

PHILIPPINE NATIONAL STANDARD

PNS/BAFS 397:2024
ICS 65.060.01

Internal Combustion Engine — Methods of Test



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Foreword

In 2023, the University of the Philippines Los Baños (UPLB)-Agricultural Machinery Testing and Evaluation Center (AMTEC) proposed the development of the Philippine National Standards (PNS) on Internal Combustion Engine — Specifications and Methods of Test. According to the agency, there were conflicting requirements on measuring the noise and setting of the engine during continuous running test during the implementation of Philippine Agricultural Engineering Standards (PAES) 117:2000 (Agricultural machinery — Small engine — Methods of test). The proposal was submitted to and reviewed by the Philippine Council for Agricultural and Fisheries (PCAF)-National Sectoral Committee on Agricultural and Fisheries Mechanization (CAFMech).

In the same year, the Committee issued Resolution No. 19, series of 2023 (Recommending to the Bureau of Agriculture and Fisheries Standards [BAFS] the Prioritization of the Review and/or Amendment of the Standards for Small Engines and Agricultural Pumpsets). The development intends to harmonize the standards with the updated international and regional standards on reciprocating internal combustion engine, as applicable. Further, it also aims to set the minimum performance parameters and testing methods for engine to ensure and improve the quality of the machine and its suitability in the local setting.

In response, the Department of Agriculture (DA)-BAFS officially created a Technical Working Group (TWG) to develop the PNS under the Special Order (SO) No. 305, series of 2024 (Creation of TWG and Project Management Team (PMT) for the Development of PNS for Agricultural and Fishery Products and Machinery) and SO No. 905, series of 2024 (Addendum to SO No. 305, series of 2024 entitled, “Creation of TWG and Project Management Team [PMT] for the Development of PNS for Agricultural and Fishery Products and Machinery”).

The TWG was composed of relevant stakeholders from the government sector, academe/research institutions, private sector organizations, and Civil Society Organizations (CSO). The draft PNS underwent an extensive series of TWG meetings and stakeholder consultations, facilitated through online platform, from January to October 2024 prior to its endorsement to the DA Secretary for approval.

This Standard includes the following significant changes compared to the PAES 117:2000:

1. Modification on the title to harmonize with other international standards;
2. Updating of Terms and Definitions to include additional terminology;
3. Updating of classifications to include provisions and figures for different type of engines;
4. Updating of requirements for the methods of test to harmonize with ANTAM Standard Codes for Testing of Power Tillers; and
5. Updating of Annexes and inclusion of additional normative and informative references.

This Standard cancels and replaces PAES 117:2000 which has been technically revised. This document was written in accordance with the formatting and editorial rules of the Standardization Guide No. 1 (Writing the PNS) developed by the Standards Development Division (SDD) of the BAFS.

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1 Scope

This Standard specifies the methods of test and inspection for fully equipped reciprocating internal combustion engines with up to 20 kW rating used for agricultural and biosystems purposes. Specifically, it shall be used to:

- a) Verify the mechanism, main dimensions, materials, accessories of engine, and the list of specifications submitted by the test applicant;
- b) Determine the performances of the machine;
- c) Describe the handling and safety features; and
- d) Prepare the test report.

2 Normative References

The following documents are referred to in the text in such a way that some or all their contents constitute the requirements of this document. The latest edition of the referenced document (including any amendments) applies.

Bureau of Agriculture and Fisheries Standards (BAFS)-Department of Agriculture (DA). (2024). Internal combustion engine — Specifications (PNS/BAFS 396:2024).

