.82)	175	2
ii)	3 500	Full (1.84)	175	2
iii)	4 200	Full (1.93)	175	2
iv)	4 800	Full (1.95)	175	2

PHASE III

i)	2 000	—	—	10
ii)	2 500	25% (0.5)	175	10
iii)	3 000	50% (1.05)	175	10
iv)	4 000	75% (1.6)	175	10
v)	5 000	Full (1.9)	175	10
vi)	5 500	Full (2.0)	175	10

B-16 HAWKINS AND PEROLD TEST METHOD FOR DISCARDING MAVERICK RESULTS

Let $X_1, X_2 \ldots\ldots\ldots\ldots X_n$ be the test results

The X_1 figures follow approximately a normal law with a mean of μ and a variance of σ^2, μ and δ^2 being unknown and independent of the X_1 figures.

Calculate the quantities:

$$\bar{X} = \frac{1}{n} \sum_{i=1}^{n} \times i$$

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

$$B* = Max \left(\frac{|X_1 - \bar{X}_1|}{\sqrt{S}} \right) \quad 1 \leq i \leq n$$

Compare the value of B^* as recorded with the critical vlaue of B given in the table below:

n	0.10	0.05	0.01	0.001
5	0.835 7	0.857 5	0.881 8	0.891 7
6	0.811 9	0.844 0	0.882 3	0.903 2
7	0.791 2	0.824 6	0.843 3	0.905 4

If $B^* \geq$ critical B, the result in question should be rejected.

B-17 COMPUTATION OF RESULTS (AN EXAMPLE)

B-17.1 In an experiment the following rate of drop in torque values were obtained:

Set No.	Oil	$\Delta T/\Delta t$(kgf-m/s × 100)					
1	Bench mark	0.394 9	0.424 4	0.378 1	0.395 0	0.394 8	0.424 4
2	Candidate oil	0.404 7	0.554 0	0.424 4	0.434 3	0.424 7	0.415 0
3	Bench mark	0.454 2	0.434 1	0.402 0	0.398 0	0.392 5	0.412 4
4	Candidate oil	0.413 8	0.414 5	0.414 5	0.434 3	0.424 4	0.415 5

B-17.2 As indicated in **B-7.4** first reading in each set is not taken into account when interpreting the results that is 0.394 9, 0.404 7, 0.454 2, 0.413 8 — first value in each set is considered as dropped.

B-17.3 Now for remaining five values in each set, Hawkins and Perold method for discarding Maverick results is followed (*see* **B-18**).

For Set 2:

$$\bar{X} = \frac{1}{5}\sum_{1}^{5} Xi \quad 0.450\,48$$

$$S = \sum_{1}^{5} (X_i - \bar{X})^2 = 135.815 \times 10^{-4}$$

$$B* = Max\left(\frac{|X_1 - \bar{X}|}{\sqrt{S}}\right) = 0.858 \text{ (for } i = 1), 1 \le i \le 5$$

on comparison with the critical value of B for $n = 5$ and α=0.10 we find that

$B^* >$ Critical B

Hence X_1 should be rejected. Therefore the values for set 2 which may be taken into account for interpretation are as follows:

Set 2 : 0.424 4, 0.434 3, 0.424 7, 0.415 0

For other sets, no values are rejected by adopting this method for discarding Maverick results.

B-17.4 Mean value of the rate of torque drop for bench mark reference oil as well as for candidate oil is calculated as follows:

$$\text{Mean } \bar{x} = \frac{1}{n}\sum x\,n$$

Now for the data given in **B-17.1** and modified as in **B-17.3** for the rejected vlaue, the following mean value of the rate of torque drop are worked out:

X_c = 0.422 4 $\qquad$ X_b = 0.405 5

Suffix b, c stands for bench mark reference and candidate oil.

B-17.5 Interpretation of Results

The candidate oil shows a slightly greater mean rate of torque drop (0.422 4) then does the bench mark reference oil (0.405 5) which means than the performance of candidate oil is inferior. Because of the relatively small number of readings for either oil, this can be a statistical chance and their performance can in fact be equivalent. This possibility can be evaluated using the one-tail student small-sample '*t*' test for significance of difference of means.

B-17.5.1 On the assumption that experimental errors are the same for both oils, a combined estimate of standard deviation S_{cb} can be calculated from the expression:

$$S_{cb} = \frac{(n_b - 1).S_b^{\,2} + (n_c - 1).S_c^{\,2}}{n_b + n_c - 2}$$

where

$$S = \frac{\sqrt{[\Sigma X_n) - (\Sigma X_n])^{2/n}\,]}}{\sqrt{n-1}}$$

And then t^* is calculated from

$$t^* = \frac{|\bar{X}_c - \bar{X}_b|}{S_{cb}\sqrt{(1/n_b + 1/n_c)}}$$

t^* is compared to the critical value of t from Table 5 and if $t^* \le$ critical at the required confidence level normally 90 percent, the two means are considered to be equivalent and the candidate passes.

B-17.6 From the data given in **B-1** and modified in **B-3** we get:

n_b	= 9	n_c	= 10
X_b	= 0.402 5	X_c	= 0.422 4
S_b	= 0.520 15	S_c	= 0.520 66
S_{cb}	= 0.270 834 2		
t^*	= 0.159 9		

From Table 5 for 90 percent degree of confidence corresponding to 17 degrees of freedom, t critical=1.333.

Since $t^* < t$ critical, the difference between the mean torque drop is not significant and the candidate oil passes.

Table 5 Critical Values of the *t*-Distribution
(*Clauses* B-17.5.1 *and* B-17.6)

Degree of Freedom[1)]	Degree or Confidence				
	90%	95%	97.5%	99%	99.5%
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.080	2.518	2.831
22	1.321	1.717	2.074	2.508	2.819
23	1.319	1.714	2.069	2.500	2.807
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.706	2.060	2.485	2.787
26	1.315	1.706	2.058	2.479	2.779
27	1.314	1.703	2.052	2.473	2.772
28	1.313	1.701	2.048	2.467	2.763
29	1.311	1.699	2.045	2.462	2.756
30	1.310	1.697	2.042	2.457	2.750

[1)]Degree of freedom $= n_b \rightarrow n_c - 2$

ANNEX C

(*Clauses* 6.4 *and* 7.3)

ENGINE TEST METHOD FOR EVALUATION OF PRE-IGNITION TENDENCY OF 2-STROKE AIR COOLED ENGINE LUBRICANTS (2T OILS) OF TSL-2 (BAJAJ SUPER 05 SERIES ENGINE TEST)

C-1 GENERAL

The purpose of this mehod is to evaluate the effect of a lubricant to induce preignition caused by combustion chamber deposits in two-stroke air cooled gasoline engines.

C-2 OUTLINE OF TEST METHOD

The test is run of a 150 cc, single cylinder, two-stroke air cooled, spark ignition, Bajaj Super 05 series engine for a duration of 50 hours at 4 000 rpm, wide open throttle (WOT) using 5:100 oil to gasoline ratio by volume. The number of incidence of major preignition, as indicated by a rapid increase in combustion chamber temperature, is recorded.

C-3 APPARATUS

The test bench shall consist of a Bajaj Super 05 series engine prescribed in **C-21** and fitted with additional equipments as prescribed in **C-22**. For the purpose of this test, the cylinder head must be modified as specified in **C-11**.

C-3.1 Test Stand

The dynamometer must be able to absorb 4.4 KW (6.0 bhp) at 4 000 rpm with an inherent torque measuring accuracy of ± 0.5 percent or better and be capable of maintaining 4 000 ± 30 rpm. A direct shaft drive from the engine brake shaft after the transmission gear box may be used.

C-4 TEST FUEL

C-4.1 The test fuel used during running-in and the test duration would be a leaded gasoline conforming to the physico-chemical characteristics of IS 2796 as given in Table 6. The level of lead content, saturetes, olefins and aromatics shall be as given in Table 6. If required, TEL may be added to the test fuel to raise its lead content to specified level of 0.4 to 0.63 g/l. Fuel shall not contain non-lead metallic antiknock compounds or oxygenated blending compounds such as alcohols or ethers. It shall contain lead as lead alkyls (conventional motor mix) and shall have a minimum motor octane number of 83 and maximum sensitivity (RON-MON) of 12.

C-4.2 Fuel from the same source shall be used in series of tests in which the performance of test oil is compared with reference oil for calibration.

C-4.3 About 150 l fuel is required for a test and additional 40 l for the running-in.

C-5 REFERENCE OILS

C-5.1 CEC high reference oil RL-05 and low reference oil RL-81 are used for calibration purposes. The properties of these oils are summarized in Table 7. Equivalent indigenous high and low reference oils duly approved may also be used. CEC RL-05 reference oil or equivalent indigenous oil is used for running-in and as an assembly lubricant.

C-5.2 About 7.5 l of reference oil is required to run a calibration test, and 2.0 l for running-in.

C-6 CANDIDATE OIL

About 7.5 l are required for a 50 h test. At least twice this amount should be provided to take care of the eventuality rerun of the test.

C-7 PREPARATION OF APPARATUS

A systematic inspection and calibration of all equipments and instruments shall be made as per manufacturers recommendations and ensure their proper functioning. Any defective or worn out parts must be replaced. For initial build of the engine, use a new cylinder, piston, rings, cylinder head and cylinder base gaskets. The cylinder head is fitted with a thermocouple as specified in C-11.

Rebuild the test engine as per procedure given in C-21. If the engine has been used twice for this sequence, the following parts must be replaced with new parts.

Piston-rings-cylinder assembly, spark plug and new or reconditioned muffler.

The cylinder will usually require replacement after 100 to 150 running hours. After about 1 000 to 1 500 running hours the entire engine will normally require replacement.

C-8 SPARK PLUG

MICO W-175-z 1 or equivalent. Reset gap to 0.5 mm.

C-9 IGNITION CONTROL

Spark advance : 25° btdc.

Contact breaker points gap : 0.3 to 0.5 mm.

C-10 CLEANING OPERATION

Before each test sequence, the engine must be cleaned. Cylinder head and piston crown is decarbonized and washed in a suitable degreasing bath. Wash cylinder and piston in white spirit and when dry smear the bore with the high quality reference oil or test oil.

C-11 MODIFICATION OF CYLINDER HEAD

The cylinder head must be fitted with a shielded thermocouple. The thermocouple should preferably be of the iron-constanton type J, but any thermocouple capable of performing satisfactorily under the test conditions may be used. The general dimensions of a typical thermocouple are shown in Fig. 1 and machining required for through hole in cylinder head are shown in Fig. 2. The through hole in which the thermocouple must fit closely, should be about 10 mm diameter but the thread diameter must be less than 14 mm. The thermocouple is mounted in the head so that its tip is flush with the internal surface of the head without penetrating the shield. Ensure proper contact of the hot junction with the inner surface of the tip of the thermocouple assembly.

C-12 SPARK PLUG GASKET TEMPERATURE

Replace the standard washer of the spark plug with a copper washer fitted with a thermocouple to it for the measurement of its average temperature. The design of the washer and thermocouple is shown in Fig. 3. For this test sequence the spark plug gasket temperature (SPGT) is controlled at 190°±5°C by controlling the cooling air flow.

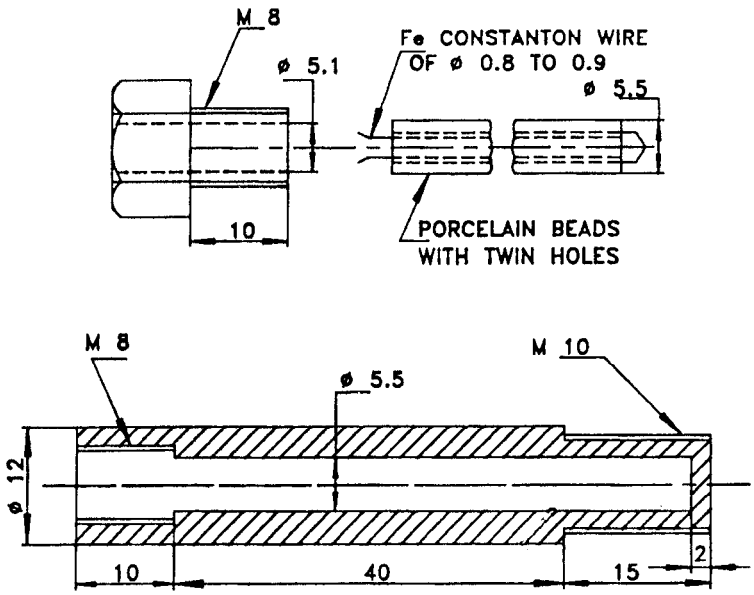
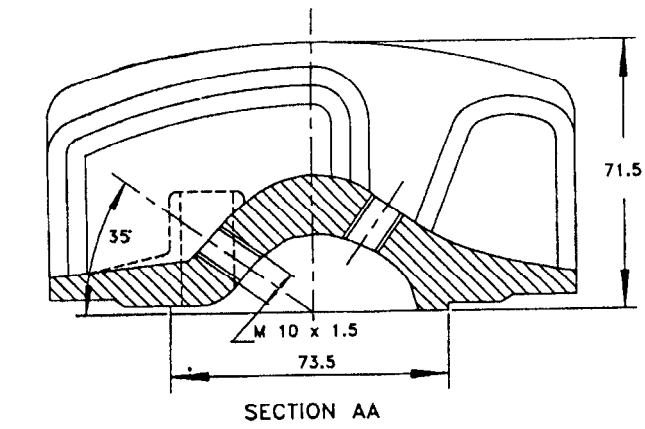


