



Standard Operating Procedures for Deployment of Liquefied Petroleum Gas (LPG) Retrofitted on Marine Fishing Vessels

DEPARTMENT OF FISHERIES
MINISTRY OF FISHERIES, ANIMAL HUSBANDRY AND DAIRYING
GOVERNMENT OF INDIA

YEAR 2024

TABLE OF CONTENTS

1.	BACKGROUND	
2.	SCOPE	4
3.	ABBREVIATIONS, DEFINITIONS & TERMINOLOGIES USED	5
4.	STANDARD OPERATING PROCEDURES.....	
4.1.	DESIGN AND SAFETY REQUIREMENTS OF LPG KIT.....	6-9
4.2.	CRITERIA FOR TESTING OF LPG KITS TOWARDS ACCEPTANCE	9-10
4.3.	ON-BOARD INSTALLATION ON FISHING VESSELS	10-11
4.4.	OPERATIONS.....	11-12
5.	EMISSION AND PERFORMANCE LEVELS.....	12
6.	RECOGNIZED AGENCY TO CERTIFY THE SAFETY OF LPG KITS	12
	ANNEXURE – I.....	13-14

1. BACKGROUND

- 1.1. As a proactive initiative of the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India for greening the Indian marine fisheries sector, the Department vide Order No. j-21001/14/2021-Fy-Part(1) dated 23.02.2024 has constituted an Expert Committee to promote use of low-cost alternate fuels such as Liquefied Petroleum Gas (LPG), Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG) in fishing vessels. Promoting use of such low cost fuel for fishing primarily is to support environmental sustainability by reducing the carbon emission in marine fisheries, savings in terms of fuel cost to the fishermen and also alleviates the problem of traditional fishermen for sourcing of kerosene, which is a restricted commodity.
- 1.2. This standard operating procedure is applicable only for LPG Kits and prepared as per the terms of reference of the aforesaid Committee. This standard operating procedure also intends to assist the relevant and recognized agencies for certification of the LPG Kits intended for fitment on fishing vessels.

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2. SCOPE

- 2.1. This standard operating procedure shall apply to design, manufacture, installation, operation, inspection, testing and fueling of retrofitted LPG kits intended for existing OBM engines & also for new OBM engines of marine fishing vessels.
- 2.2. This standard operating procedure is for internal combustion engines designed for outboard motor (OBM) applications intended for propulsion and running on petrol or kerosene fuel.
- 2.3. This standard operating procedure is not applicable for vessels engaged in activities other than marine fishing and also not applicable for kits designed for LNG/ CNG fuels.

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3. ABBREVIATIONS, DEFINITIONS & TERMINOLOGIES USED

3.1. ABBREVIATIONS

- (a) LPG – Liquified Petroleum Gas
- (b) LNG – Liquified Natural Gas
- (c) CNG – Compressed Natural Gas
- (d) OBM – Outboard Motor
- (e) AIS – Automotive Industry Standard
- (f) CMVR – Central Motor Vehicles Rules

3.2. DEFINITIONS & TERMINOLOGIES

- (a) AGENCY/ RECOGNIZED AGENCY: means an agency responsible for the particular aspect as recognized by the Central Government / State Government.
- (b) AUTOMATIC FUEL SHUT-OFF VALVE: means a device such as solenoid valve for shutting off the supply unless certain essential conditions exist.
- (c) BI-FUEL SYSTEM: A system equipped to operate with either on LPG or some other fuel e.g. petrol or kerosene.
- (d) GAS AIR MIXER: means a device for introducing gaseous fuel to the induction air of the engine.
- (e) LPG TANK: means cylinder meant for containing LPG to be used as fuel for the engine and approved for compliance to the specifications of latest BIS Standard IS 14899: *Liquefied petroleum gas (LPG) containers for automotive use - Specification.*
- (f) LPG KIT: means a complete system assembly from LPG tank to gas-air mixer for converting the engine to run on LPG. The kit needs to be duly tested and approved by concerned agency in a bi-fuel mode of LPG/gasoline or dedicated mode of LPG.
- (g) OUTBOARD MOTOR (OBM): means a propulsion system for boats/ fishing vessels, consisting of a self-contained unit that includes engine, gearbox and propeller or jet drive, designed to be affixed to the outside of the hull transom.
- (h) VAPOURISER/REGULATOR: means a device which vaporizes liquid LPG and reduces fuel pressure at a level appropriate for delivery to the gas-air mixer in case of liquid/vapor withdrawal system.

