PHILIPPINE NATIONAL STANDARD

PNS/BAFS 396:2024
ICS 65.060.01

Internal Combustion Engine — Specifications

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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) 116:2001 (Agricultural machinery — Small engine — Specifications). 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 internal combustion 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 116:2001:

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 provisions for the technical requirements of engine; and
5. Inclusion of “Engine breakdown/malfunction classification” and “Occupational safety and health standards (Rule 1074.01–1074.03)” as Annexes.

This Standard cancels and replaces PAES 116:2001 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.

Table of Contents

1 Scope

This Standard specifies the requirements for the manufacture and performance of fully equipped reciprocating internal combustion engines with up to 20 kW rating used for agricultural and biosystems purposes.

2 Normative References

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

Bureau of Agriculture and Fisheries Standards (BAFS)-Department of Agriculture (DA). (2022). Technical means for ensuring safety — Guidelines (PNS/BAFS 330:2022).

BAFS-DA. (2024). After-sales service — Guidelines (PNS/BAFS 192:2024).

BAFS-DA. (2024). Internal combustion engine — Methods of test (PNS/BAFS 397:2024).

BAFS-DA. (2024). Methods of sampling for agricultural and biosystems power and machinery — Guidelines (PNS/BAFS 391:2024).

BAFS-DA. (2024). Operator's manual for agricultural and biosystems power and machinery — Guidelines (PNS/BAFS 390:2024).

Occupational Safety and Health Center (OSHC)-Department of Labor and Employment (DOLE). (2020). Occupational safety and health standards. https://oshc.dole.gov.ph/wp-content/uploads/2020/02/OSH-Standards-2020-Edition.pdf

3 Terms and Definitions

For the purpose of this Standard, the following definitions shall apply:

3.1
cylinder bank
arrangement of cylinders in which the centerline of the crankshaft journals lies in or is parallel to the plane containing the center line of the engine cylinders, all cylinders being on the same side of the crankshaft (International Organization for Standardization [ISO], 2017)

3.2
engine cooling system
system which removes the heat flow from the elements exposed directly to the high temperature, preventing local overheating. At the same time, is responsible for maintaining the optimal operating temperature of the internal combustion engine (Śliwiński & Szramowiat, 2018, *modified*)

3.2.1
air-cooled
system wherein air is used to remove excess heat from the engine through metal fins or shrouds which are located around the cylinder thus creating the flow of air to the engine body to maintain its operating temperature (Agricultural Machinery Testing and Evaluation Center [AMTEC]-University of the Philippines Los Baños [UPLB], 2024)

3.2.2
liquid-cooled
system in which water/liquid-coolant serves as the cooling medium which circulates in the water jackets to absorb the heat of the engine to maintain its operating temperature (AMTEC-UPLB, 2024)
admitted term: water-cooled

3.3
engine
mechanism delivering shaft power by the conversion of fuel chemical energy into mechanical work during combustion in one or more cylinders in which working pistons reciprocate (ISO, 2017)
admitted term: reciprocating internal combustion engine

3.4
fuel consumption
quantity of fuel consumed by an engine per unit of time, expressed in liters per hour, L/h (ISO, 2017)

3.5
rated engine speed
engine speed specified by the manufacturer for continuous operation at full load, expressed in revolutions per minute, rpm (Centre for Sustainable Agricultural Mechanization [CSAM]-United Nations Economic and Social Commission for Asia and the Pacific [ESCAP], 2023)

3.6
specific fuel consumption
fuel consumption rate per unit of power output, expressed in grams per kilowatt-hour, g/kW-h (ISO, 2017, *modified*)

3.7
working cycle
complete series of changes in the parameters of the working medium (e.g., mass, volume, pressure, temperature) present in each cylinder of a reciprocating internal combustion engine, accomplished before repetition occurs (ISO, 2017, modified)
admitted term: operating engine cycle

3.7.1
two-stroke
working cycle which, for completion, needs two successive strokes of a working piston of a reciprocating internal combustion engine (ISO, 2017)

3.7.2
four-stroke
working cycle which, for completion, needs four successive strokes of a working piston of a reciprocating internal combustion engine (ISO, 2017)

4 Classifications

The classifications of an engine shall be based on, but not limited to the following:

4.1 Type of ignition system

4.1.1 Spark ignition engine

An engine where the combustion process is induced by the use of a spark plug. The spark plug gives a high-voltage electrical discharge between two electrodes which ignites the air-fuel mixture in the combustion chamber surrounding the plug.