FIG. 1 COMBUSTION CHAMBER THERMOCOUPLE



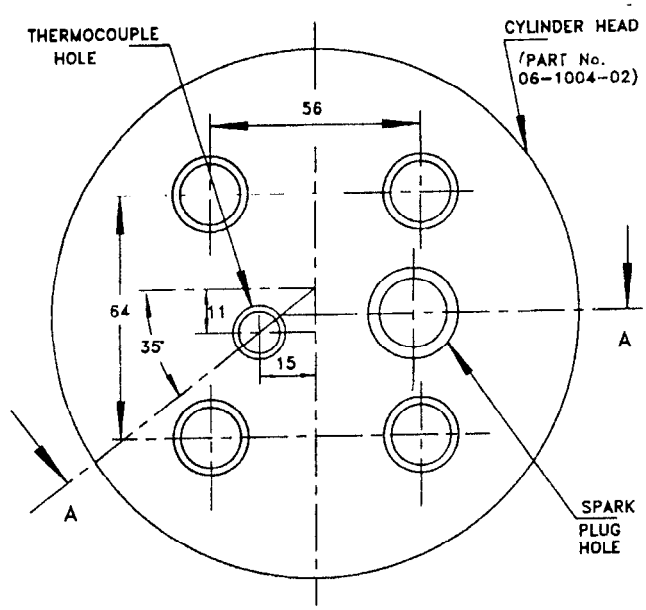


FIG. 2 COMBUSTION CHAMBER THERMOCOUPLE LOCATION IN CYLINDER HEAD

C-13 EXHAUST TEMPERATURE

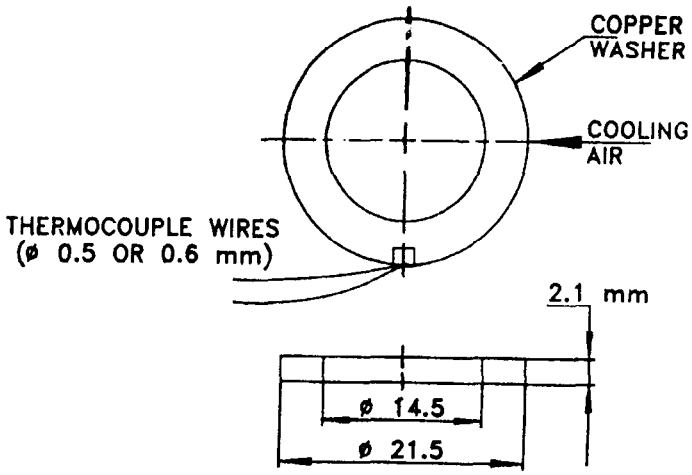
A thermocouple is fitted in the exhaust elbow at 55 ± 5 mm of the cylinder exhaust port to monitor exhaust temperature. A typical thermocouple design is shown in Fig. 4. The thermocouple junction must be located within ± 3 mm from the centre of the exhaust pipe.

C-14 TEMPERATURE AND TORQUE RECORDER

A suitable multichannel recorder shall be used for continuous recording of combustion chamber and spark plug gasket temperatures. A recorder with a range of 50 to 500°C and an overall accuracy of ±2°C is suitable.

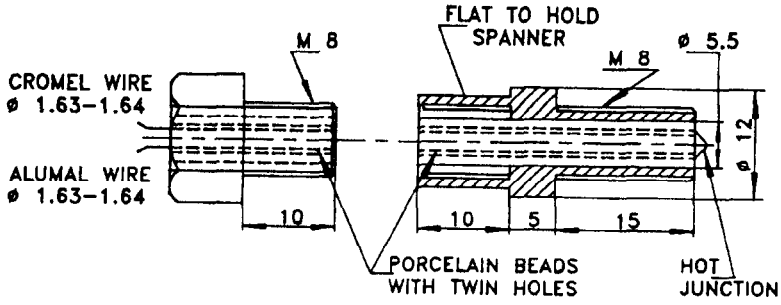
C-15 COOLING AIR CONTROL SYSTEM

A suitable shutter for closing the admission of air to the inbuilt engine blower as shown in Fig. 5 shall be used for keeping spark plug gasket temperature within prescribed limits.



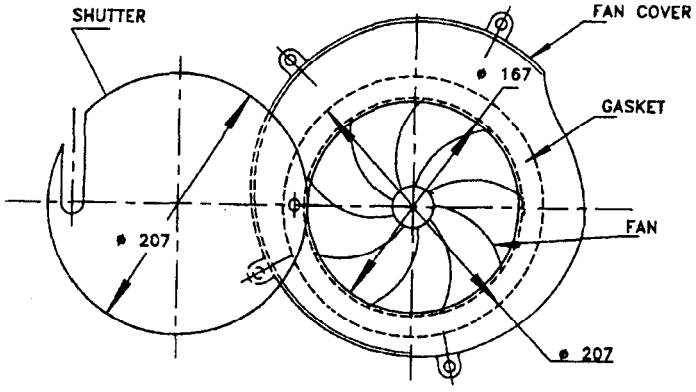
All dimensions in millimetres.

FIG. 3 SPARK PLUG GASKET THERMOCOUPLE



All dimensions in millimetres.

FIG. 4 EXHAUST THERMOCOUPLE



All dimensions in millimetres.

FIG. 5 EXHAUST THERMOCOUPLE

C-16 ENGINE SHUTDOWN PROVISION

Provision must be made for shutdown of the engine in case of a rapid (1 min or less) combustion chamber temperature increase of 50°C or more. This normally indicates as incidence of major preignition and is required to minimize the risk of damage to the engine. Preferably engine shutdown should be automatic.

C-17 RUNNING-IN

If a new cylinder piston has been fitted the engine shall be run-in for 14 h - 50 min according to the schedule given in **C-23**. For runing-in use (5:100) oil fuel ratio by volume of high reference oil RL-05, or any indigenized reference oil. After completion of running-in the engine must be cleaned as described in **C-10**.

C-18 PRE-IGNITION TEST PROCEDURE

C-18.1 Warm Up

When starting after any shutdown run the engine at idling for 10 min. This time is not counted towards the total test time.

C-18.2 Conditioning Period

Run the engine for 30 min at 4 000 rpm 3.26 kW.

C-18.3 Test

The engine is run at 4 000 rpm under WOT condition. The fuel consumption must be between 2.02 ± 0.11 kg/h. The spark plug gasket temperature is adjusted to 190 ± 5°C by controlling the engine cooling air flow.

C-18.3.1 The combustion chamber temperature, and spark plug gasket temperature and engine torque must be recorded continuously. Set the automatic shut down or alarm 50°C above the normal combustion chamber temperature recorded after 90 min duration taking care to compensate for any gradual change in the temperature level that may occur.

C-18.3.2 The exhaust temperature though not a test parameter shall be monitored for general condition of the engine. A change of more than 20°C from normal level must be investigated. Such a change may be possible due to change in cooling air supply or an obstruction of the exhaust gases.

C-18.3.3 *Spark Plug Malfunction*

If the engine slows down by more than 100 rpm and does not return to specified speed within a further 2 min with a reduction of combustion chamber temperature, check whether the spark plug is whiskered/bridged or fouled. Remove and replace the plug with new one, record the time and label the plug.

C-18.3.4 *Exhaust System Plugging*

If at any time, the torque fall to 90 percent of its initial steady value, remove exhaust port deposits if any. If this does not restore the power, investigate and repair as appropriate.

C-18.3.5 *Major Pre-ignition*

If at any time the combustion chamber temperature measured by cylinder head thermocouple rises rapidly by more than 30°C above its stable temperature at 4 000 rpm and WOT condition, this is an indication of major preignition and it is necessary to stop the engine automatically and promptly. Log the accurance to the nearest 0.1 h and decarbonise the engine.

C-18.3.6 *Inspection and Restart after Major Pre-ignition*

Do not remove the spark plug immediately. Remove the exhaust silencer and cylinder head. Inspect the cylinder bore. If there is no mechanical damage clean the deposit from the cylinder head, piston top and exhaust port and assemble the cylinder head. Use new spark plug. The engine is then restarted and the test completed. The test duration is 50 h. If scuffing or seizure marks are noticed, the test shall be abandoned and test shall be restarted from the begining with new assembly.

C-19 INTERPRETATION OF RESULTS

A cycle consists of deposit formation-preignition-cleaning. The number of cycles that can be run throughout the test duration varies according to the oil quality. The Preignition Index (PI), that is ratio of the number of preignitions to the test duration is a measure of the preignition tendency of the test lubricant which is expressed as follows:

$$\text{Preignition Index} = \frac{\text{No. of pre-ignitions}}{\text{Test duration (h)}} \times 100$$

C-20 CALIBRATION

A qualification test must be run before beginning testing with a new or completely rebuilt engine and after 10 tests or 90 operating days, which ever happens first. The test is run using high and low reference oils. There must be a minimum of 4 and a maximum of 10 major preignitions during the test on low reference oil. If less than four preignitions occur, investigate the problem, correct and run the test. On high reference oil no major preignition shall occur. If these conditions are satisfied the test

bench is calibrated and accepted for testing and qualification of candidate oils.

Table 6 Physico-Chemical Characteristics of Test Fuel
(*Clause* C-4.1)

Sl No.	Characteristics	Requirement
i)	Distillation, °C	As per IS 2796
ii)	Reid vapour pressure at 37.8 °C, kg/cm^2, *Max*	do
iii)	Octane number (R)	do
	Octane number (M)	83 min
iv)	Sulphur content, percent by mass	As per IS 2796
v)	Copper corrosion, 3h @ 100°C	do
vi)	Gum content, mg/100 ml	do
vii)	Oxidation stability, *Min*	do
viii)	Lead content, g/l	0.4-0.63
ix)	Composition, percent by volume	
	a) Saturates	40-85
	b) Olefines	10-20
	c) Aromatics	10-45

Table 7 Physico-Chemical Characteristics of Reference Oils
(*Clause* C-5.1)

Characteristics	RL-05 (High Ref Oil)	RL-81 (Low Ref Oil)
Diluent Nil	Nil	
Kinematic viscosity, cSt		
@ 100 °C	11.9	12.4
@ 40 °C	111.0	—
Viscosity index	95	
Sulphated ash, percent by mass	0.25	1.28
TBN,mg KOH/g	0.84	8.1
Elemental analysis, percent by weight		
Ca	0	0.21
Ba	0	0.26
Zn	0.09	0.08
P	0.09	0.08
N	0.05	0.02

C-21 ENGINE DETAILS AND REBUILDING FOR TEST

C-21.1 Engine Description

The test apparatus consists of a two-stroke single cylinder 150 cc Bajaj Super engine having following specifications:

Sole Manufacturer : M/s Bajaj Auto Ltd, Akardi, Pune 411035

Type : Bajaj Super 05 Series, 150 cc, Two-stroke, single cylinder, forced air cooled, spark ignition, gasoline engine

Bore, mm : 57

Stroke, mm : 57

Capacity : 145.45

Compression ratio : 7.4:1

Maximum power, kW : 4.63 @ 5 200 rpm

Carburettor : Dellor to SI 20/15D

Main jet size : 83

Pilot jet size : 42

Idling jet size : 60

Cooling system : Forced air cooled by inbuilt blower mounted on crank-shaft

Ignition system : 12V, magneto ignition, contact breaker type

Spark plug type : MICO HB-W-175 Z1

Transmission gear ratios :

1st gear : 1:13.35

2nd gear : 1:9.32

3rd gear : 1:6.64

4th gear : 1:4.73

C-21.2 Test Components

Engine assembly : Part No. 05-1001-02

Cylinder block : Part No. 06-1004-12
06-1004-01

Piston assembly : Part No. 06-1005-01

Cylinder head : Part No. 06-1004-02

Silencer assembly : Part No. 03-1015-01

Cowling assembly (Polymer) : Part No. 03-1013-01

Contact breaker : Part No. 03-1003-18

Parts needing replacement may be obtained from the manufacturer.

C-21.3 Overhauling of the Engine

C-21.3.1 The test engine shall be completely stripped when it is new and subsequently after a maximum of every twenty tests or after an earlier breakdown.

C-21.3.2 *Cleaning Procedure*

Any petroleum product equivalent to white spirit may be used. Components removed by dismantling the engine or coming from store shall be thoroughly immersed in the solvent and whipped off with clean cloth before being air dried for assembly.

C-21.3.3 *Replacement of Parts*

Original spare parts shall be used. After every two tests new cylinder piston assembly, spark plug and silencer assembly shall be used.

C-21.3.4 *Running Clearness*

These shall be as follows:

	At Assembly, mm	
	Min	*Max*
Cylinder piston Clearance[1)]	0.085	0.10
Ring gap		
1st ring	0.20	0.35
2nd ring	0.20	0.35
Ring side clearance		
1st ring	0.06	0.10
2nd ring	0.06	0.10

C-21.3.5 Measure the cylinder block bore in two directions across and longitudinal to gudgeon pin axis at 8, 35, 60, 75 mm from the top. Use new cylinder block if wear exceeds 0.200 mm or out of roundness exceeds 0.025 mm.