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4. STANDARD OPERATING PROCEDURES

4.1. DESIGN AND SAFETY REQUIREMENTS OF LPG KIT

4.1.1. General

- (a) All LPG appliances fed from LPG system shall be designed for use at the maximum working pressure.
- (b) Pipelines for LPG systems are, as far as practicable, to be of a single continuous length of solid drawn copper piping or drawn stainless steel piping from the LPG Tank housing or locker to the appliance or the shut-off valve.
- (c) The minimum wall thickness for piping shall be 0.6 mm for O.D. (outside diameter) less than or equal to 12 mm and 0.9 mm for piping greater than 12mm OD.
- (d) Piping shall not be of steel (other than stainless), aluminum, lead, plastic or other materials susceptible to either heat and/or corrosion.
- (e) The hoses used for supply of LPG from cylinder/tanks to the OBM unit should be metallic. Hose assemblies shall have permanently attached end fittings such as swaged sleeve or sleeve and threaded insert.
- (f) Pressure regulators shall not be capable of external manual adjustment.

4.1.2. **Filter:** At the termination of every LPG fuel line, immediately before entry to the LPG shut off valve, shall be fitted with a properly designed filter capable of removing all particulate matter from the fuel that could cause malfunction of shut-off valve or pressure regulator.

4.1.3. **Automatic fuel shut-off device:** This device shall be fitted between the filter and the inlet of the vaporizer/regulator. The device shall automatically act to prevent the flow of liquid into the vaporizer in case of liquid withdrawal or regulator in case of vapour withdrawal unless both the following conditions are satisfied.

- (i) The ignition is on.
- (ii) The engine is turning.

4.1.4. **Vaporizer and regulator or regulator system:** The system shall not permit gas to pass after the engine has stopped turning, irrespective of whether the ignition is on or off. This system shall be installed so that:

- (a) It is securely mounted and as close to the engine carburetor position as convenient.
- (b) It is easily accessible for routine maintenance, adjustment and inspection.
- (c) It is situated as far from the exhaust system as practical. Where this distance is less than 150 mm it shall be shielded from radiant heat and any impingement from exhaust gases due to exhaust system failure.
- (d) It is reasonably protected from impact in a collision.
- (e) It is adjacent to or connects directly with the LPG shut-off valve, any fuel line connection to which shall be kept as short as possible.

- (f) For liquid withdrawal system, the water circulating system (where required) is connected in accordance with the manufacturer's instructions, and no flow control valve in the system can shut-off original equipment water flow.
 - (g) Where possible, the vaporizer should not be at a level which may result in insufficiency of water and may cause freezing.
 - (h) It allows sufficient free movement of all hoses.
- 4.1.5. The **regulator assembly** shall not be attached to the engine assembly unless otherwise specified by the manufacturer and then shall be fitted only in accordance with the manufacturer's recommended instructions.
- 4.1.6. **Backfire Deflector:** Immediately prior to the mixer, a backfire deflector to arrest flash back, shall be installed in the air intake.
- 4.1.7. The **gas-air mixer** shall be securely mounted and when remotely fitted shall be suitably bracketed to support its own weight and applied working forces.
- There shall be no air filter element fitted downstream of the gas air mixer.
- 4.1.8. For **bi-fuel type kits** a shut-off device shall be installed in the bi-fuel system. This device shall shut-off the optional fuel supply to the engine when this fuel is not required.
- If the shut-off device is in the form of a solenoid operated shut-off valve, it must be fitted between the fuel pump and the carburetor.
- Where the shut-off device is mounted remotely from the engine, flexible hose of sufficient length shall be used to accommodate engine movement.
- In all cases the device shall be mounted in a position reasonably protected from damage in a collision and shall be as far as practicable from high tension electrical equipment.
- 4.1.9. **Bypass relief device:** A bypass relief device shall be installed in the fuel pump or between the fuel pump and the automatic shut-off valve in the liquid fuel line to the carburetor on engines equipped with bi-fuel systems for the use of petrol/kerosene and gaseous fuel. The relief device need not be installed on fuel pumps containing a bypass relief device as original equipment.
- 4.1.10. **Fuel selection control:** A fuel selection control shall be provided which shall be clearly marked for the selection of each of the two fuels.
- 4.1.11. **Electrical Wiring**
- (a) All wiring shall be properly installed, taped clipped or contained in a loom along its length.
 - (b) Wiring cables shall comply with the requirements of JIS C 3406 or equivalent standard. The kit manufacturer shall submit the test certificate/test report complying to these requirements.
 - (c) The electrical circuit shall be provided with a current limiting device. This equipment or fuse shall be dedicated to the LPG fuel system. A circuit breaker meeting these requirements is acceptable.
 - (d) Connectors and terminals shall be insulated to prevent accidental earthing during operations or routine servicing.