4.1.2 Compression ignition engine

An engine where the combustion process is induced when the air-fuel mixture self-ignites due to high temperature in the combustion chamber caused by high compression.

4.2 Number of combustion cycles

4.2.1 Two-stroke

Engine which has a two-stroke cycle and two piston movements over one revolution for each cycle.

4.2.2 Four-stroke

Engine with a four-stroke cycle which experiences four piston movements over two engine revolutions for each cycle.

4.3 Valves and camshaft location

4.3.1 Side valve

An engine in which the valves are mounted in the crankcase at the side of the piston as shown in Figure 1. Also known as flat head, valves-in-block, and L-Head engine.

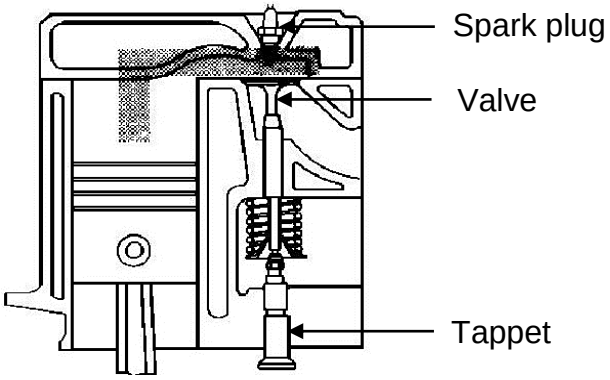

Figure 1. Side valve engine also known as flat-head and L-head engine (adapted from Shaikh, 2015)

4.3.2 Overhead valve

An engine in which the valves are mounted in the cylinder head and are opened by rocker arms as shown in Figure 2.

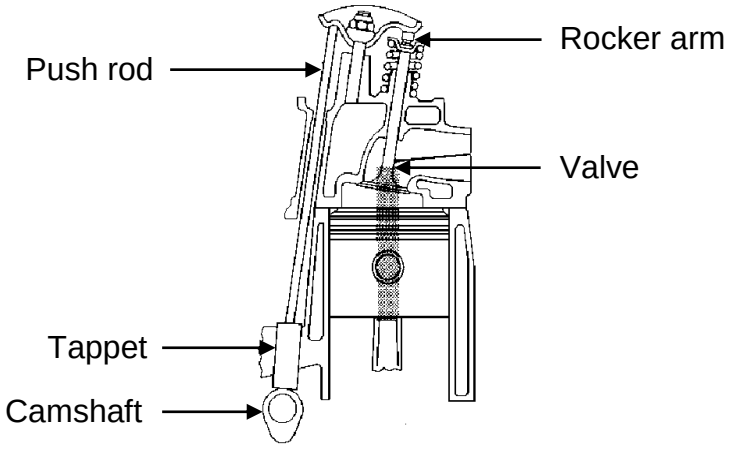

Figure 2. Overhead valve also known as I-head engine (adapted from Shaikh, 2015)

4.3.3 Single overhead camshaft (SOHC)

An engine with a single camshaft within the cylinder head serves to either directly control valve operation or through mechanical or hydraulic linkage (push rods, rocker arms, or tappets) for valve actuation as shown in Figure 3.

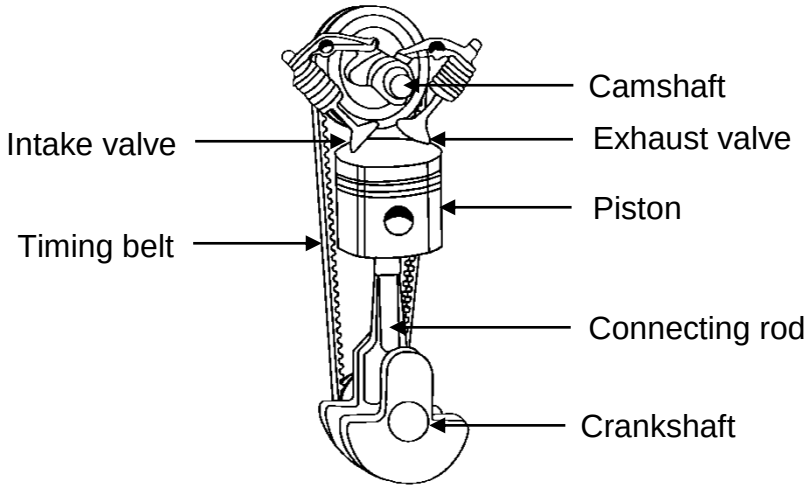

Figure 3. SOHC (adapted from Grayen, 2013)

4.3.4 Dual/Double/Twin-cam overhead camshaft (DOHC)

An engine with two camshafts that are located overhead as shown in Figure 4. It operated for various intake and exhaust valves since each header has two camshafts.