C-21.3.6 *Torque Applied for Rebuilding the Engine*

The following recommended tightening torque shall be applied when rebuilding the engine for test:

Sl No.	*Part No.*	*Nomenclature*	*Torque* m-kg
i)	39-0293-15	Nuts securing crank case halves	1.3-1.5
ii)	39-0295-15	Nuts for securing MG pin	3-3.5
iii)	39-0293-15	Nuts for securing cylinder head	1.5-1.8
iv)	01-1006-13	Nuts for securing magneto rotar	6-6.5
v)	01-1006-15	Nuts for securing clutch nut	4-4.5
vi)	01-1003-44	Ring nut	18-
vii)	39-0012-01	Bolt for securing stator plate	0.3
viii)	39-0092-04	Bolt for clutch cover	0.6-0.8
ix)	01-1201-04	Bolt for securing carburetor	1.6-2
x)	39-0295-15	Nut for securing of kick starter	2.3-2.6
xi)	39-0073-04	Bolt for securing fan	0.6-0.8
xii)	01-1105-01	Spark plug	3.73

C-21.3.7 *Engine Settings*

The following settings shall be made	
Spark plug electordes gap, mm	0.5
Contact breaker points gap, mm	0.4
Ignition timing, °CA btdc	25±1

[1)] Bore dimension is to be checked on a plane normal to the gudgeon pin axis. Clearance between finished bore and piston size measured at 21.2 mm from bottom edge of piston.

C-22 ADDITIONAL EQUIPMENTS

C-22.1 A suitable engine dynamometer equipped with torque transducer should be used. The dynamometer should be capable of maintaining engine speed constant at the desired value.

C-22.2 A suitable cylinder head fitted with a shielded thermocouple inside the combustion chamber for the measurement of the average cycle temperature shall be used. The general dimensions and machining required for the through hole for fitting the thermocouple are as shown in Fig. 2.

C-22.3 A thermocouple fitted to the spark plug seating ring shall be used for the measurement of the temperature (*see* Fig. 3).

C-22.4 A suitable multi-channel recorder for continuous recording of combustion chamber temperature, spark plug gasket temperature and engine torque shall be used.

C-22.5 A suitable shutter for partially closing the admission of cooling air to the engine shall be used (*see* Fig. 5).

C-22.6 A flowmeter for gasoline/oil mixture consumption shall be used.

C-23 RUNNING-IN SCHEDULE

Duration : 14 h-50 min
Oil : High quality reference oil
Oil/Fuel ratio : 5 : 100

Engine rpm	*Break Power* bhp	*Duration* min	*Transmission Gear Position*
1 300 ± 100 (Idling)	—	20	Neutral
2 500	0.86	20	Top
3 000	1.04	20	Top
3 500	1.21	20	Top
4 000	1.38	20	Top
4 500	1.55	20	Top
5 200	1.80	20	Top
3 000	1.90	30	Top
3 500	2.21	30	Top
4 000	2.48	30	Top
4 500	2.84	30	Top
5 200	3.29	30	Top
3 000	3.02	30	Top
3 500	3.52	30	Top
4 000	4.02	30	Top
4 500	4.52	30	Top
5 200	5.24	30	Top
3 500	*Max*	30	Top
5 000	*Max*	60	Top
4 000	*Max*	120	Top
4 500	*Max*	120	Top
5 000	*Max*	120	Top

NOTE — During idling CO should be set at 3.5±0.5 percent by volume.

ANNEX D

(*Clause* 7.1)

LUBRICITY TEST SEQUENCE: BAJAJ SUPER 05 SERIES ENGINE TEST — EVALUATION OF PISTON ANTI SEIZURE CHARACTERISTICS OF TWO-STROKE AIR COOLED ENGINE LUBRICANTS (2T-OILS) OF TSL-2 LEVELS

D-1 GENERAL

The object of this method is to evaluate the ability of lubricant to protect against tightening of piston in the cylinder bore, which is a premonitory sign of seizure under severe conditions of lubrication.

D-2 OUTLINE OF METHOD

Severe operating conditions are obtained by running the engine with the cooling cut off to simulate condition of restricted cooling. As a result of the consequent temperature rise, the viscosity of the lubricant and hence its bearing capacity, decreases and the piston-cylinder clearance is reduced until tightening may occur.

At this point the lubricating ability of the oil is of the atmost importance in reducing the tightening tendency. The immediate effect is an increase in friction in sudden decrease of engine torque.

As the engine speed is kept constant, the drop in power output is manifested only by a decrease in the engine torque. The greater the drop in torque over a given temperature increase, and more rapid the drop in torque, the poorer is the ability of the oil to avert tightening and hence the onset of scuffing and seizure.

D-3 APPARATUS

A single cylinder two-stroke cycle, spark ignition Bajaj Super 150 cc engine, described in **D-11** is used for the test. Engine is also fitted with equipment [viz. suitable shutter, thermocouple for measuring spark plug gasket (SPG) temperature] which is detailed in **D-12**. A dual channel recorder is used for obtaining continuous trace of SPG temperature and engine torque. The test engine is coupled to a suitable dynamometer viz. eddy current type, capable of maintaining the engine speed constant at the desired value.

D-4 TEST FUEL

The test fuel (at 5 percent oil-fuel ratio) used during running in and the test period will be leaded gasoline conforming to the physico-chemical characteristics of IS 2796 as given in Table 1. The level of lead content, saturates, Olefins and aromatics shall be as stipulated in Table 8. If required, TEL may be added to the test fuel to raise the lead content to the specified level of 0.4 to 0.6 g/l.

D-5 PREPARATION OF TEST EQUIPMENT

Rebuilt the test engine as per procedure given in **D-11**. Carry out systematic inspection of all equipments and instruments and ensure their proper functioning. Any defective or worn parts must be renewed.

D-5.1 Spark Plug

MICO W5 Bc of equivalent; clean before each test and reset the gap to 0.7 mm.

D-5.2 Ignition Controls

Spark advance : 22 ± 1 BTDC.

Contact breaker point gap : 0.3 to 0.5 mm.

D-5.3 Cleaning Operation

After each test sequence the engine must be cleaned as follows:

Cylinder head and piston crown is decarbonized and washed in a suitable degreasing bath. Wash cylinder and piston in white spirit and when dry, smear the bore with the high quality (H) reference oil or test oil. The reference oil has been defined in **D-10**.

D-6 RUNNING-IN

D-6.1 A new engine is run-in on a mixture of test fuel and reference oil H or 2T oil at 5 percent oil-fuel ratio. The operating condition is to be maintained according to procedure given in **D-13**. After completion of running-in the engine must be cleaned as described in **D-5.3**.

D-7 TEST PROCEDURE

D-7.1 Start the engine and run it for 1 h at 3 800 rpm and 3.1 kW power output, with the reference oil "H" in the mixture at 5 percent oil-fuel ratio. The above operating conditions are maintained throughout the sequence.

D-7.2 After 1 h of engine conditioning, the first test may be carried out. The engine cooling is then cut off and the chart recorder started. When the spark plug gasket temperature reaches 290°C the engine is stopped. The decrease in engine torque for a spark plug temperature rise of 100°C (from 190°C to 290°C) and the corresponding test time

are reported. These operating conditions have been decided based on the test method CEC-L-21-T-77 Sequence I.

D-7.3 The following tests are carried out in sequence after the engine is again started and its temperature has reached a constant value.

Test No.	*Oil*
1	Reference oil H
2	do
3	do
4	do
5	Test oil S
6	do
7	do
8	do
9[1)]	Reference oil H
10	do
11[1)]	Reference oil low quality L
12	do

D-7.4 Record continuously the torque and spark-plug gasket temperature. Record the cycle duration for each test.

D-8 INTERPRETATION OF RESULTS

D-8.1 From the recording the average values of the following quantities are derived:

- $(\Delta TQ)H_1$ Average torque decrease with high quality reference oil 'H' in test nos. 1, 2, 3, 4.
- $(\Delta t)H_1$ Average time interval corresponding to $(\Delta TQ)H_1$
- $(\Delta TQ)S$ Average torque decrease with test oil
- $(\Delta t)S$ Average time interval corresponding to $(\Delta TQ)S$
- $(\Delta TQ)H_2$ Average torque decrease with high quality reference oil in test nos. 9,10.
- $(\Delta t)H_2$ Average time interval corresponding to $(\Delta TQ)H_2$
- $(\Delta TQ)L$ Average torque decrease with low quality reference oil
- $(\Delta t)L$ Average time interval corresponding to $(\Delta TQ)L$

Hence, the following two indices are calculated:

$$\text{Discrimination Index, percent} = \frac{\frac{(\Delta TQ)H_1}{(\Delta t)H_1} - \frac{(\Delta TQ)S}{(\Delta t)S}}{\frac{(\Delta TQ)H_1}{(\Delta t)H_1}} \times 100$$

$$\text{Selectively Index, percent} = \frac{\frac{(\Delta TQ)H_2}{(\Delta t)H_2} - \frac{(\Delta TQ)L}{(\Delta t)L}}{\frac{(\Delta TQ)H_2}{(\Delta t)H_2}} \times 100$$

D-8.2 The first index gives an assessment of the test oil quality and the second index is an indication of the degree of selectivity of the engine used for the test.

D-9 PRECISION

D-9.1 Repeatability

Duplicate results on the same apparatus should be regarded as satisfactory if they do not differ by ± 10 percent.

D-10 REFERENCE OIL

D-10.1 The reference oils used in this sequence test are RL-56 (high quality) and RL-55 (low quality) or equivalent indigenous reference oils may be used.

D-10.2 Record continuously the torque and the spark plug temperature. Report the cycle duration for each test run.

Table 8 Physico-Chemical Characteristics of Test Fuel
(*Clause* D-4)

Sl No. (1)	Characteristics (2)	Requirement (3)
i)	Distillation, °C	As per IS 2796
ii)	Reid vapour pressure at 37.8°C kg/cm^2, *Max*	do
iii)	Octane number (R)	As per IS 2796
iv)	Sulphur content, percent by mass	do
v)	Copper corrosion, 3h @ 100°C	do
vi)	Gum content, mg/100 ml	do
vii)	Oxidation stability, *Min*	do
viii)	Lead content, g/l	0.4 to 0.63
ix)	Composition, percent by volume:	
	a) Saturates	40 to 85
	b) Olefins	5 to 15
	c) Aromatics	10 to 45

D-11 Engine Details and Rebuilding for Test

D-11.1 Engine Description

The test apparatus consists of two-stroke single cylinder 150 cc Bajaj Super engine having following specification:

Sole manufacturer : M/s Bajaj Auto Co Ltd, Akurdi Pune 411035

Type : Bajaj Super
150 cc, two-stroke, single cylinder, forced air cooled, spark ignition, gasoline engine

[1)] The engine must be run for at least 30 min before the test. The above test sequence must be completed during the same day.

Bore, mm	:	57
Stroke, mm	:	57
Capacity, ml	:	145.45
Compression ratio	:	7.4 : 1
Maximum power, kW	:	4.63 @ 5 200 rpm
Carburettor	:	Dellor to SI 20/15D
Main jet size[1]	:	90 (4 - 5 percent CO under test condition)
Pilot jet size	:	42
Idling jet size	:	60
Cooling system	:	Forced air cooled by inbuilt blower mounted on crankshaft
Ignition system	:	12 V magneto ignition contact breaker type
Spark plug type[1]	:	MICO WSBC or equivalent
Cowling assembly[1]	:	Metallic

D-11.2 Test Components

Engine assembly	Part No. 05-1001-02
Cylinder block	06-1004-12-06-1004-01
Piston assembly	Part No.06-1005-01
Cylinder head	Part No. 06-1004-02
Silencer assembly	Part No. 03-1015-02
Cowling assembly (Polymer)	Part No. 03-1013-01
Contact breaker	Part No. 03-1103-18

Parts reading replacement may be obtained from the manufacturer.

D-11.3 Overhauling of the Engine

D-11.3.1 The test engine shall be completely stripped when it is new and subsequently after a maximum of every six tests or after an earlier break-down.

D-11.4 Cleaning Procedure

D-11.4.1 Any petroleum product equivalent to white spirit may be used. Components removed by dismantling the engine or coming from store shall be thoroughly immersed in the solvent and whiped off with clean cloth before being air dried for assembly.

D-11.5 Replacement of Part

D-11.5.1 Original spare parts shall be used.

[1] Changed for piston seizure test.

D-11.6 Running Clearances

D-11.6.1 These shall be as follows:

	At Assembly, mm	
	Min	*Max*
Cylinder piston clearance[1]	0.08	0.09
Ring gap		
1st ring	0.20	0.35
2nd ring	0.20	0.35
Ring side clearance		
1st ring	0.06	0.10
2nd ring	0.06	0.10

D-11.7 Measure the cylinder block bore in two directions across and longitudinal to gudgeon pin axis at 8, 35, 60 and 75 mm from the top. Use new cylinder block if wear exceeds 0.200 mm or out of roundness exceeds 0.025 mm.

D-11.8 Torque Applied for Rebuilding the Engine

D-11.8.1 The following recommended tightening torque shall be applied when rebuilding the engine for test:

Sl No.	*Part No.*	*Nomenclature*	*Torque* m-kg
i)	39-0293-15	Nuts securing crankcase halves	1.3-1.5
ii)	39-0295-15	Nuts for securing MG pin	3-3.5
iii)	39-0293-15	Nuts for securing cylinder head	1.5-1.8
iv)	01-1006-13	Nuts for securing magneto rotar	6-6.5
v)	01-1006-15	Nuts for securing clutch cut	4-4.5
vi)	01-1003-44	Ring nut	18-20
vii)	39-1003-44	Bolt for securing stator plate	0.3-0.4
viii)	39-0092-04	Bolt for clutch cover	06-08
ix)	01-1201-04	Bolt for securing carburettor	1.6-2
x)	39-0295-15	Nuts for securing of kick starter	2.3-2.6
xi)	39-0073-04	Bolt for securing fan	0.6-0.8
xii)	01-1105-01	Spark plug	3.73

1) Bore dimension is to be checked on a plane normal to the gudgeon pin axis. Clearance between finished bore and piston size measured at 21.2 mm from bottom edge of piston.