4.1.12 Other Safety requirements

- (a) Only appliances designated by the manufacturer for use with LPG in a marine environment shall be installed in the system. All appliances shall be fitted strictly in accordance with the manufacturer's instructions.
- (b) All connections in LPG pipeline are to be readily accessible.
- (c) Fittings for joints to piping shall be metallic, galvanically compatible with the piping and of the following types:
 - Hard soldered
 - Cutting ring fittings
 - Compression fittings of copper alloy with solid or thick-walled copper rings on copper piping
 - Stainless steel rings on stainless steel piping.
 - Joints shall be made without jointing compound on flared or compression fittings.
- (d) The LPG Kit should not be made of heat sensitive materials like aluminium, plastic or rubber.
- (e) Components such as Hose, Regulating Valve, Vaporizer, Safety Valves, Pressure Regulating station, Filter and Gauges are to be certified for LPG use by appropriate agency and documents regarding the same are to be verified.
- (f) Hoses of plastics materials such as Teflon or Nylon, (which are used for the purposes mentioned above), where reinforcement is not possible by incorporating closely woven integral wire braid are to have suitable reinforcing material as far as practicable. The rubber or plastic material hoses shall have external wire braid protection or metallic shield.
- (g) Each LPG system shall be provided with a pressure reduction system, located within the LPG Tank housing or locker, designed to provide a fixed working pressure suitable for the consuming appliances.
- (h) LPG systems should have an automatic safety gas cut-off device, located within the LPG Tank housing, which will shut off the supply of gas in the event of a loss of pressure in the supply line. This device should be of the manual resetting type.
- (i) Each LPG system shall:
 - have an over pressure device, located within the LPG Tank housing or locker, to prevent uncontrolled pressure in the low-pressure side;
 - be fitted with a readily accessible manually operated shut off valve in the supply pressure side, located within the LPG Tank housing or locker and which may be the LPG Tank valve.
- (j) A shut-off device shall be installed in the bi-fuel system. This device shall shut-off the optional fuel supply, *i.e. petrol/kerosene when want to operate on LPG or LPG when want to operate on petrol/kerosene*, to the engine when this fuel is not required.
- (k) All shut-off valves are to be clearly marked to indicate their function and the open and close positions.

4.2 CRITERIA FOR TESTING OF LPG KITS FOR ACCEPTANCE

- 4.2.1 LPG Kits lots are to be type tested as per below Procedure. The Conformity of Production (CoP) Procedure of the LPG Kit manufacturer is to be assessed and endorsed biannually by agencies recognized by the Central Government and/or relevant State Authorities.
- 4.2.2 Every LPG Kit manufacturer shall submit the LPG Kit to be manufactured by him for test by agencies recognized by the Central Government and/or relevant State Authorities for granting a certificate as to the compliance of provisions of Central Motor Vehicles Rules (CMVR).
- 4.2.3 An application for approval of LPG Kit shall contain the following information -
 - (a) the identity of the manufacturer and the country of origin of the LPG kit
 - (b) the specification to which the LPG kit is manufactured, and
 - (c) the quality control procedures adopted during manufacturing of the LPG kit.
- 4.2.4 The certification of the LPG kit may be revoked or the conditions of approval may be altered if the LPG kit or any component thereof is found to be unsafe in service or if the circumstances of use of the LPG kit or any component thereof alter those originally envisaged.
- 4.2.5 Inspection of the LPG Kit and components shall be carried out by the recognized agency, which shall also carry out a complete examination to ensure that the system complies with all relevant sections of these Procedures and any statutory requirements as specified by the Government of India. The components to be used by the kit manufacturers should be compliant with the requirements of the similar components for LPG kits as per the CMVR. Testing of the LPG Kit components is to be carried out as per the existing requirements of CMVR for similar components.
- 4.2.6 The LPG kit system shall be leak tested. For leak testing, the complete system shall be subjected to a pressure test using LPG or a gas inert to LPG such as nitrogen in accordance with the following procedure:
 - (a) Pressurize the system to a minimum pressure of 2.0 bar.
 - (b) Check all joints, components and drain plugs for leaks.
 - (c) Where a leak is indicated, the fault shall be rectified and system shall be re-tested for leaks.
- 4.2.7 In the case of bi-fuel installations, the ability of the LPG kit fitted engine to operate on the optional fuel shall also be tested.
- 4.2.8 Approval of Conformity of Production shall be performed in accordance with the latest requirements of AIS 037.
- 4.2.9 The performance and emission testing of the LPG kit upon installation on the engines shall be carried out as per the procedure mentioned in Annexure – 1.
- 4.2.10 Operational Performance: The operation of the LPG Kit shall be tested on-board fishing vessel under LPG at normal working pressure to prove satisfactory performance of the entire system and further leak test shall be carried out using a non-corrosive foaming agent. During performance test, the OBM engine parameters viz. exhaust gas