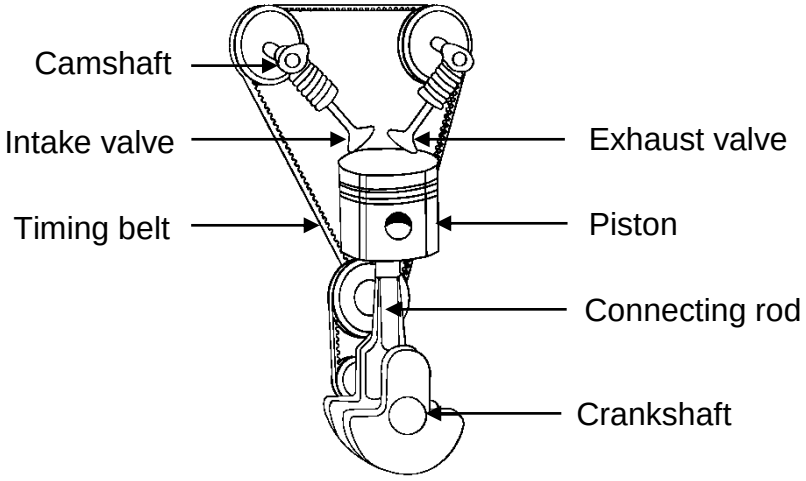

Figure 4. DOHC (adapted from Grayen, 2013)

4.4 Type of fuel used

4.4.1 Gasoline

An engine in which the combustion happens when fuel is mixed with air, compressed by pistons and ignited by sparks from spark plugs.

4.4.2 Diesel

An engine in which the air is compressed first, and then the fuel is injected. When it's compressed, air heats up and the fuel ignites.

4.4.3. Liquified Petroleum Gas (LPG)

An engine that utilizes LPG as fuel, commonly known as autogas which is either propane or a propane and butane mix.

4.4.4 Multifuel engine

An engine which uses gasoline or diesel oil for starting purpose and kerosene or biogas as primary fuel.

4.5 Cooling method

4.5.1 Air-cooled engine

An engine in which heat is carried away by the air flowing in and around the cylinder using cooling fins as shown in Figure 5.

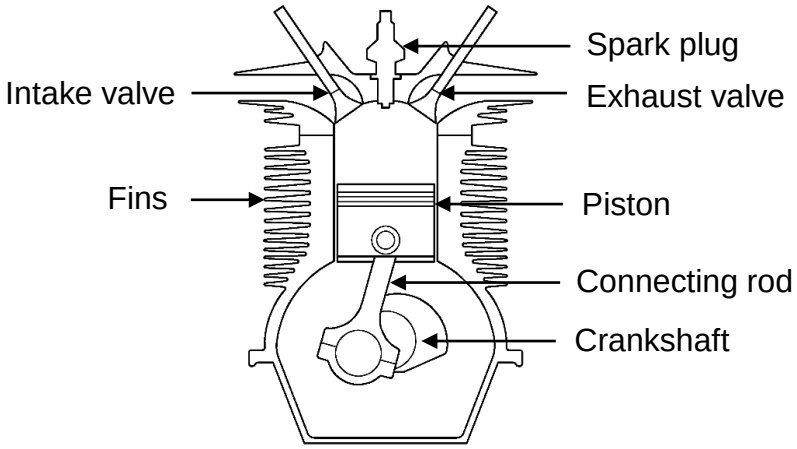

Figure 5. Air-cooled engine (adapted from Adenwala, 2018)

4.5.2 Liquid-cooled engine

An engine in which the cylinders and cylinder heads are directly cooled by liquid as shown in Figure 6.

NOTE The term “water-cooled engine” is also used when the liquid is predominantly water.