D-11.9 Engine Setting

D-11.9.1 The following settings shall be made:

Spark plug electrodes gap, mm	0.7
Contact breaker points gap, mm	0.3-0.5
Ignition timing, CA btdc	18 ± 1

D-12 DETAILS OF EQUIPMENTS

D-12.1 A thermocouple fitted to the spark plug seatting ring should be used for the measurement of the average temperature.

D-12.2 A suitable engine dynamometer should be used. The dynamometer should be capable of maintaining the engine speed constant at the desired value.

D-12.3 A suitable dual-channel recorder for the continuous recording of the average temperature and torque should be used.

D-12.4 A suitable shutter for closing the admission of air to the engine.

D-13 RUNNING-IN SCHEDULE

Duration	14 h-50 min
Oil	High quality reference or test oil
Oil/Fuel ratio	5 : 100

Engine rpm	*Brake Power bhp*	*Duration min*	*Transmission gear position*
1300 ± 100 (Idling)	–	20	Neutral
2 500	0.86	20	Top
3 000	1.04	20	Top
3 500	1.21	20	Top
4 000	1.38	20	Top
4 500	1.55	20	Top
5 200	1.80	20	Top
3 000	1.90	30	Top
3 500	2.21	30	Top
4 000	2.48	30	Top
4 500	2.84	30	Top
5 200	3.29	30	Top
3 000	3.02	30	Top
3 500	3.52	30	Top
4 000	4.02	30	Top
4 500	4.52	30	Top
5 200	5.24	30	Top
3 500	*Max*	30	Top
4 500	*Max*	60	Top
5 000	*Max*	60	Top
4 000	*Max*	120	Top
4 500	*Max*	120	Top
5 000	*Max*	120	Top

NOTE — During idling CO should be set at 3.5 ± 0.5 percent volume.

ANNEX E

(*Clause* 7.2)

DETERGENCY TEST SEQUENCE: BAJAJ SUPER 05 SERIES ENGINE TEST EVALUATION OF DEPOSITS AND GENERAL PERFORMANCE CHARACTERISTICS OF TWO-STROKE AIR COOLED ENGINE LUBRICANTS (2T OILS) OF TSL-1 AND TSL-2 LEVEL

E-1 GENERAL

E-1.1 The method is intended to evaluate the following characteristics of two-stroke air-cooled engine oils of TSL-1 and TSL-2 levels.

a) Piston varnish,
b) Piston ring sticking,
c) Spark plug fouling,
d) Exhaust port blocking, and
e) Power loss.

E-2 OUTLINE OF THE METHOD

E-2.1 The test method consists of:

A 50 h test operation on a single cylinder, two-stroke spark ignition, Bajaj super engine under cyclic operation conditions at wide open throttle (WOT) at maximum torque and maximum power rev/min.

E-2.2 A determination of a set of full power curves. The effect of deposits on power loss is evalutated after the 50 h test operation by observing average power, first with the "fouled" engine and then afterwards, with the engine deposits completely cleaned.

E-2.3 After removing the cylinder head, cylinder block and piston for cleaning of deposits, engine

running for 3 h stabilization is specified before taking engine WOT power.

E-3 APPARATUS

E-3.1 The test bench shall consist of a Bajaj super engine prescribed in E-11 and fitted with additional equipments as prescribed in E-12. Provisions of thermocouple in the exhaust line is very critical and therefore its installations details alongwith relevant dimension is included in E-17. The sketch of exhaust thermocouple and details of its design are given in Fig. 4.

E-4 TEST FUEL

E-4.1 The test fuel used during running-in and the test period will be leaded gasoline conforming to the physico-chemical characteristics of IS 2796 : 1995 as given in E-13. The level of lead content, saturates, olefins and aromatics shall be as stipulated for CEC-L 2 1 fuel and given in E-13. If required, TELK may be added to the test fuel to raise its lead content to specified level of 0.4 to 0.6 g/l.

E-4.2 Fuel from the same source of supply shall be used in series of test in which the performance of a test oil is compared with the CEC reference oil RL-07 or any indigenised reference oil.

E-5 PREPARATION OF APPARATUS

E-5.1 For each test use new cylinder piston assembly spark plug, CB Point and new or decarbonized cylinder head (use new cylinder head after 3 tests). Part numbers of the components are given in E-11.2.

E-5.2 Cleaning Procedure

Wash the cylinder piston assembly by immersing in a peteroleum solvent (80/20 petrolcum spirit) and wipe off with clean cloth.

E-5.3 Measure the dimension of cylinder piston and ring to ensure proper running clearance as given in E-11.4.

E-5.4 Rebuild the test engine as per procedure given in E-11. Carry out inspection of all equipments and instruments as per manufacturers recommendation and ensure their proper functioning.

E-6 RUNNING-IN

E-6.1 Engine shall be run-in for 14 h-50 min according to running-in schedule given in E-14.

E-6.2 The engine fuel during running-in shall be mixed 5:100E by volume of reference oil RL-07 or any indigenised reference oil.

E-7 TEST PROCEDURE

E-7.1 The engine shall be run according to the test procedure given in E-15. The test consists of 11 phases of operation. The test duration is 56 h including two phases of stabilization each of 3 h duration and excluding the operating time for determination of WOT power curves.

E-7.2 The engine fuel shall be mixed with 2:100E by volume of test oil for the test.

E-7.3 During the test, any engine stoppage or deviation from standard operating conditions etc be noted alongwith detailed information regarding nature of incidence, time and duration of incidence etc.

E-8 AFTER COMPLETION OF TEST

E-8.1 After completion of test, the engine shall be stopped by cutting off the fuel supply.

E-8.2 The engine shall be stripped off as soon as possible after the completion of the test and ring conditions shall be recorded immediately after dismantling the engine.

E-8.3 During dismantling and transfer of test parts, the deposits shall not be disturbed.

E-8.4 Rate the piston and other parts when they have cooled down to room temperature.

E-8.5 The piston shall be rated within 48 hours of completion of the test. Before rating the piston, it shall be stored in a dessicator in order to prevent the colour change of piston deposits.

E-9 RATING OF ENGINE PARTS

E-9.1 Examine and rate the following parts in accordance with the method given in E-16 (As per IP 247/69 'Deposit rating system for engine cleanliness and wear').

a) Piston ring sticking,
b) Piston skirt (exterior) deposits,
c) Piston under skirt deposits,
d) Piston under crown deposits,
e) Ring groove varnish/lacquer deposits,
f) Ring land deposits,
g) Spark plug fouled Nos.
h) Exhaust port blockage, percent area blocked,
j) Average power loss at WOT, percent

$$= \frac{P_3 - P_2}{P_3} \times 100$$

k) Deposits massing on piston top, cylinder head and exhaust port, and
m) Piston rings, wear, mass loss in mg; ring gap increase, mm.

E-10 PHOTOGRAPHS

E-10.1 Photograph of piston thrust side anti-thrust side, piston underside, piston top, cylinder head, exhaust port and spark plug for record and evidence of deposits.

E-11 ENGINE DETAILS AND REBUILDING FOR TEST

E-11.1 Engine Description

E-11.1.1 The test apparatus consists of Bajaj super engine having following specification:

Sole manufacturer	:	M/s Bajaj Auto Ltd, Akrudi, Pune 411035
Type	:	Bajaj Super 150 cc, Two-stroke, single cylinder, forced air cooled, spark ignition, gasoline engine
Bore, mm	:	57
Stroke, mm	:	57
Capacity, ml	:	145.45
Compression ratio	:	7.4 : 1
Max power, kW	:	4.63 @ 5 200 rpm
Carburettor	:	Dellor to SI 20/15D
Main jet size	:	83 (or suitable for specified fuel flow)
Pilot jet size	:	42
Idling jet size	:	60
Cooling system	:	Forced air cooled by inbuilt blower mounted on crankshaft
Ignition system	:	12 V magneto ignition contact breaker type
Spark plug type	:	MICO HB-W-175 Z1
Transmission gear ratio :		
1st gear	:	1: 13.35
2nd gear	:	1: 9.32
3rd gear	:	1: 6.64
4th gear	:	1: 4.73

E-11.2 Test Components

Engine assembly	:	Part No. 05-1001-02
Cylinder block	:	Part No. 06-1004-12] 06-1004-01
Piston assembly	:	Part No. 06-1004-01]
Cylinder head	:	Part No. 06-1004-02]
Silencer assembly	:	Part No. 03-1015-02
Cowling assembly (Polymer)	:	Part No. 03-1013-01
Contact breaker	:	Part No. 03-1103-18

Parts needing replacement may be obtained from the manufacturer.

E-11.3 Overhauling of the Engine

E-11.3.1 The test engine shall be discarded after running six tests or after an earlier breakdown. Out of the six test, first test should be run on bench mark reference oil with a purpose to calibrate the test stand.

E-11.3.2 *Cleaning Procedure*

Any petroleum product equivalent to white spirit may be used. Components removed by dismantling the engine or coming from store shall be thoroughly immersed in the solvent and whiped off with clean cloth before being air dried for assembly.

E-11.3.3 *Replacement of Part*

Original spare parts shall be used. For each test new cylinder piston assembly spark plug and silencer assembly shall be used. Cylinder head may be used in three consecutive tests.

E-11.4 Running Clearence

These shall be as follows:

	At Assembly, mm	
	Min	*Max*
Cylinder piston clearance[1)]	0.08	0.10
Ring gap		
1st ring	0.20	0.35
2nd ring	0.20	0.35
Ring side clearance		
1st ring	0.06	0.10
2nd ring	0.06	0.10

E-11.5 Measure the cylinder block bore in two directions across and longitudinal to gudgeon pin axis at 8, 35, 60, 75 mm from the top. Use new cylinder block if wear exceeds 0.200 mm or out of roundness exceeds 0.025 mm.

E-11.6 Torque Applied for Rebuilding the Engine

The following recommended tightening torque shall be applied when rebuilding the engine for test:

Sl No.	*Part No.*	*Nomenclature*	*Torque* m-kg
i)	39-0293-15	Nuts securing crank case halves	1.3-1.5
ii)	39-0295-15	Nuts for securing MG pin	3-3.5

1) Bore dimension is to be checked on a plane normal to the gudgeon pin axis. Clearance between finished bore and piston size measured at 21:2 mm from bottom edge of piston.

Sl No.	*Part No.*	*Nomenclature*	*Torque* m-kg
iii)	39-0293-15	Nuts for securing cylinder head	1.5-1.8
iv)	01-1006-13	Nuts for securing magneto rotar	6-6.5
v)	01-1006-15	Nuts for securing clutch nut	4-4.5
vi)	01-1003-44	Ring nut	18-20
vii)	39-0012-01	Bolt for securing stator plate	0.3-0.4
viii)	39-0092-04	Bolt for clutch cover	0.6-0.8
ix)	01-1201-04	Bolt for securing carburettor	1.6-2
x)	39-0295-15	Nut for securing of kick starter	2.3-2.6
xi)	39-0073-04	Bolt for securing fan	0.6-0.8
xii)	01-1105-01	Spark plug	3.73

E-11.7 Engine Setting

The following settings shall be made:

Spark plug electrodes gap, mm	0.5
Contact breaker point gap, mm	0.4
Ignition timing, °CA btdc	22 ± 1

E-12 ADDITIONAL EQUIPMENTS

E-12.1 A suitable dynamometer having proper load indicating system shall be coupled to the engine for absorbing load. The engine should be approximately mounted on the test bench.

E-12.2 A flowmeter for gasoline/oil mixture consumption shall be used. The head, that is the difference between the height of the constant level of the fuel tank and the level of the carburettor float chamber should be maintained at about 500 mm during all tests.

E-12.3 For the temperature measurement any suitable instrument may be used. A thermocouple fitted to the spark plug seating ring should be used for the measurement of the average temperature.

E-13 PHYSICO CHEMICAL CHARACTERISTICS OF TEST FUEL

Sl No.	*Characteristics*	*Requirement*
i)	Distillation, °C	As per IS 2796
ii)	Reid vapour pressure at 37.8°C kg/cm^2, *Max*	do
iii)	Octane number (R)	do
iv)	Sulphur content, percent by mass	do
v)	Copper corrosion, 3h @ 100°C	As per IS 2796
vi)	Gum content, mg/100 ml	do
vii)	Oxidation stability, *Min*	do
viii)	Lead content, g/l	0.4-0.63
ix)	Compostion, percent volume	
	a) Saturates	40-85
	b) Olefins	10-20
	c) Aromatics	10-45

E-14 RUNNING-IN SCHEDULE

Duration	:	14 h-50 min
Oil	:	High Reference Oil
Oil/Fuel ratio	:	5 : 100

Engine rpm (1)	*Brake Power* bhp (2)	*Duration* min (3)	*Transmission Gear Position* (4)
1 300 ± 100 (idling)	–	20	Neutral
2 500	0.86	20	Top
3 000	1.04	20	Top
3 500	1.21	20	Top
4 000	1.38	20	Top
4 500	1.55	20	Top
5 200	1.80	20	Top
3 000	1.90	30	Top
3 500	2.21	30	Top
4 000	2.48	30	Top
4 500	2.84	30	Top
5 200	3.29	30	Top
3 000	3.02	30	Top
3 500	3.52	30	Top
4 000	4.02	30	Top
5 200	5.24	30	Top
3 500	*Max*	30	Top
4 500	*Max*	30	Top
5 000	*Max*	60	Top
4 000	*Max*	120	Top
4 500	*Max*	120	Top
5 000	*Max*	120	Top

NOTE — During idling CO should be set at 3.5 ± 0.5 percent volume. The CO measurement should be done using appropriate exhaust gas analyzer with suitable accuracy whi ch enables CO measurement without any interfrence from HC level in the exhaust gas.