Centre for Sustainable Agricultural Mechanization (CSAM)-United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). (2015). ANTAM standard codes for testing of power tillers. https://un-csam.org/sites/default/files/2020-10/ANTAM_Codes_PT.pdf

3 Terms and Definitions

For the purpose of this Standard, the definitions given in PNS/BAFS 396:2024 (Internal combustion engine — Specifications) and the following shall apply:

3.1

bore

nominal inner diameter of the working cylinder, expressed in millimeters, mm (International Organization for Standardization [ISO], 2017)

3.2

brake power

power or the sum of the powers delivered at the crankshaft, expressed in kilowatts, kW (ISO, 2017, *modified*)

admitted term: output power

3.3**compression ratio**

numerical value of the total cylinder volume divided by the numerical value of the nominal clearance volume (ISO, 2017, *modified*)

3.4**continuous brake power**

power recommended by the manufacturer for satisfactory operation under continuous duty conditions within a specified speed range, expressed in kilowatts, kW (Belonio, 2006)

3.5**maximum brake power**

highest power developed at a given speed, expressed in kilowatts, kW (ISO, 2017)

3.6**overall height**

distance between the horizontal supporting plane surface and the horizontal plane touching the uppermost part of the machine, expressed in millimeters, mm (Agricultural Machinery Testing and Evaluation Center (AMTEC)-University of the Philippines Los Baños [UPLB], 2021)

3.7**overall length**

distance between the vertical planes perpendicular to the median plane of the machine, each plane touching the front and rear extremities of the machine, expressed in millimeters, mm (AMTEC-UPLB, 2021)

3.8**overall width**

distance between the vertical planes parallel to the median plane of the machine, each plane touching the outermost point of the machine on its left and right sides, expressed in millimeters, mm (AMTEC-UPLB, 2021)

3.9**stroke**

nominal distance through which a working piston moves between two successive reversals of its direction of motion, expressed in millimeters, mm (ISO, 2017)

3.10**torque**

turning moment delivered by the engine at the driving shaft, expressed in newton-meters, N-m (ISO, 2017)

4 Principles of Test

The test shall be carried out to verify the actual specifications of the engine. Its specifications shall be validated with PNS/BAFS 396:2024 (Internal combustion engine — Specifications).

5 Test Equipment and Instruments

The suggested minimum list of laboratory test equipment and instruments needed to carry out the test is shown in Annex A (Minimum list of laboratory test equipment and instruments). The test equipment and instruments to be used shall be calibrated regularly, physically checked for operation, and shall be cleaned before and after each test.

6 General Considerations

6.1 Machine conditions prior to testing

The engine should be brand new and in good condition and shall have undergone a break-in process as conducted by the test applicant before the test under their responsibility and in accordance with the procedure prescribed by the manufacturer.

6.2 Test site conditions

The engine shall be tested under normal operations with ample space. It shall be mounted on a dynamometer or any power measuring test devices. The site should be suitable for normal working conditions. Adequate ventilation and lighting shall be provided in the area.

6.3 Natural ambient test

No correction shall be made to the measured values of torque or power for atmospheric conditions or other factors. The atmospheric pressure shall not be less than 96.6 kPa. In cases that it is not possible due to the altitude, a modified fuel pump setting may be used, the details of which shall be included in the report. The surrounding temperature shall be from 16 °C to 34 °C.

6.4 Pre-test activities

6.4.1 Verification of specifications

The specifications claimed by the manufacturer and other physical details given in Annex B (Specifications of engine) shall be verified. A stable and even surface shall be used as a reference plane for verification of dimensional machine specifications when fully assembled and ready for testing.

6.4.2 Preparation of the internal combustion engine for testing

The engine shall be checked to ensure that the machine has been assembled and installed in conformance with the instruction of the manufacturer.

6.4.3 Running-in and preliminary adjustments

During the running-in period, various adjustments to the internal combustion engine shall be made according to the prescribed protocol of the testing agency.

6.5 Suspension of test

6.5.1 The operator's manual of the engine shall be submitted by the test applicant prior to testing, otherwise, the test shall be suspended.

6.5.2 The information indicated in the nameplate of the engine shall be consistent and the same with its corresponding operator's manual, otherwise, the test shall be suspended.

6.5.3 During the test run, if the engine stops (due to breakdown or malfunction) affecting its performance, the test shall be suspended.

6.6 Termination of test

6.6.1 In cases of terminated tests, test reports shall be prepared. The test shall be terminated when any of the following conditions are observed:

6.6.1.1 If the engine fails to reach the rated speed within the specified test duration.

6.6.1.2 If the engine speed fails to stabilize for five minutes during testing.

6.6.1.3 If the machine is unable to continue operation after three attempts and all efforts have been exerted without replacing any major parts that can affect the performance of the machine.