temperature, lube oil & cooling water temperature, etc. are to be monitored in order to ensure that they are within the OEM recommended ranges.

- The specification of LPG test fuel shall conform to IS:14861.
- The operation of engine with LPG fuel shall be tried out effectively to at least permanent list of 10° and permanent trim of 5°.

4.2.11 Fire Extinguisher: A 10 kg fire extinguisher conforming to IS:2171 of dry chemical powder type shall be kept ready at a safe distance at the time of performing the test. If ignition occurs, cut-off the LPG supply and the extinguisher be used to quell any fire.

4.3. ON-BOARD INSTALLATION ON FISHING VESSELS

- (a) There shall be no changes or modifications made by the kit manufacturers in the original engine components or architecture.
- (b) The safeties on LPG applications are to be tried out satisfactorily as per acceptable test protocol for trials.
- (c) Ensure that the lubrication oil to the engine is to be provided with filter.
- (d) Considering the condition for rolling & pitching for fishing boats, provision for adequate securing the LPG Tanks (including the spare or reserve tanks) on-board is to be made to make its connections intact with the on-board piping system. The securing arrangement should be made of metallic material.
- (e) The LPG Tanks shall comply to the specifications of latest BIS Standard IS 14899: *Liquefied petroleum gas (LPG) containers for automotive use – Specification* or equivalent acceptable national /international standards.
- (f) The LPG Tanks are to be given external anti corrosive painting.
- (g) LPG Tanks must be clearly marked with their contents and must be stored & used upright.
- (h) Appliances should be clearly marked for use for LPG systems.
- (i) Appliances shall be installed away from flammable materials and having regard to inadvertent contact of persons and materials with hot surfaces.
- (j) Compartments/enclosure containing LPG appliance should not have access doors or openings to accommodation spaces or their passageways.
- (k) Compartments/enclosure containing LPG appliance, which are situated on an open deck with direct access to the open deck and no opening direct to accommodation spaces or their passageways, should be adequately natural ventilated which will prevent a dangerous accumulation of gas.
- (l) Leak tests (using soap solution) of all joints in LPG circuit and performance of the LPG pressure regulator shall be done prior use upon installation. Soap solutions shall be non-corrosive and non-toxic.
- (m) The operation of OBM with LPG fuel shall be tried out effectively to at least permanent list of 10° and permanent trim of 5°.
- (n) After installation of the LPG Kits, the respective fishing vessels are to be appropriately labeled with “LPG” mark/sticker.