E-15 TEST PROCEDURE

E-15.1 Phase 1, First Cleaning

Piston and cylinder should be examined to ensure that there is no scuffing or seizure or ring sticking Decarbonize and clean the cylinder head, cylinder, piston rings, piston and carburettor after running-in.

E-15.2 Phase 2, Second Stabilization

Engine rpm	*Brake Power* bhp	*Duration* min
1 300 ± 100 (Idling)	Zero	10
4 000	4.25	50
5 000	*Max*	50
Idling	Zero	10
3 500	*Max*	50
Idling	Zero	10
	Total time	3 h

NOTES

1 At WOT 5 000 engine rpm, the fuel flow rate should be controlled at 2.85 ± 0.15 l/h. If required replace the main jet size with another of proper size.

2 At WOT 3 500 rpm the fuel flow rate would generally be obtained within 2.38 ± 0.15 l/h.

3 The following power values would generally be obtained with high reference oil as a preliminary indication:

WOT 5 000 engine rpm minimum 5.4 bhp.

WOT 3 500 engine rpm minimum 4.5 bhp.

E-15.3 Phase 3, 1st Full Power Curve

Engine rpm	*Brake Power* bhp	*Duration* min	*Transmission Gear Position*
3 000	*Max*	25	Top gear
3 500	*Max*	25	Top gear
4 000	*Max*	25	Top gear
4 500	*Max*	25	Top gear
5 000	*Max*	25	Top gear

NOTE — The average power relevant to the entire curve is indicated by P_1 and should be corrected for standard conditions

$$P_{C1} = \alpha . P_1$$

As per IS 10000 (Part 4) : 1980 the correction factor for SI engines is determined by the following formula

$$\alpha = \frac{100}{P} \cdot \sqrt{\frac{T}{300}}$$

where

P = Ambient pressure at site condition, kPa; and

T = Air intake temperature at ambient site condition, °K.

E-15.4 Phase 4, Deposit Build Up Test

Engine rpm	*Brake Power* bhp	*Duration* min	*Transmission Gear Position*
3 500	*Max*	50	Top gear
Idling	Zero	10	Neutral
5 000	*Max*	50	Top gear
Idling	Zero	10	Neutral

NOTE — The spark plug gasket temperature is to be controlled between 170° ± 10°C.

This may require either

i) additional external cooling arrangements.

ii) regulation of cooling air-flow depending upon the temperature level observed.

E-15.5 Phase 5, First Check

Check ignition timing and contact breaker points gap and replace the spark plug with new one (Type HB-W-175 Z 1).

E-15.6 Phase 6, Progress of Deposit Build Up

5 000 engine rpm, WOT for 60 min.

E-15.7 Phase 7, Second Full Power Performance Curve

As in Phase 3 (*see* **E-15.3**)

NOTE — The average power relevant to the entire curve is indicated by P_2.

E-15.8 Phase 8, Engine Dismantling

Dismantle the engine to remove silencer, cylinder head, cylinder block, piston and spark plug for inspection of deposits and photographs of parts for evidence of deposits. The condition of engine components for deposits etc, is assessed by rating as mentioned in **E-9.1**.

E-15.9 Phase 9, Second Cleaning

Clean the deposits in the grooves, piston top, cylinder head, exhaust port etc and wash with 80/100 petroleum spirit, dry and put some test oil on the piston and cylinder bore and again assemble the engine parts.

E-15.10 Phase 10, Second Stabilization

Same as 1st stabilization for 3 h.

E-15.11 Phase 11, Third Full Power Curve

Same as in Phase 3 (*see* **E-15.3**).

NOTE — The average power relevant to the entire curve is indicated by P_3.

E-15.12 Record the Following Parameters During the Test

a) Speed,

b) Load,

c) Fuel consumption,
d) Spark plug gasket temperature,
e) Exhaust temperature
f) CO, CO_2, O_2, AFR, and
g) Ambient temperature and pressure.

E-16 MERIT RATING SYSTEM FOR ENGINE CLEANLINESS AND WEAR

E-16.1 Definitions

E-16.1.1 *Lacquer*

A hard, dry, generally lustrous, oil insoluble deposit of insignificant thickness, which may vary in colour from pale yellow to black, and which is not easily removed by wiping.

E-16.1.2 *Carbon*

A term applied to a black deposit of appreciable thickness (other than sludge), normally without lustre.

E-16.1.3 *Free Ring*

A ring which will fall under its own weight when its plane is moved from the horizontal to the vertical.

E-16.1.4 *Sluggish Ring*

A ring which will not fall under its own weight when its plane is moved from the horizontal to the vertical, but which will move under moderate finger pressure.

E-16.1.5 *Pinched Ring*

A ring which will not move in its groove under moderate finger pressure but which has a bright polished face over its entire circumference, showing that it was free during engine operation.

E-16.1.6 *Stuck Ring*

A ring which will not move under moderate finger pressure and whose face is covered with lacquer or carbon over parts of its circumference, showing that the ring was not bearing against the cylinder wall during engine operation.

E-16.1.7 *Piston Crown Land Carbon Cutting*

Abrasion of the area above the top ring as result of excessive build-up of hard carbon on the liner, or of the passage of hard carbon between the liner and the piston. The abrasion may appear as wide lines or grooves, or as plastic deformation of the metal surface.

E-16.2 Method of Rating Parts for Cleanliness

E-16.2.1 *Ring Sticking*

Allow the piston to cool to room temperature then assign a demerit rating of each compression ring in accordance with the numerical values given below:

Condition		*Demerit Rating*
Ring free in groove		0
Ring sluggish		0.5
Ring pinched over	0 – 75°	1
	75 – 150°	2
	150 – 225°	3
	225 – 300°	4
	300 – 360°	5
Ring stuck over	0 – 75°	6
	75 – 150°	7
	150 – 225°	8
	225 – 300°	9
	300 – 360°	10

Subtract the demerit ring for each ring from ten and quo the individual Merit Ratings.

E-16.2.2 *Piston Ring Groove Deposits*

E-16.2.2.1 *Carbon filling*

Estimate for each ring groove the percentage of the clearance volume between the black of the ring and the back of the ring groove which is filled with carbon, assuming the ring to be constrained in the cylinder bore. This may be assessed by dividing the periphery of the ring groove into, say twenty-four sections, estimating the carbon filling in each section, and then taking an average to arrive at the final percentage carbon filling.

Assign a Merit Rating of 0 for a ring groove which is 100 percent with carbon and a Merit Rating of 10 for one which is free from carbon deposits, that is each 1 percent of carbon filling reduces the Merit Rating by 0.1.

E-16.2.2.2 *Overall ring groove depostis*

For each ring groove estimate the percentage area covered by each type of lacquer deposit listed in Table 9 (carbon to be considered the same as black lacquer). Assign an area demerit for each type of deposit, on the basis that 1 percent area covered carries a demerit of 0.1, and modify these area demerits by multiplying by the appropriate factor given in Table 6. Add the resulting demerit ratings for each ring groove and subtract from 0 to obtain the Merit Rating.

Table 9 Colour Factors for Lacquer
(*Clauses* 16.2.2.2, 16.2.4, 16.2.5, 16.2.6 *and* 16.2.7)

Clean	0
Discoloration	0.1
Light brown or light grey	0.25
Medium brown or medium grey	0.50
Dark brown or dark grey	0.75
Black	1.0

E-16.2.3 *Piston Crown Land Deposits*

Estimate the percentage are of the crown land which is covered by deposits. Convert the percentage covered to an area demerit on the basis that 1 percent of the area covered carries a demerit rating of 0.1. Estimate the average thickness and multiply the area demerit by the appropriate thickness factor (Table 10), and then determine the Merit Rating by subtracting the demerit from 10.

Table 10 Piston Crown Land Deposits Thickness Factor
(*Clause* E-16.2.3)

Thickness, Percentage of Clearance Between Crown Land and Cylinder Liner	Factorr
Nil	0
25	0.25
50	0.50
75	0.75
100	1.00

E-16.2.4 *Piston Ring Land Deposits*

For each ring land estimate the percentage area covered by each type of lacquer deposit listed in Table 9 (carbon to be considered the same as black lacquer). Assign an area demerit for each type of demerit on the basis that 1 percent area covered carries a demerit of 0.1, and modify these area demerits by multiplying by the appropriate factor given in Table 9. Add the resulting demerit ratings and subtract from 10 to obtain the Merit Rating for each ring land separately.

E-16.2.5 *Piston Skirt Lacquer Deposits*

Estimate the percentage area covered by each type of lacquer deposit listed in Table 9 (carbon to be considered as black lacquer) and obtain Merit Rating as for **E-16.2.4.**

E-16.2.6 *Underside of Piston Deposits*

Estimate the percentage area covered by each type of lacquer deposit listed in Table 9 (carbon to be considered the same as black lacquer). The combined area of the underside of the crown and inner walls is to be considered as the total area. Obtain Merit Rating as for **E-16.2.4.**

E-16.2.7 *Cylinder Bore Deposits*

Estimate the percentage area of the swept portion of the cylinder bore covered by each type of lacquer deposit listed in Table 9 (carbon to be considered the same as black lacquer) and obtain Merit Rating as for **E-16.2.4.**

E-16.2.8 *Piston Crown Land Carbon Cutting*

Estimate separately the areas of the crown land which show either light or heavy carbon cutting of the metal, as percentages of the total area of the crown land. Convert to area demerits on the basis that 1 percent of the surface affected by cutting carries a demerit of 0.1. Multiply the light carbon cutting demerit by 0.5 and add it to the heavy carbon cutting demerit. Subtract this final demerit from 10 to obtain the Merit Rating.

NOTE — Light carbon cutting is considered to be of such severity that it has not affected the performance of the engine, and is unlikely to progress to a stage where metal may be dragged down into the top ring groove and so impair the free movement of the top ring.

Heavy carbon cutting is considered to be of such severity that metal has been dragged down to the top rig groove, or, that due to the depth and/or longitudinal extent of the cutting, it could develop to a stage where it would impair the free movement of the top ring.

E-16.3 Wear Measurement

E-16.3.1 *Cylinder Bore Wear*

After cleaning the cylinder, measure the internal diameter, with a micrometer capable of recording increments 0.000 1 in, parallel to and at 45°, 90°, and 135° to the crankshaft centre line at a position midway between the upper limit of ring travel and the top of the liner. Then take a similar set of measurements at the position of maximum wear in the region of the upper limit of top ring travel.

Average each set of readings and report the difference between these as the cylinder bore wear.

E-16.3.2 *Piston Ring Wear*

E-16.3.2.1 *Side clearance increase*

Measure the side clearance of each piston ring before test and again after test before the rings or grooves are cleaned.

Report the Side Clearance Increase for each ring in mm.

E-16.3.2.2 *Weight loss*

Weigh each piston ring before test and again after cleaning at the completion of the test. Quote the weight loss for each ring in grammes.

E-16.3.2.3 *Ring gap increase*

Measure the gap of each piston ring before and after test using a ring gauge of the same diameter as the nominal size of the cylinder bore. If a ring gauge is not available use the same new cylinder linear to determine the ring gaps before and after test.

Quote the ring Gap Increase for each piston ring in mm.

E-17 INSTALLATION OF THERMOCOUPLE IN EXHAUST LINE

A thermocouple of typical design as shown in Fig. 4 should be fitted in the exhaust elbow at 55 ± 5 mm of cylinder exhaust port to monitor exhaust temperature. The thermocouple junction should be located within ± 3 mm from the centre of the exhaust pipe.

ANNEX F

(Clause 7.4)

RING STICKING 1A1.5RD : RAJDOOT 1A1.5RD 350 ENGINE TEST EVALUATION OF RING STICKING AND DEPOSIT CHARACTERISTICS OF TWO-STROKE AIR COOLED ENGINE LUBRICANTS (2T-OILS) OF TSL-2

F-1 GENERAL

F-1.1 The method is intended to evaluate the ring sticking and deposit characteristics of two-stroke engine oils of TSL-2 level. This method evaluates the performance of lubricants intended for use in two-stroke cycle spark ignition gasoline engines which are particularly prone to ring sticking, and moderately prone to damage arising from deposit induced pre-ignition and piston scuff. These are typically larger air-cooled engines which operate with fuel/oil ratio of about 50/1 (2 percent oil) at full power. Spark plug fouling and piston lacquer are also evaluated.

F-2 OUTLINE OF TEST METHOD

F-2.1 The test is run-in Rajdoot 350 motor cycle engine of type 1A1.5RD. It is a 347 cm^3 LET twin-cylinder air-cooled motor cycle engine which is produced by M/s Escorts Ltd, in collaboration with M/s Yamaha Motor Co. It is intended primarily to evaluate ring sticking and piston skirt deposits. Spark plug fouling, combustion chamber deposits, and exhaust port blockage are also observed. The engine is normally set up with one cylinder supplied with the candidate oil and the other with the reference oil. The test is generally repeated by exchanging the oils between cylinder for the second run, unless the performance of the candidate oil exceeds that of the reference oil by a specified margin, in which case the second run need not be made. Each run is made for 20 h on a 25 min part throttle 5 min idle cycle, with a 60 min minimum shutdown after each 150 min of running time.