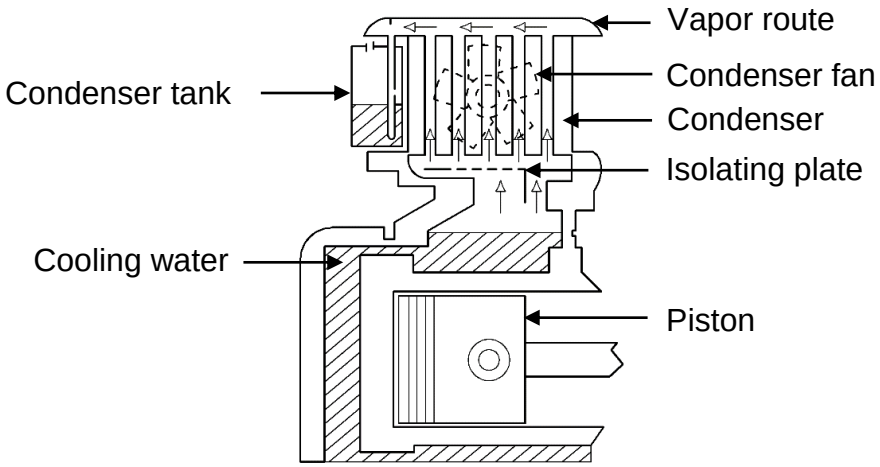

Figure 6. Liquid-cooled engine (adapted from Adenwala, 2018)

4.6 Position and number of cylinders

4.6.1 Single cylinder engine

An engine with one cylinder and piston connected to the crankshaft as shown in Figure 7.

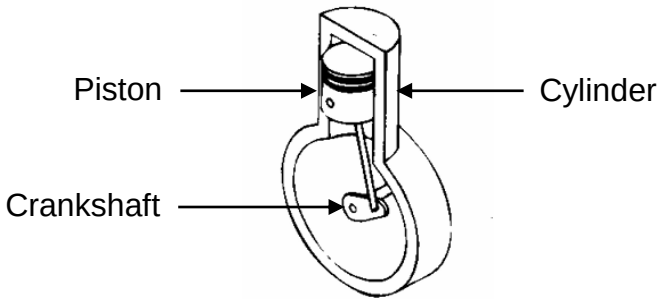

Figure 7. Single cylinder (adapted from Pulkrabek, 2004)

4.6.2 In-line engine

An engine in which cylinders are positioned in a straight line, one behind the other along the length of the crankshaft as shown in Figure 8.

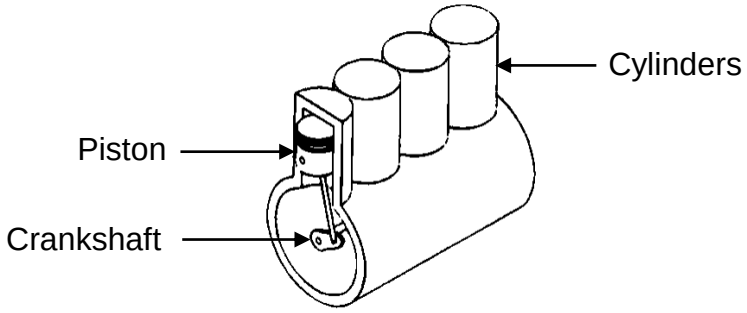

Figure 8. In-line cylinder (adapted from Pulkrabek, 2004)

4.6.3 V-type engine

An engine with two banks of cylinders at an angle with each other along a single crankshaft as shown in Figure 9. The angle between the banks of cylinders can be anywhere from 15° to 120°, with 60° to 90° being common. V engines have even numbers of cylinders.

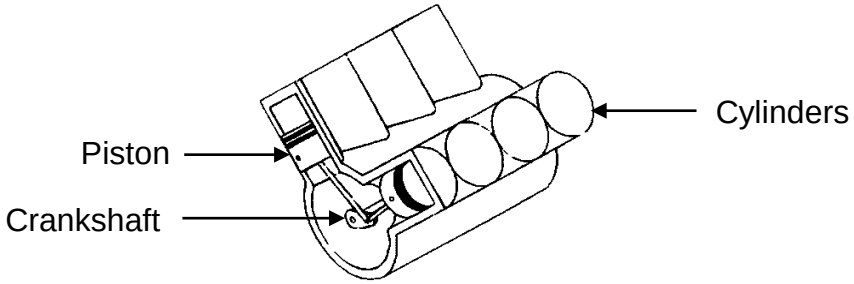

Figure 9. V-type cylinder (adapted from Pulkrabek, 2004)

4.6.4 Opposed cylinder engine

An engine with two banks of cylinders opposite to each other on a single crankshaft as shown in Figure 10. These engines are often called flat engines (e.g., flat four).