6.6.1.4 If the test applicant voluntarily terminates the test.

7 Performance Test and Procedures

7.1 Operation of the machine

7.1.1 The engine shall be operated using the recommended setting of the manufacturer.

7.1.2 The test shall be conducted at full throttle for both spark-ignition and compression-ignition engines.

- 7.1.3 Performance data shall be obtained under stabilized normal operating conditions, with an adequate fresh air supply to the engine.
- 7.1.4 The angle of the connection of the shaft connecting the crankshaft to the dynamometer shall not exceed 2° .
- 7.1.5 The governor control shall be set for maximum power.
- 7.1.6 No data shall be taken until the speed has been maintained substantially constant at ± 10 rpm from the set speed for two minutes for at least three readings.
- 7.1.7 The engine speed during a run or reading shall not deviate from the selected speed by ± 10 rpm.
- 7.1.8 Observed torque, engine speed, fuel consumption, temperature, and sound emitted by the engine shall be recorded and shall in each case be the average of three stabilized values.
- 7.1.9 A performance curve, which shows output power, torque, fuel consumption, and specific fuel consumption shall be plotted against engine shaft speed at full throttle setting.
- 7.1.10 The temperature of the lubricating oil measured in the oil sump or at the outlet from the oil cooler, if fitted, shall be maintained within the limits established and provided by the engine manufacturer.
- 7.1.11 The exhaust temperature shall be measured at a point in the exhaust pipe/s adjacent to the outlet flange/s of the exhaust manifold/s.

7.2 Data collection

The performance requirements for maximum power, power at rated engine speed, varying speed at full load, varying load, and continuous running of the engine shall be measured in conformance with Chapter 4 (Codes) clause 2 (Engine Performance Test) of Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) Standard Codes for Testing of Power Tillers.

7.2.1 Maximum power test

- 7.2.1.1 The engine shall be operated at the speed where the maximum power occurs for a period of two hours subsequent to a warming-up period to reach stabilized running conditions. The power, torque, and fuel consumption shall be measured.
- 7.2.1.2 The maximum power quoted in the test report shall be the average of at least 6 readings made at regular intervals during a two-hour period. If the power

varies by more than ± 2 % from the average, repeat the test. If the variation continues, report the deviation.

7.2.2 Power at rated engine speed test

If maximum power does not occur at rated engine speed, an additional one-hour test shall be carried out.

7.2.3 Varying speed test at full load

Power, torque, and fuel consumption as a function of speed at full power shall be measured at approximately 10% speed increments. The minimum speeds at which the measurements are made shall be at the speed of maximum torque and, if possible, 15% below that speed.

7.2.4 Varying load tests

The power, speed, and fuel consumption at the values listed below of torque with the governor control set for maximum power at the rated engine speed:

- a) The torque corresponding to maximum power available at rated engine speed;
- b) 85% of the torque obtained in (a);
- c) 75% of the torque obtained in (b);
- d) 50% of the torque obtained in (b);
- e) 25% of the torque obtained in (b); and
- f) Unloaded [with the dynamometer disconnected if the residual torque is greater than 5% of the torque defined in (b)]

7.2.5 Continuous running test

The engine shall be run continuously for 5 hours. For the first 4 hours, the engine shall be run at 80 % of load (torque) corresponding to maximum power. During the last hour of the test, the engine shall be run at a load corresponding to maximum power. During the test, all the parameters specified in 7.2.1 shall be recorded after every half-an-hour during the first 4 hours and after every 15 minutes during the 5th hour.

7.2.6 Noise level

The sound emitted by the engine, shall be measured using a sound level meter 45° on the output shaft and 7.5 m away from the exhaust pipe at a height of 1.2 m from the ground during the continuous running test. There shall be no obstructions that may affect the measurement between the engine and the sound level meter. For each data to be taken, there shall be a minimum of three observations. The engine noise level shall be tested in a low-noise area where there are minimal to no noise disturbances that may affect the measurement of the noise level of the engine.