F-3 APPARATUS

F-3.1 A Yamaha Rajdoot 1A1.5RD LET twin cylinder engine is used. The technical details of the engine are given in **F-8.** It is set up on a dynamometer with a modified fuel system so that each of the cylinders is supplied independently through its associated carburettor. The dynamometer is driven through the motorcycle transmission output shaft.

F-3.2 Lubrication System

The test engine, as manufactured is provided with an oil injection system in which oil is metered to the carburettor bowls from a common source. As the test is run using a different fuel/oil mixture in each carburettor, the oil pump and its connections must be removed and the oil connections to the carburettor plugged.

F-3.3 Dynamometer

A dynamometer capable of absorbing atleast 8 kW (10 hp) is used.

F-3.4 Cooling Air

A cooling air fan with a free flow capacity of about 350 m^3/min of air is required. The flow from the fan must be directed towards the exhaust side of the engine so as to deliver an approximately constant stream to each cylinder.

F-3.5 Combustion Air

The air should be supplied to each carburettor preferably through separate flow meters. A plenum chamber should be provided at the intake of each carburettor to damp out pulsations.

F-3.6 Fuel Systems

Fuel may be supplied to each of the carburettor by gravity or an individual electric fuel pump with a capacity of at least 2.5 l/h (0.6 gal.h) taking the fuel mix from separate tanks through a paper or ceramic filter and a fuel flow meter.

F-3.7 Exhaust System

The standard motorcyle exhaust system is used, discharging into a pipe of at least 200 mm (8 in) diameter leading out of the test cell.

F-3.8 Instrumentation

F-3.8.1 *Plug Gasket Temperature*

Plug gasket thermocouples are required for measuring/recording temperature. Provision

should be made for automatic shutdown of the engine in the case of a spark plug gasket temperature increase of 10°C (18°F) or more. At the very least an alarm must be provided set to operator after a temperature increase of 6-7°C (11-13°F) to allow manual shutdown by the operator.

F-3.8.2 *Exhaust Temperature*

An unshielded thermocouple is required in each exhaust elbow within 75 mm (3 in) of the cylinder exhaust port to monitor exhaust temperature. The exhuast temperature is not a test parameter, but any change of 10°C (18°F) or more from the normal "baseline" operating conditions will normally indicate a malfunction, usually a change in the ventilation of the test cell or obstruction of the exhaust.

F-3.8.3 *Temperature Recorder*

The plug gasket temperature and the exhaust temperature must be recorded continuously. Maximum interval between successive recordings of the same temperature should not exceed 10 s. The ambient temperature should also be recorded continuously, if not,it must be reocrd at intervals of not more than 30 min. A recorder with a range of 40-750°C (100 to 1 400 °F) is suitable for the recording of plug gasket and exhaust temperature.

F-3.8.4 *Ambient Pressure and Humidity*

The barometric pressure and humidity in the test cell must be logged at least hourly.

F-4 MATERIALS AND REAGENTS

F-4.1 Test Fuel

The test fuel used during running-in and the test period will be gasoline conforming to the physicochemical characteristics of IS 2796 as given in Table 11. It shall not contain more than 0.013 g/l of lead alkyls. The saturates, Olefins and aromatics shall be as stipulated for CEC-L-21 fuel and given in Table 11. About 230 litre of test fuel are required for a complete test (two runs) of one candidate and one reference oil.

F-4.2 Reference Oil

A designated reference oil is used as the "bench mark" reference oil whose performance the candidate oil must match or better. About 31 are required for a complete test, mixed with the fuel at a 50/1 (2 percent oil) volumetric ratio.

F-4.3 Candidate Oil

3 l of the candidate oil are also required for a test. At least twice this amount should be provided in case the test must be re-run.

F-5 PROCEDURE

F-5.1 Assembly of the Engine

The dismantling, inspection and reassemble details of the engine are given in **F-8**. The following parts must be new for each test:

2 Piston and ring assemblies complete
2 Cylinders
2 Cylinders head gaskets
2 Cylinder base gaskets
2 Exhaust gaskets
2 Sets of breaker points
2 MICO 5W BC spark plugs.

F-5.2 Expected Life

It is recommended that the engine be rebuilt after five complete crossover tests (normally ten runs plus the reference oil run) have been completed. The crankcase, crankshafts, rods and associated seals and bearings must be examined and replaced, if necessary.

F-6 OPERATING PROCEDURE

F-6.1 Break In

A new or rebuilt engine must be broken in as specified below using the same fuel/oil mixture in each cylinder as will be used in the test. The power output specified is approximate and may vary by about ± 5%.

Duration	*Rev/min*	*Power kW(hp)*	*Plug temp °C*
5	2 000-2 400	*Min*	Record
25	4 400-4 600	3.75 (5.0)	Record

F-6.2 Test Run

Before starting each test cycle, idle for 5-6 min at 700-800 rev/min, to warm up. Run the test in the following cycle, varying the cooling air to maintain the specified plug gasket temperature.

Minutes	*Rev/min*	*Power* (hp)	*Plug Temp* °C	*Exht Temp* °C	*A/F Ratio*
25	5 950-6 050	(9-10)	183±3	650-700	12.4-12.7
5	2 000-2 400	*Min*	Record	Record	N/A

Repeat 5 times for a total of 150 minutes.
Shut down for a minimum of 60 minutes.

Repeat for full cycle for 20 total running hours.

F-6.3 Observations

The temperature specified above must be recorded continuously, and be logged at least twice per hour and the cooling air stream varied as necessary to correct and tendency to drift. The crankshaft rev/min power output, fuel consumption, air/fuel

ratio and ambient conditions should preferably be continuously recorded and must be logged at least twice per hour.

F-6.4 Pre-ignition

An increase of 10°C (18°F) in the spark plug gasket temperature over the steady state level constitutes an incident of major preignition. Remove the spark plug and retain it, labelled with the oil used, the cylinder number, the total test hours, and the hours on that plug to the nearest 0.1 h. Replace with a new gapped plug. If major preignition occurs again with the candidate oil terminate the test and record a failure. If more than one major preignition occurs with the reference oil, stop the test to investigate and correct the problem before re-running. Sudden temporary increase of less than 10°C (18°F) constitute minor preignition. These should be logged and reported, but the test should not be interrupted.

F-6.5 Other Plug Malfunction

Plug problem of fouling or bridging are normally indicated by a loss of power accompanied by a decrease in plug gasket temperature of the affected plug. The plug must be replaced and labelled and the incident reported.

F-6.6 End of Test

Remove the cylinders and cylinder heads. Remove the pistons from the rods, but do not remove the rings from the grooves. Rate the following to the procedure described:

Piston ring sticking
Piston skirt varnish
Piston crown deposits
Cylinder head deposits
Exhaust port blockage

F-7 INSPECTION AND RATING OF ENGINE PARTS

F-7.1 Inspection

Inspection and rating should be performed as soon as possible after completion of the test, and in any case within 8 h of the end of the test. As soon as the engine has cooled to within 5°C (9°F) of ambient temperature, remove the exhaust system, cylinder head(s), cylinder(s), and piston(s), from the engine. Do not remove the rings from the piston. Engine parts may be washed in Stoddard solvent or wiped with a soft cloth, but must not otherwise be cleaned. Deposits those are removed by washing in Stoddard solvent or by wiping gently with a dry or solvent wetted cloth are not considered for rating purposes.

F-7.2 Rating

Piston ring sticking and piston skirt and land deposits are given a numerical rating from 10 (best) to 0 (worst). The condition of the cylinder bore is stated qualitatively as is that of the combustion chamber surface (piston crown and cylinder head) port plugging is rated as the mean percentage of exhaust port area blocked by carbon deposits. Preignition and plug fouling and whiskering are rated by the number of occurrences. These procedures are discussed in more detail in the balance of this section.

F-7.3 Piston Rings

Rating numbers are given according to the tightness of the ring in its groove and the number of circumferential degrees over which it may be stuck. Each ring is rated and reported separately. The criteria are given below:

F-7.3.1 *Free*

A ring that will move under gravity if the piston is turned with its axis horizontal. A slight touch to overcome static friction is permissible.

F-7.3.2 *Sluggish*

The ring will not fall under its own weight, but yield to pressure from a finger or pencil point up to the amount required to compress the ring by half its width.

F-7.3.3 *Cold Stuck*

Will not move under pressure but shows no evidence of blowby across its face, indicating that it is free when running. The ratings range from 9 for a ring that is cold stuck over 30° or less of its circumference to 5 for a ring cold stuck over 300-360°.

F-7.3.4 *Hot Stuck*

Firmly stuck in its groove with evidence of blowby or scuff across its face. Any hot stuck ring is a failure for the oil, but a numerical rating is normally assigned, from 4 for a ring hot stuck over 30° or less to zero from a ring hot stuck over 330-360°.

F-7.3.4.1 *Piston skirt varnish*

Follow the CRC manual No. 14 (Varnish Rating) in allocating numbers from 10 (clean) to 0 (completely black). Rate the inlet and exhaust side of the piston separately, looking in the direction at right angles to thus axis of the wrist pin.

F-7.3.4.2 *Piston damage*

Any occurence of scuffing or scoring must be reported as to extent and location.

F-7.3.4.3 *Piston crown*

Describe the deposits by type, thickness, and location. A colour photograph, oriented with regard to the ports, may be provided.

F-7.4 Cylinder Head

As for the piston crown.

F-7.5 Condition of the Cylinder Bore

Rate the inlet and exhaust sides separately. Report any lacquer deposits by area covered and appearance. If the condition of the bore indicates scuffing or other lubricant related damage, or is in any other way unusual, add an appropriate description.

F-7.6 Exhaust Port Blocking

Report the percent of the total port area blocked by deposits. If this is greater than 10 percent photographs are required.

F-7.7 Spark Plugs

Report the condition of any spark plug removed during the test and the operating time. Report similarly the condition of the plug in use at the end of the test.

F-7.8 Other Discrepancies

Any scuffing of piston or bore, and any unusual wear or damage in any part of the engine, must be reported.

F-8 TEST ENGINE MANDATORY INFORMATION: RAJDOOT 350 ENGINE

F-8.1 Model

1A1.5RD LET

F-8.2 General

Twin cylinder, Loop Scavege

Aluminium piston, slightly domed, standard size

Two pegged rings, Ist oversize

Cast Iron Bore in Aluminium (Rebored)

Removable Hemispherical Head

Two Mikuni Carburettors setting 514 — 4 No. 140 Main Jet

Idle Setting 2 000-2 400 rev/min

F-8.3 Dimensions

Displacement	347 cc
Cylinder bore	64 mm
Stroke	54 mm
Compression ratio	6.6/1
Exhaust port	42 × 21 mm
Transfer port (2)	27 × 12 mm 11 × 12 mm
Maximum Power	30.5 bhp at 6 750 rpm
Maximum torque	3.3 m-kg at 6 500 rpm

F-8.4 Ignition Settings

Timing 2.4 - 2.6 mm BTDC

Break gap *Max* 0.4 mm

F-8.5 Spark Plug

MICO 5WBC or equivalent

Plug gap setting 0.6 - 0.7 mm

Plug Torque 19 - 20 Nm

Table 11 Physico Chemical Characteristics of Test Fuel
(*Clause* F-4.1)

Sl No.	Characteristics	Requirement
i)	Distillation, °C	As per IS 2796
ii)	Reid vapour pressure at 387.8°C, kg/cm^2, *Max*	do
iii)	Octane number (Research)	do
iv)	Sulphur content, percent by mass	do
v)	Copper corrosion, 3 h @ 100 °C	do
vi)	Gum content, mg/100 ml	do
vii)	Oxidation stability, *Min*	do
viii)	Lead content g/l percent, *Max*	0.013
ix)	Composition, percent by weight	
	a) Saturates	40-85
	b) Olefins	5-15
	c) Aromatics	10-45

F-9 YAMAHA, RAJDOOT 1A1.5RD, LET ENGINE BUILD PROCEDURE

F-9.1 General

This procedure summarizes the inspection and part replacement of the test engine required between tests. For greater detail and for operations other than those summarized here, refer to the Yamaha Rajdoot Service Manual.

F-9.2 Inspection

F-9.2.1 *Cylinder*

Measure and record to an accuracy of ± 0.001 mm (0.000 4 in) the cylinder bore along the crank axis and at right angles to it in the following locations.

18-20 mm (0.71-0.79 in) below the top of the bore

Just above the exhaust ports

Just below the exhaust ports

Just above the cut away at the bottom of the bore

Record the maximum out of round and the taper, which must not exceed 0.025 mm (0.001 in) total indicated run out (TIR). If it is necessary to hone the bores, a No. 150 grit stone should be used for the intial hone and No. 250 grit for the finish hone. Finish must in any case be in the range of 0.45-0.7 μm (18-28 μ in) arithmetic average.

F-9.2.2 *Piston*

Measure and record the piston diameter along the crank axis and at right angles to it 9 to 11 mm (0.35-0.43 in) above the bottom of the skirt.

F-9.2.3 *Clearances*

Calculate the following for diameters measured in the same directions:

Minimum clearance = Smallest bore dia – largest skirt dia

Maximum clearance = Largest bore dia – Smallest skirt dia

These clearances must be in the range of 0.20 - 0.22 mm (0.007 5 - 0.005 5 in). If these limits are exceeded use selective assembly to make up pairs of pistons and cylinders that are within limits or hone the cylinder as described above. Record the clearances and letter or number mark the matching piston and cylinder pairs.