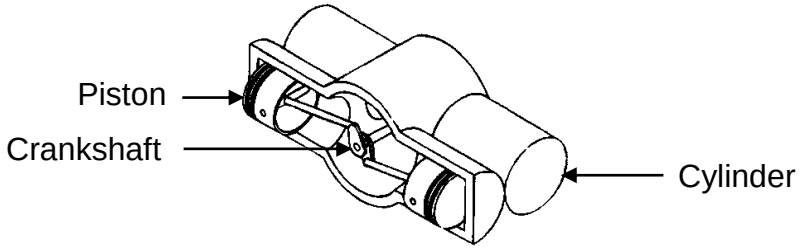

Figure 10. Opposed cylinder engine (adapted from Pulkrabek, 2004)

4.6.5 Opposed piston engine

An engine with two pistons in each cylinder with the combustion chamber in the center between the pistons as shown in Figure 11. A single-combustion process causes two power strokes at the same time, with each piston being pushed away from the center and delivering power to a separate crankshaft at each end of the cylinder. Engine output is either on two rotating crankshafts or on one crankshaft incorporating complex mechanical linkage.

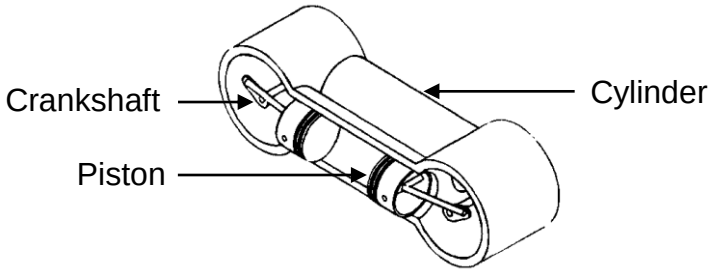

Figure 11. Opposed piston engine (Pulkrabek, 2004)

4.7 Orientation of cylinder

4.7.1 Vertical engine

An engine with one or more-cylinder banks each located in a vertical plane above its crankshaft as shown in Figure 12.

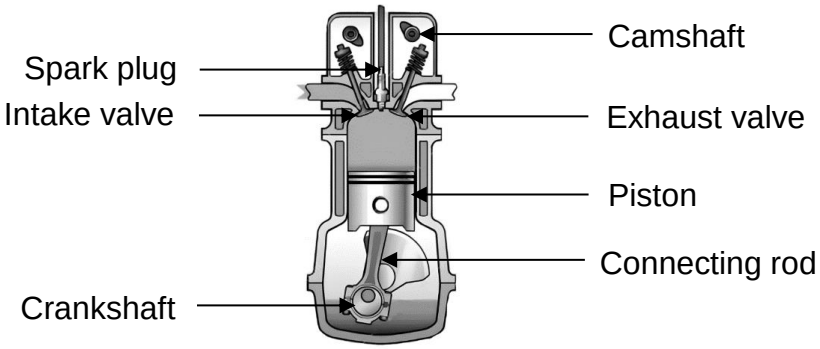

Figure 12. Vertical engine (adapted from Brain and Hall-Geisler, 2024)

4.7.2 Horizontal engine

An engine with one or more-cylinder banks each located in a horizontal plane as shown in Figure 13.

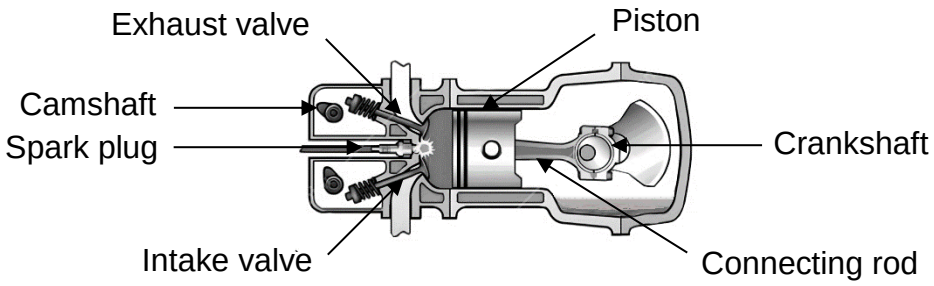

Figure 13. Horizontal engine (adapted from Brain and Hall-Geisler, 2024)

4.7.3 Inclined engine

An engine with one-cylinder bank which is located in an inclined plane lying between the vertical and horizontal planes through the crankshaft as shown in Figure 14.