7.2.7 Speed of components

The speed of the output shaft of the engine expressed in rpm shall be measured using a tachometer. For each data to be taken, there shall be a minimum of three observations.

7.2.8 Fuel consumption

The fuel consumption shall be obtained using the appropriate fuel consumption meter. The fuel consumption shall be computed using the formula specified in Annex C (Formulas for calculations of test parameters).

7.3 Data recording and observations

Necessary observations and other parameters to be taken during the performance test should be recorded in a performance test data sheet as provided in Annex D (Performance test data sheet).

8 Formula

The formulas to be used during calculations and testing are given in Annex C (Formulas for calculations of test parameters).

9 Test Report

The test report shall include the following information in the order given:

- a) Name of testing agency;
- b) Test report number;
- c) Title;
- d) Summary of results;
- e) Purpose and scope of test;
- f) Methods of test;
- g) Description of the machine;
- h) Specifications;
- i) Results;
- j) Observations (include pictures); and
- k) Names, signatures, and designation of test engineers

Annex A
(Informative)

Minimum list of test equipment and instruments

| | Laboratory test equipment and instruments | Quantity |
|-------------|---|-----------------|
| A.1 | Sound level meter Range: 30 dB(A) to 130 dB(A) | 1 |
| A.2 | Stopwatch Maximum resolution: 0.1 sec | 1 |
| A.3 | Measuring tape Minimum length: 10 m | 1 |
| A.4 | Camera | 1 |
| A.5 | Vernier caliper Maximum resolution: 0.1 mm | 1 |
| A.6 | Weighing scale | 1 |
| A.7 | Graduated cylinder | 1 |
| A.8 | Tachometer | 1 |
| A.9 | Pressure gauge Maximum resolution | 1 |
| A.10 | Computer | 1 |
| A.11 | Fuel consumption meter | 1 |
| A.12 | Dynamometer | 1 |

Annex B
(Normative)

Specifications of engine

Name of Applicant : _____
 Address : _____
 Tel. No. : _____

Name of Manufacturer : _____
 Address : _____
 Tel. No. : _____

GENERAL INFORMATION

Make : _____ Type : _____
 Serial No. : _____ Brand/Model : _____
 Country of Manufacture/Origin : _____ Date of Manufacture : _____
 Testing Agency : _____ Test Engineer : _____
 Location of Test : _____ Date of Test : _____

| No. | Item ^a | Manufacturer's specification | Verification by the testing agency |
|------------|--|------------------------------|------------------------------------|
| 1 | Overall dimensions and weight | | |
| 1.1 | Length, mm | | |
| 1.2 | Width, mm | | |
| 1.3 | Height, mm | | |
| 1.4 | Weight, kg | | |
| 2 | Fuel ignition system | | |
| 3 | Fuel system | | |
| 3.1 | Type of fuel used | | |
| 3.2 | Type of fuel feed | | |
| 3.3 | Tank capacity, L | | |
| 4 | Cooling method | | |
| 5 | Cylinder arrangement | | |
| 6 | Valves and camshaft Arrangement | | |
| 7 | No. of combustion cycles | | |
| 8 | No. of cylinder | | |
| 9 | Cylinder dimension | | |
| 9.1 | Bore, mm | | |
| 9.2 | Stroke, mm | | |
| 10 | Displacement volume, cm³ | | |

| No. | Item ^a | Manufacturer's specification | Verification by the testing agency |
|--|---------------------------------------|------------------------------|------------------------------------|
| 11 | Maximum brake power at rpm, kW | | |
| 12 | Continuous brake power at rpm, kW | | |
| 13 | Lubrication System | | |
| 13.1 | Splash type | | |
| 13.2 | Forced-feed | | |
| 14 | Starting system | | |
| 14.1 | Rope recoil | | |
| 14.2 | Hand cranked | | |
| 14.3 | Electrically started | | |
| 15 | Governor system | | |
| 16 | Air Cleaner | | |
| 17 | Exhaust system | | |
| 18 | Safety features | | |
| 19 | Other attachments/ accessories | | |
| ^a The parameter will be checked upon availability | | | |

Annex C
(Normative)