F-9.2.4 *Ports*

Inspect the ports for sharp edges or burrs. If found, use a soft rubber grit wheel on a hand grinder or hand stoning to correct. Do not enlarge the ports.

F-9.2.5 *Cylinder Gasket Surface*

Place the cylinder headgasket surface on a surface plate and try to wobble it. If it is possible to insert a 0.005 mm (0.002 in) feeler between the surface plate and the gasket surface, it must be corrected or the cylinder rejected.

F-9.2.6 *Cylinder Head*

Check its gasket surface for flatness as for the cylinder gasket surface, and correct or discard if necessary.

F-9.2.7 *Piston Rings*

With the rings removed from the piston and compressed into the cylinder 5-10 mm (0.2-0.4 in) below the top of the bore, the gaps must be 0.20 - 0.40 mm (0.008 - 0.016 in). These should be recorded. Assemble the piston rings onto the pistons. Check that they are free, with 0.03 - 0.07 mm (0.001 2 - 0.002 8 in) side clearance, after positioning over the pins. The markings on the piston rings must face upward.

F-9.2.8 *Carburettors*

These must flow 1.7 - 1.8 kg/h (3.7 - 3.9 lb/h) of fuel. This should be checked before each run.

F-9.2.9 *Other Components*

Make a general inspection of the engine, including the ignition system; cleaning, repairing, or replacing as necessary.

F-9.3 Determination and Adjustment of Compression Ratio

All procedures of this section, as required must be performed and recorded for each set of engine test parts (cylinder head, cylinder and piston assembly) checked. These must be marked in some reasonably permanent manner and kept together. More than one set of test parts may be rechecked at a time; but if the crankcase and crank assembly are changed after a particular set of test parts have been checked, at least one set must be rechecked on the new crankcase assembly. If the difference is such as will not put any of the prechecked sets of parts out of specification these need not be rechecked.

F-9.4 Initial Assembly

Wash all parts with MTO and allow to air dry. Mount each piston on the rod so that the arrow on the piston crown points to the exhaust port. Apply gasket sealer to the cylinder base gasket and mount it on the cylinder. Oil the cylinder bore and the piston assembly lightly with test oil and mount the cylinder over the piston assembly. Using spacers on the studs to make up the thickness of the cylinder head flange, torque the nuts to 22 -21 Nm (177 - 185 lbf. in).

F-9.5 Determination of Effective Swept Volume

F-9.5.1 Set the piston at bottom dead centre (BDC) and measure the distance from the piston crown surface adjacent to the cylinder wall to the top of the exhaust port (the effective port height) using either of the following procedures.

F-9.5.2 Measure from the piston crown to the cylinder head mounting surface. Turn the crank to align the top edge of the upper land of the piston with the top of the exhaust port and measure again to determine the piston movement. If the top edge of the upper land is Chemfered, align the lower edge of the chamfer with the top of the port before making the second measurement. Record the piston movement, which equals the effective exhaust port height. If the gauge does not contact the piston crown at its outer edge, make sure that the distance from the cylinder wall at which the measurement is taken for both measurement.

F-9.5.3 After determining the effective port height, locate the piston at top dead center (TDC) and measure from the edge of the crown to the piston head mounting surface again. The difference between the BDC and TDC measurements minus the effective port height equals the effective stroke.

F-9.5.4 Multiply the effective stroke by the area corresponding to the cylinder bore (bore 2 × 0.789 4) to obtain the effective volume. The cross-section area of the cylinder bore of the Yamaha Rajdoot 350 cc engine is 32.17 cm^2 and the effective volume is approximately 87 cm^3 or in numerically identical ml, as all commercially available burettes are so calibrated.

F-9.6 Determination of Compressed Volume

F-9.6.1 Position the engine so that the spark plug gasket mounting surface will be up and horizontal when the cylinder head is in place.

F-9.6.2 Position the piston at top dead centre.

F-9.6.3 Using the finger tips, press heavy petroleum into the space between the piston and the cylinder wall so that no gap appears around the piston circumference. Wipe off any excess on the piston crown or on the cylinder head gasket surface. Be careful not to move the piston during this operation.

F-9.6.4 Mount the cylinder head and gasket, torquing to 20-21 Nm (177-196 lbf in).

F-9.6.5 Using the designated reference oil diluted with about 20 volume percent of MTO which should give about 4.0 - 5.5 (m^2/sec) viscosity at 100 °C (212 °F), fill the combustion chamber just to the top of the spark plug hole, measuring the amount of oil to ±0.1 ml (cm^3). Tap gently to dislodge any air bubbles and make sure that the oil level has stabilized before recording the amount used, which should be 18-22 ml. This is most easily done using a 50 ml burette set in a stand over the engine.

F-9.6.6 Subtract 1.1 ml from the volume of oil to allow for the volume of the spark plug. This is the compressed volume, which should be 17-18 cm^3.

F-9.7 Calculation of Compression Ratio

The compression ratio is: (ESV + CV)/CV

where

ESV = Effective swept volume (ml or cm^3), and

CV = Compressed volume (ml or cm^3).

F-9.8 Adjustment of Compression Ratio

F-9.8.1 The compression ratio should fall into the range specified for the engine. For the Yamaha Rajdoot 350 cc engine, this is 6.6 to 1. If the compression ratio is too low, it will be necessary to grind the cylinder head gasket surface to remove metal. Removal of 0.25 mm (0.01 in) of metal will normally increase the compression ratio by approximately 0.1. Thus to increase the compression ratio from 6.3/1 to 6.6/1 remove 0.75 mm (0.03 in) of metal.

F-9.8.2 If the compression ratio is too high, try to correct by interchange of heads. Only if this is not possible, remove small quantities of metal from the inside of the cylinder using a high speed hand grinder evenly over the surface. Be careful not to remove too much material.

F-9.9 Final Assembly

F-9.9.1 Empty out the oil used for volume determination. Remove the cylinder heads and cylinders. Wash with MTO to remove the grease, and lubricate lightly with test oil.

F-9.9.2 Replace the cylinders, cylinder heads and gaskets. The gaskets may normally be re-used after the volume determination procedure.

F-9.9.3 Complete the rebuilding of the engine as specified in the service manual.

F-9.9.4 Before inserting the spark plug, turn the engine over by hand to ensure that it is free.

F-9.9.5 Gap two new MICO 5WBC spark plugs to 0.70 - 0.75 mm (0.028 - 0.029 in). Torque to 19-20 Nm (170-180 lbf in) using a thermocouple wash.

ANNEX G

(*Clause* 7.5)

TEST METHOD FOR EVALUATION OF VISIBLE SMOKE INTENSITY OF TWO-STROKE AIR COOLED GASOLINE ENGINE LUBRICANTS (BAJAJ SUPER SMOKE TEST METHOD)

G-1 SCOPE

This method is intended to evaluate the exhaust smoke level of two-stroke engine oils.

G-2 APPARATUS

Bajaj Super 05 series 150 cc single cylinder, two-stroke, air cooled gasoline engine as prescribed in **G-10** is used for the test. The engine is fitted with additional equipments as prescribed in **G-11**. The test bench is instrumented to measure engine power (bhp), fuel consumption, exhuast temperature and spark plug gasket temperature. The smoke opacity is measured using Hartridge smokemeter.

G-3 PREPARATION OF APPARATUS

Rebuild the test engine as per procedure given in **G-10**. Carry out inspection and calibration of all equipments and instruments as per manufacturers recommendation and ensure their proper functioning.

NOTES

1 Measurement of visible smoke from two-stroke engine is not yet a standard technique. Hartridge (Sampling type) and USPHS (full flow) opacimeters used for diesel engine smoke measurement have been utilized by some researchers.

2 Measurement of smoke density at 'No Load Acceleration Test' is generally recommended by researchers as 'Steady State Test' have poor discriminating ability among oils of different quality.

G-4 TEST FUEL

The fuel used during running in and the test, is a gasoline conforming to IS 2796 but its hydrocarbon composition that is saturates, olefines and aromatics as well as level of lead content shall be as given in **G-12**. If required, TEL (motor mix) may be added to the test fuel to raise its lead content to specified level of 0.4 to 0.63 g/l.

G-5 RUNNING-IN

G-5.1 Engine rebuilt with new parts shall be run-in for 14 h-50 min according to the running-in schedule given in **G-13**.

G-5.2 The engine fuel during running-in, shall be mixed with 5 : 100 by volume of high reference oil.

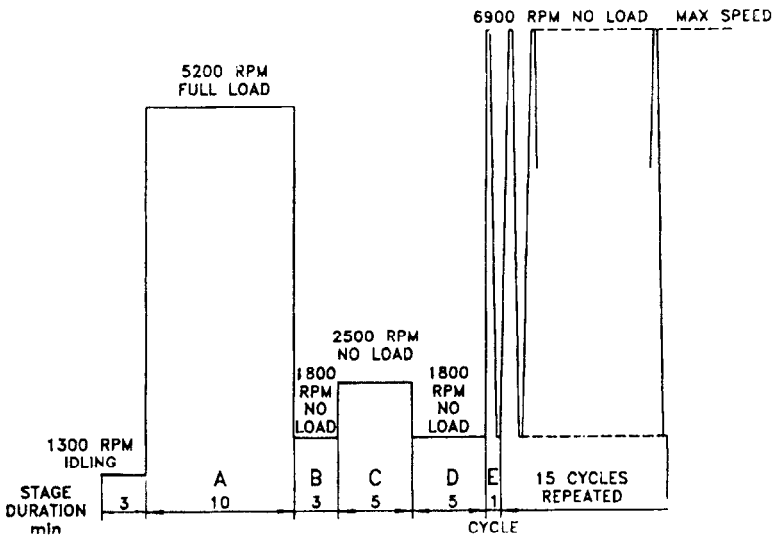
G-6 TEST PROCEDURE

G-6.1 After completion of running-in the engine silencer shall be replaced with new silencer and its exhaust sampling line shall be connected to Hartridge smokemeter by high temperature resisting flexible pipes such as Teflon etc of maximum 2 meter length.

G-6.2 The test oil shall be mixed in the fuel at 2 : 100 oil/fuel ratio by volume.

G-6.3 The smoke level shall be determined under 'No Load Acceleration Test'. The test operating conditions are as follows:

G-6.3.1 The operating test cycle is shown in Fig. 6.



All dimensions in millimetres.

FIG. 6 NO LOAD ACCELERATION TEST PROCEDURE

G-6.3.2 The test consists of stages A, B, C, D and E.

G-6.3.3 Stages, A, B, C and D are the flush stage to remove the effect of previous oil and conditioning with test oil.

G-6.3.4 Stage E, therefore, is the smoke measurement stage in which engine throttle is pulled to wide open (WOT) and accelerated to maximum rpm.

G-6.3.5 Initial 10 cycles may give high values of smoke density, smoke then stabilizes. This level is defined as the smoke level. 5 cycles are repeated to obtain the maximum values of the smoke density. The average value of smoke in these 5 cycles is reported as the smoke level of test oil.

G-7 REPORTING

The smoke level of test oil will be reported on 0-100 uniform scale of Hartridge Smoke Units (HSU) which indicate the light opacity characteristics of visible smoke 0.0 gives complete transmission and 100 complete extinction of light.

G-8 REFERENCE OIL

TSR-2[1)] 2T oil having synthetic base oil formulation or any other equivalent oil formulation may be used as high reference oil.

G-9 CALIBRATION

In order for a test stand to be accepted for candidate oil qualification, it must have been calibrated by this procedure with reference oil T-511 or other equivalent oil as if it was a candidate oil. The average value of smoke with reference oil must be a maximum of 15 HSU.

A qualification test must be run on a new or completely rebuilt engine or test bed and also each time before beginning evaluation of candidate oils.

G-10 ENGINE DETAILS AND REBUILDING FOR TEST

G-10.1 Engine Description

The test apparatus consists of a two-stroke single cylinder 150 cc Bajaj Super Engine having following specification:

Sole manufacturer	:	M/s Bajaj Auto Ltd, Akurdi Pune 411035
Type	:	Bajaj Super 05 Series, 150 cc, Two-stroke, single cylinder, forced air cooled, spark ignition, gasoline engine.
Bore, mm	:	57
Stroke, mm	:	57
Capacity, ml	:	145.45
Compression ratio	:	7.4 : 1
Max Power, kW	:	4.63 @ 5 200 rpm
Carburettor	:	Dellor to SI 20/15D
Main jet size	:	83
Pilot jet size	:	42
Idling jet size	:	60
Cooling system	:	Forced air cooled by inbuilt blower mounted on crank-shaft
Ignition system	:	12V, magneto ignition contact breaker type
Spark plug type	:	MICO HB-W-175 Z1

Transmission gear ratios:

1st gear	:	1 : 13.35
2nd gear	:	1 : 9.32
3rd gear	:	1 : 6.64
4th gear	:	1 : 4.73

G-10.2 Test Components

Engine assembly	:	Part No. 05-1001-02
Cylinder block	:	Part No. 06-1004-12
Piston assembly	:	Part No. 06-1005-01
Cylinder head	:	Part No. 06-1004-02
Silencer assembly	:	Part No. 03-1015-02
Cowling assembly (Polymer)	:	Part No. 03-1013-01
Contact breaker	:	Part No. 03-1003-18

Parts needing replacement may be obtained from the manufacturer.

G-10.3 Overhauling of the Engine

G-10.3.1 The test engine shall be completely stripped when it is new and subsequently after a maximum of every ten tests or after an earlier breakdown.