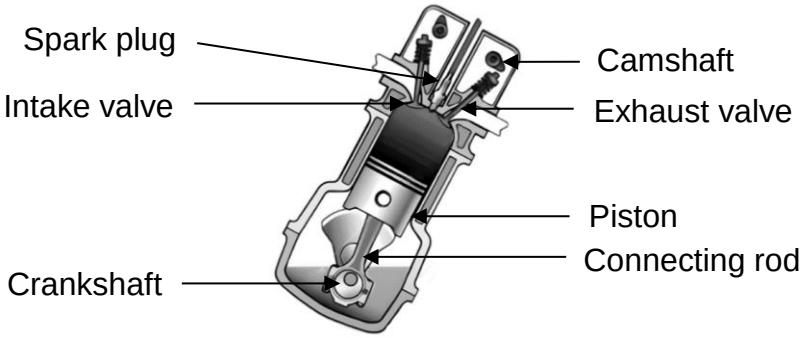

Figure 14. Inclined engine (adapted from Brain and Hall-Geisler, 2024)

5 Manufacturing Requirements

5.1 The base shall be durable and shall have provision for easy mounting of the engine.

5.2 For gasoline engines, spark plug wirings and terminal connectors shall be properly insulated with ethylene propylene diene monomer (EPDM) rubber, silicone, and/or other appropriate flexible and heat-resistant material.

5.3 The fill opening of the fuel tank shall be fitted with a fuel cap and strainer with mesh size according to the specifications of the manufacturer.

5.4 For a liquid-cooled engine, there shall be a provision for an automatic pressure relief valve with sensing mechanism to set the pressure and discharge fluid to acceptable levels to avoid overpressure and bursting.

6 Performance Requirements

6.1 At least 80% of the rated maximum output power specified by the manufacturer shall be attained during the varying load test.

6.2 The average specific fuel consumption during the 5-hr continuous running test shall not exceed 400g/kWh for gasoline and 350g/kWh for diesel engines.

6.3 The rated maximum power at rated speed (kW) and rated continuous power at rated speed (kW) as indicated by the manufacturer in the nameplate and/or in the operator's manual shall be attained.

6.4 The engine shall not have major breakdowns/malfunctions during the test. The classifications for minor and major breakdowns/malfunctions of an engine are shown in Annex A (Engine breakdown classification).

7 Safety, Workmanship, and Finish

7.1 The use of engine in terms of operator's exposure on permissible noise level shall conform to Rule 1074.01 to 1074.03 of Occupational safety and health standards of OSHC-DOLE as shown in Annex B (Occupational safety and health standard [Rule 1074.01– 1074.03]).

7.2 If the machine exceeds the noise level of 90 dB(A), an ear protective device shall be provided.

7.3 The engine should be equipped with a muffler and silencer to reduce the noise level of the machine.

7.4 For safety purposes, the operator should not be directly exposed to the exhaust of the engine.

7.5 The engine shall be free from defects that may be detrimental to its use and shall be free from sharp edges and surfaces that may harm the operator. All metal parts should be machine bent, pressed and cut and all rough surfaces should be machine finished and smoothed.

7.6 Any uncoated metallic surfaces shall be free from rust upon inspection.

7.7 Warning notices shall be provided in conformance with PNS/BAFS 330:2022 (Technical means for ensuring safety — Guidelines).

8 After-sales Service Requirements

Requirements for after-sales services shall be in conformance with PNS/BAFS 192:2024 (After-sales service — Guidelines).

9 Maintenance and Operation

9.1 Each unit of the pumpset shall be provided with a set of standard tools for operation and basic maintenance as prescribed by the manufacturer.

9.2 An operator's manual for the engine shall be provided in conformance with PNS/BAFS 390:2024 (Operator's manual for agricultural and biosystems power and machinery — Guidelines). The operator's manual shall include emphasis on the safety and health hazards especially the use of basic personal protective equipment.

10 Sampling

The engine shall be sampled for testing in conformance with PNS/BAFS 391:2024 (Methods of sampling for agricultural and biosystems power and machinery — Guidelines) or other suitable methods of selection validated by the testing authority.