Formulas for calculations of test parameters

C.1 Varying Load Test

C.1.1 Output Power, kW

$$P_0 = \frac{2\pi \times T \times N}{60 \times 1000} \quad (1)$$

$$P_0 = \frac{T \times N}{9549.2966} \quad (2)$$

where:

P_0 is the output power, kW
 N is the shaft speed, rpm
 T is the shaft torque, N-m

C.1.2 Fuel consumption, L/h

$$F_{ct} = \frac{F_v}{T_e}$$

where:

F_{ct} is the fuel consumption rate, L/h
 F_v is the total volume of fuel consumed, L
 T_e is the total time to consume the fuel, h

C.1.3 Specific Fuel Consumption, g/kWh

$$SFC = \frac{F_c \times \rho_f}{P_0}$$

where:

SFC is the specific fuel consumption, g/kWh
 F_c is the fuel consumption rate, L/h
 ρ_f is the density of fuel, g/L
 P_0 is the output power, kW

C.2 Continuous Running Test

The formulas, that are used during the calculation of maximum brake power, fuel consumption, and specific fuel consumption for continuous-running tests, are the same formulas used for varying load tests.

Annex D
(Normative)

Performance data sheet

Test Trial No. : _____ Test Applicant : _____
 Test Engineer/s : _____ Machine : _____
 Assistants : _____ Manufacturer : _____

D.1 Varying Speed Test

Date of test : _____ Location : _____

| Test Conditions | Test | Power, kW | Crank Shaft Torque, kg-m (N-m) ^a | Engine Speed, rpm | Fuel Consumption | | Temperature, °C | | | Atmospheric Conditions | | |
|-------------------------------|--|-----------|---|-------------------|---------------------------------|-----------------|-----------------|------------|---------|------------------------|----------------------|---------------|
| | | | | | Hourly, L/h (kg/h) ^a | Specific, g/kWh | Fuel | Engine oil | Coolant | Temp, °C | Relative Humidity, % | Pressure, kPa |
| Natural ambient test (Normal) | a) Maximum power test | | | | | | | | | | | |
| | b) Power at rated engine speed | | | | | | | | | | | |
| Natural ambient test (Normal) | Varying engine speed at full load i) ii) | | | | | | | | | | | |

| Test Conditions | Test | Power, kW | Crank Shaft Torque, kg-m (N-m) ^a | Engine Speed, rpm | Fuel Consumption | | Temperature, °C | | | Atmospheric Conditions | | |
|-------------------------------|---|-----------|---|-------------------|---------------------------------|-----------------|-----------------|------------|---------|------------------------|----------------------|---------------|
| | | | | | Hourly, L/h (kg/h) ^a | Specific, g/kWh | Fuel | Engine oil | Coolant | Temp, °C | Relative Humidity, % | Pressure, kPa |
| | iii) iv) v) vi) | | | | | | | | | | | |
| Natural ambient test (Normal) | Rated engine speed at Varying load i) ii) iii) iv) v) vi) | | | | | | | | | | | |

^a conversion to equivalent in unit in parenthesis may also be included, if necessary

Observations:

D.2 Continuous Running Test

Date of test : _____ Location : _____

| Test Conditions | Test | Power, kW | Crank Shaft Torque, kg-m (N-m) ^a | Engine Speed, rpm | Fuel Consumption | | Temperature, °C | | | Atmospheric Conditions | | |
|-------------------------------|---|-----------|---|-------------------|---------------------------------|-----------------|-----------------|------------|---------|------------------------|----------------------|---------------|
| | | | | | Hourly, L/h (kg/h) ^a | Specific, g/kWh | Fuel | Engine oil | Coolant | Temp, °C | Relative Humidity, % | Pressure, kPa |
| Natural ambient test (Normal) | Five hours engine rating test a) At load corresponding to 80% of maximum power (4 hr) i) ii) iii) etc. | | | | | | | | | | | |
| | At load corresponding to maximum power i) ii) iii) | | | | | | | | | | | |

^a conversion to equivalent in unit in parenthesis may also be included, if necessary

Observations:

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Internal Combustion Engine — Methods of Test**

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