G-10.3.2 *Cleaning Procedure*

Any petroleum product equivalent to white spirit may be used. Components removed by dismantling the engine or coming from store shall be thoroughly immersed in the solvent and whipped off with clean cloth before being air dried for assembly.

G-10.3.3 *Replacement of Part*

Original spare parts shall be used. For each set of tests new spark plug and silencer assembly shall be used.

1) Reference oil will be made available by IOC (R&D) Centre, Faridabad.

G-10.3.4 *Running Clearness*

These shall be as follows:

	At assembly, mm	
	Min	*Max*
Cylinder piston Clearance[1)]	0.085	0.095
Ring gap		
1st ring	0.20	0.35
2nd ring	0.20	0.35
Ring side clearance		
1st ring	0.06	0.10
2nd ring	0.06	0.10

G-10.3.5 Measure the cylinder block bore in two directions across and longitudinal to gudgeon pin axis at 8, 35, 60, 75 mm from the top. Use new cylinder block if wear exceeds 0.200 mm or out of roundness exceeds 0.025 mm.

G-10.3.6 *Torque Applied for Rebuilding the Engine*

The following recommended tightening torque shall be applied when rebuilding the engine for test.

Sl No.	*Part No.*	*Nomenclature*	*Torque* m-kg
i)	39-0293-15	Nuts securing crank case halves	1.3-1.5
ii)	39-0295-15	Nuts for securing MG pin	3-3.5
iii)	39-0293-15	Nuts for securing cylinder head	1.5-1.8
iv)	01-1006-13	Nut for securing magneto rotar	6-6.5
v)	01-1006-15	Nut for securing clutch nut	4-4.5
vi)	01-1003-44	Ring nut	18-20
vii)	39-0012-01	Bolt for securing stator plate	0.3-04
viii)	39-0092-04	Bolt for clutch cover	0.6-0.8
ix)	01-1201-04	Bolt for securing carburettor	1.6-2
x)	39-0295-15	Nut for securing of kick starter	2.3-2.6
xi)	39-0073-04	Bolt for securing fan	0.6-0.8
xii)	01-1105-01	Spark plug	3.73

G-10.3.7 *Engine Settings*

The following settings shall be made	
Spark plug electordes gap, mm	0.5
Contact breaker points gap, mm	0.4
Ignition timing, °CA btdc	25°C ±1

G-11 ADDITIONAL EQUIPMENTS

G-11.1 A suitable dynamometer having proper load indicating system shall be coupled to the engine for absorbing load. The engine should be appropriately mounted on the test bench.

G-11.2 A flowmeter for gasoline/oil mixture consumption shall be used. The head that is the difference between the height of the constant level of the fuel tank and the level of the carburetor float chamber should be maintained at about 500 mm during all tests.

G-11.3 For the temperature measurement any suitable instrument may be used. A thermocouple fitted to the spark plug seating ring (*see* Fig. 2) should be used for the measurement of the average temperature.

G-11.4 Throttle actuating motor along with remote control system.

G-11.5 Programmer unit for controlling engine acceleration+cruising time and deceleration + waiting time for 30 s each during 1 minute test cycle and also repeating the test cycle for specified number of times.

G-12 PHYSICO CHEMICAL CHARACTERISTICS OF TEST FUEL

Sl No.	*Characteristics*	*Requirement*
i)	Distillation, °C	As per IS 2796
ii)	Reid vapour pressure at 37.8°C kg/cm^2 *Max*	do
iii)	Octane number (R)	do
iv)	Sulphur content, percent by mass	do
v)	Copper corrosion, 3h @ 100°C	do
vi)	Gum content, mg/100 ml	do
vii)	Oxidation stability, *Min*	do
viii)	Lead content, percent by volume	0.4-0.63
ix)	Composition, percent by volume	
	a) Saturates	40-85
	b) Olefines	10-20
	c) Aromatics	10-45

G-13 RUNNING-IN SCHEDULE

Duration	: 14 h-50 min.
Oil	: High quality reference oil
Oil/Fuel ratio	: 5:100

Engine rpm	*Break power* bhp	*Duration* min	*Transmission gear position*
1300 ± 100 (Idling)	—	20	Neutral
2 500	0.86	20	Top
3 000	1.04	20	Top
3 500	1.21	20	Top
4 000	1.38	20	Top
4 500	1.55	20	Top
5 200	1.80	20	Top
3 000	1.90	30	Top

[1)]Bore dimension is to be checked on a plane normal to the gudgeon pin axis. Clearance between finished bore and piston size measured at 21.2 mm from bottom edge of piston.

Engine rpm	*Break power* bhp	*Duration* min	*Transmission gear position*
3 500	2.21	30	Top
4 000	2.48	30	Top
4 500	2.84	30	Top
5 200	3.29	30	Top
3 000	3.02	30	Top
3 500	3.52	30	Top
4 000	4.02	30	Top
5 200	5.24	30	Top
3 500	*Max*	30	Top
4 500	*Max*	30	Top
5 000	*Max*	60	Top
4 000	*Max*	120	Top
4 500	*Max*	120	Top
5 000	*Max*	120	Top

NOTE — During idling CO should be set at 3.5±0.5 percent volume. The CO measurement should be done using appropriate exhaust gas analyzer with suitable accuracy which enables CO measurement without any interefrence from HC level in the exhaust gas.

ANNEX H

(*Clauses* 9.1 *and* 9.2)

HOMOGENEITY AND MISCIBILITY TEST

H-1 GENERAL

This test determines whether an oil is and will remain homogenous and whether it is miscible and be stable when blended with certain standard reference oils after being submitted to a prescribed cycle of temperature changes.

H-2 REFERENCE STANDARD TEST METHOD

This test method generally conforms to U.S. Federal Test Standard No. 791B—Method 3470 dated January 15, 1969 excepting in one feature that the reference oils are those approved by the qualifying authority.

H-3 SAMPLE

H-3.1 Test Sample

Approximately 300 ml.

H-3.2 Standard Reference Oils

As approved by the qualifying authority (Ref. Oil TSR-1).

H-4 APPARATUS

H-4.1 Test Jar

A test jar of clear glass, cylindrical form, flat bottom, approximately 30 to 35 mm in inside diameter and 115 and 125 mm in height.

H-4.2 Thermometer

Minus 50°C to plus 50°C range, conforming to ASTM EI-67 or its equivalent.

H-4.3 Cork

To fit the test jar, bored centrally to take the test thermometer.

H-4.4 Jacket

Glass or metal, water-tight, of cylindrical form, bottom, about 115 mm in depth, with inside diameter 9.5 to 12.5 mm greater than the outside diameter of the jar.

H-4.5 Disk

Cork or felt, 6 mm in thickness of the same diameter as the inside of the jacket.

H-4.6 Gasket

A ring gasket, about 5 mm in thickness, to fit snugly around the outside of the test jar and loosely inside the jacket. The purpose of the ring gasket is to prevent the test jar from touching the jacket.

H-4.7 Bath

A cooling bath of a type for obtaining the required temperatures.

H-5 PROCEDURE

H-5.1 Shake oil sample well and pour into six sample jars to the 37.5 mm mark and one sample to the 75 mm. Add reference oil to each of the sample jars to the 75 mm mark. Mix the oil thoroughly and heat to 46°C in a water bath. After the oil reach room temperature, observe and record the colour and evidence of separation. Determine and record the pour point of each oil.

H-5.2 Maintain the temperature of the cooling bath at −1°C to 2°C. Support the jacket, containing the test jar, firmly in a vertical position in the cooling bath so that more than 25 mm of the jacket projects out of the cooling medium.

H-5.3 Beginning at a temperature 12°C before the expected pour point, at each test thermometer reading that is a multiple of 3°C, remove the test jar from the jacket carefully and tilt it just enough to ascertain whether there is a movement of the oil in the test jar. The complete operation of removal and replacement shall require not more than 3 s. If the

oil has not ceased to flow when its temperature has reached 10°C, place the test jar in the jacket in a second bath maintained at a temperature of −18°C to −15°C. If the oil has not ceased to flow when its temperature has reached −7°C, place the test jar in the jacket in a third bath maintained at a temperature of −34.5°C. For determination of very low pour points additional baths should be maintained with successively lower temperature differentials of about 17°C. In each case transfer the jar when the temperature of the oil reaches a point of 28°C, above the temperature of the new bath. At no time place the cold test jar directly in the cooling medium. As soon as the oil in the test jar does not flow when jar is tilted, hold the test jar in a horizontal position for exactly 5 s as noted by a stop watch or other accurate timing device, and observe carefully. If the oil shows any movement under these conditions, place the test jar immediately in the jacket and repeat a test for flow at the next temperature 3°C lower.

H-5.4 Continue the test in this manner until a point is reached at which the oil in the test jar shows no movement when the test jar is held in a horizontal position for exactly 5 s. Certain lubricating oil tend to move as a whole and should be very closely observed. Record the reading of the test thermometer at this temperature, corrected for error, if necessary. Allow the samples to thaw and when the cloudiness has barely disappeared, observe and record the colour and evidence of separation. When the sample reach room temperature, place them in an oil bath after removing the thermometer. Heat the bath at 230°C and immediately remove the sample jars. Cork the samples and store them at their respective pour points for 18 to 24 h. Remove the jars and allow the sample to thaw. When cloudiness has barely disappeared, observe and record the colour and evidence of separation. Repeat the last operation when the samples reach room temperature.

H-6 METHOD OF REPORTING RESULTS

H-6.1 Report evidence of separation in the following four successive stages:

a) Initial sample;
b) Warmed to just above cloud point after having once reached pour point ;
c) After a cycle of heating to 230°C cooling to pour point storing it for 24 h at this temperature and warming to just above pour point; and
d) Warmed to room temperature.

Evidence of separation is to be reported as:

a) *Condition*
   i) Definition, and
   ii) None or doubtful.
b) *Location*
   i) Near top,
   ii) Near bottom,
   iii) Filament, and
   iv) Uniformly distributed.
c) *Particle size*
   i) Small, as in cloud or haze, and
   ii) Specks or larger particles.
d) *Colour*
   i) White or very light,
   ii) Yellow, and
   iii) Blank.

ANNEX J

(*Clause* 10.1)

PROCEDURE FOR QUALIFICATION APPROVAL

J-1 The oil shall be qualified in accordance with the provision of this standard. The authority for recommending qualification approval vests in the panel for Engine and Gear Oil Qualification Approval.

J-2 The Panel for Engine Oil Qualification Approval, has the following functions:

a) Approval of engine test facilities of laboratories for the purpose of recognizing them to carry out engine test evaluation programme as required by this standard.
b) Approval of blending and quality control facilities of lubricant manufacturers for the purpose of ensuring their ability to manufacture qualified lubricants within the tolerance limits stipulated by this standard.
c) Scrutiny of laboratory engine test data including evaluation of test components for the purposes of assessing whether the candidate lubricant formulations meet the requirements of the standard, and accordingly recommended for or against qualifying the products.

J-3 Candidate oil companies desirous of obtaining the qualification approval of their products against this standard, shall apply to the Bureau of Indian

Standards in a prescribed form which requires disclosure of full particulars of the formulation in terms of both base stocks and additive components. Such applications should be addressed as confidential documents to the designated official of the Bureau of Indian Standards. The information contained therein shall be treated in strict confidence and not disclosed to any persons or organizations, unless so authorized in writing by the candidate oil company.

J-4 On receipt of the application for qualification approval, the Bureau of Indian Standards will communicate to the oil company the quantities and mode of despatch of the candidate oil and its components. Finished lubricant blends in requisite quantities under suitable code will be sent to approved testing laboratories for engine performance evaluation with their prior concurrence of the laboratory.

J-5 The testing laboratory shall present the results of all the engine tests and other related data in the prescribed form together with specified engine components at a scheduled meeting of the panel for engine and gear oil qualification approval.

J-6. The panel based on an overall review of the test data and the condition of the components, shall decide by the census whether the candidate oil meets the requirements of this standard and accordingly communicate its decision to Bureau of Indian Standards.

J-7 In the event of the panel recommending qualification approval, the following document shall be issued by Bureau of Indian Standards for extending coverage under BIS Certification Marks Scheme.

J-7.1 Qualification Certificate

Testifying to the quality of the product and giving it a qualification number. The qualification certificate shall consist of particulars of various components used in the lubricant formulation and detail of its compliance to relevant physico-chemical engine test and other performance requirements specified in **5**, **6** and **7**.

J-7.2 Product Identification Report

In which the composition of the product is declared and certain test data (*see* **11**) are given whereby it is possible to identify the product.

J-8 At any time there is a change in the base stock source, refining treatment or additives used in the formulation, requalification will be required. Where the proposed changes are minor and may not be expected to significantly affect the performance, the panel may at its discretion recommend waiving complete requalification or may require only partial requalification in order to determine the significance and acceptability of the proposed changes.

J-9 In the event of the candidate lubricant formulation is found to be marginally failing in some engine tests, the candidate oil company may disclose its formulation particulars to the panel and request it to consider the possibility of a modified formulation meeting the requirements of the standard. In such event, the panel may, at its discretion, suggest limited re-evaluation of the modified formulation. On the basis of such re-evaluation the panel may consider recommending qualification approval to the modified formulation.

J-10 The oil approved against this standard will be qualified for a period not exceeding 4 years from the date of the original qualification. When the qualification period has expired, each product shall be requalified if the manufacturer wishes to maintain the formulation as a current product meeting this standard.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'.

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