11 Testing

The engine shall be tested in conformance with PNS/BAFS 397:2024 (Internal combustion engine — Methods of test).

12 Markings and Labeling

12.1 Each unit of the engine shall be engraved or embossed with the following information, either in the body of the engine or in a non-removable nameplate, attached in the clearly visible place:

a) Registered trademark of the manufacturer;
b) Brand;
c) Model;
d) Serial Number;
e) Manufacturer/importer/distributor Information:
    i. Name;
    ii. Address; and
    iii. Contact details
f) Country of manufacture/origin (if imported) / "Made in the Philippines" (if manufactured in the country);
g) Engine information:
    i. Rated maximum power at rated speed, kW; and
    ii. Rated continuous power at rated speed, kW

12.2 Basic safety and operation reminders shall be stated in the operator's manual.

12.3 Other marking and labeling should comply with the applicable regulations set by the competent authority.

Annex A
(Normative)

Engine breakdown/malfunction classification

A.1 Classification of breakdown/malfunction

The classifications of breakdown/malfunction shall be based on, but not limited to the following:

A.1.1 **Minor** – any irregularities in the unit that do not impact the performance of the engines. Any minor breakdown/malfunction that occurs two (2) times shall be considered major breakdown/malfunction.

Examples:

a) Loosened bolts and nuts connecting the muffler to the exhaust such that the bolts can still be refastened using basic hand tools;
b) Detached governor spring, as long as the spring can still be refastened to the unit;
c) Detached air cleaner;
d) Faulty spark plug; and
e) Snapped rope recoil

A.1.2 **Major** – any irregularities in the unit that lead the unit to shut down, stop operating, and impacts the performance of the engines.

Examples:

a) Detached muffler due to improper material fusion;
b) Detached muffler due to damaged inner threads;
c) Broken governor spring;
d) Overflowing carburetor;
e) Engine backfire resulting in flames;
f) Cracked crankcase or melted gasket;
g) Cracked radiator tank;
h) Cracked engine base due to engine vibration;
i) Deformed radiator tank due to overheating;
j) Engine hunting;
k) Broken governor spring;
l) Repetitive minor breakdown;
m) Engine shutdown due to problems in its internal mechanism (piston stuck up in the cylinder, broken connecting rod pins, failed lubrication system, etc.); and
n) Faulty transformer

Annex B
(Informative)

Occupational safety and health standards (Rule 1074.01–1074.03)

B.1 Threshold limit values for noise

B.1.1 The threshold limit values refer to sound pressure that represents conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech.

B.1.2 Feasible administrative or engineering controls shall be utilized when workers are exposed to sound levels exceeding those specified in Table B.1 hereof when measured on a scale of a standard sound level meter at slow response. If such controls fail to reduce sound within the specified levels, ear protective devices capable of bringing the sound level to permissible noise exposure shall be provided by the employer and used by the worker.

Table B.1. Permissible noise exposure (OSHC-DOLE, 2020)

Duration per day, h	Sound levels (slow response), dB(A)
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼	115

B.2 Permissible noise exposure

B.2.1 The values specified in Table B.1 apply to total time of exposure per working day regardless of whether this is one continuous exposure or a number of short-term exposures but does not apply to impact or impulsive type of noise.

B.2.2 If the variation in noise level involves maximum intervals of one second or less, it shall be considered as continuous. If the interval is over one second, it becomes impulse or impact noise.

B.2.3 When the daily noise exposure is composed of two or more periods noise exposure of different levels, their combined effect should be considered rather than the effect of each.

B.2.4 If the sum of the fraction in Equation 1 exceeds one, then the mixed exposure should be considered to exceed the threshold limit value. C indicates the total time exposure at a specified noise level, and T indicates the total time of exposure permitted at the level. However, the permissible levels indicated in Table B.1 shall not be exceeded for the corresponding number of hours per day allowed. Noise exposures of less than 90 dB(A) are not covered by Equation 1.

$$X = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \cdots + \frac{C_n}{T_n} \quad (1)$$

where:

X is the sum of the ratios of C and T
C is the total time of exposure at a specified noise level
T is the total time of exposure permitted at the level

B.2.5 Exposures to impulsive or impact noise shall not exceed 140 dB(A) peak sound pressures level (ceiling value).

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