4.4. OPERATIONS

- (a) It is advised to conduct the soap solution test before every voyage and the pressure regulator be checked on monthly basis.
- (b) A suitable notice is to be displayed near the LPG Kit/ OBM unit stating (preferably in local language) that any action resulting in source of ignition like smoking, cooking, use of mobile or radiation frequency drives, etc. is strictly prohibited.
- (c) LPG systems should be checked for leakage, general condition and correct operation at least monthly. (recommendation to be given).
- (d) Most LPG vaporizer/regulators are made from non-ferrous alloys, which can suffer pinhole corrosion under certain conditions. This may lead to admission of LPG in to the cooling water system where it will pressurize the radiator and cause a potential hazard. Hence, it is advised to have an effective anti-corrosion additive in the cooling water. It is important to ensure that the coolant additive and the diluent ratio comply fully with the engine manufacturer's requirements.
- (e) LPG systems should be serviced by a competent person at least annually or as per recommendation from the LPG Kit manufacturer, whichever is earlier.
- (f) Always check the position of LPG tank valve (Close / Open) before starting the engine.
- (g) Ensure that the lubrication oil tank always contains the lubrication oil.
- (h) Where vaporizer heat is drawn from the engine cooling water, care should be taken to ensure that the water does not freeze in the vaporizer during cold weather. Expansion of the water on freezing can cause serious damage to the pressure regulator assembly.
- (i) Always ensure that the LPG tank is fitted in vertical direction by using proper securing arrangement.
- (j) Before starting outboard engine, always ensure that all the connections to the engine are proper.
- (k) Always close the LPG tank valve after use of outboard engine.
- (l) Do not get your LPG Kit serviced by any unauthorized person/entity and never try to repair the LPG system yourself.
- (m) Always follow maintenance schedule to check/ replace or repair the LPG system.
- (n) In the event of a smell of LPG leakages, kindly follow the guidelines provided by LPG Kit manufacturer. Visit the authorized dealer of the LPG Kit for further necessary checks & repairs.
- (o) In the event of a serious leak -
 - On no account should a naked flame be used to detect a leak.
 - Shut off the engines and any electrical equipment in the immediate vicinity and away from the LPG Tank until the gas hazard is removed.
 - Smoking or naked lights must not be allowed. Extinguish all heaters, lights, gas rings, stoves and boilers in the immediate vicinity.
 - Move all people to a safe distance from the leak in an upwind or crosswind direction.

- (p) In the event of fire, cut-off the flow of LPG and fight fires with dry powder type extinguisher.

NOTE:

5. Emission and Performance Levels and Recognized agency for its certification.

5.1 The Emission and Performance levels of retrofitted LPG Kit OBM should be at par or better than the respective Baseline results on Petrol and Kerosene fuel which is to be tested at International Centre for Automotive Technology (ICAT).

5.2 The LPG Kit supplier will get their respective Kits certified in respect of Emission and Performance Levels from International Centre for Automotive Technology (ICAT) located at *Technology Plot - 26, Sector - 3, IMT Manesar, Gurugram, Haryana – 122050*

6. Recognized agency to certify the safety of LPG kits:

6.1 The safety certification of LPG Kit retrofitted on marine fishing vessels is to be done by Indian Registrar of Shipping (IRS)/ any other certified agency of Directorate General of Shipping.

6.2 The LPG Kit supplier will get the safety certification for their respective Kits from Indian Registrar of Shipping (IRS) {located at 52-A, Adi Shankaracharya Marg, Opp. Powai Lake, Powai, Mumbai, India-400072; email: typeapproval@irclass.org contact No. +91 (022)-30519400, +91 (022) 71199400} or any other certified agency of Directorate General of Shipping.

7. The cost of testing and certification will be borne by LPG Kit supplier.

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Annexure – I

1. Emission and Performance Measurement:

1.1. Baseline Test: The engine(s) to be used for deployment of ALTERNATE FUEL kits shall be tested in baseline condition as per test procedure (mentioned in clause 2), which will be used as a reference to assess the performance and emissions of the alternate fuel kits.

1.2. Retro-fitment of alternate fuel Kits and performance and emissions evaluation: The alternate fuel kit manufacturer is required to perform the installation and instrumentation of the alternate fuel kit on the same engine used for baseline test.

2. Test Procedure

2.1 The engine is first coupled with the dynamometer, which consists of a base and a rotating torque flange. The engine's output shaft is connected to the torque flange via a driveshaft, allowing the engine to turn the torque flange. The torque flange is equipped with sensors that measure the engine's torque and speed output.

2.2 Once the engine is mounted, it is started up and allowed to warm up to its normal operating temperature. The dynamometer can simulate different load conditions by applying a controlled load to the engine via the torque flange. Subsequently the performance and emissions testing of the engine (in baseline and with fitment of alternate fuel kit) is conducted as per ISO 8178, Test Cycles E4 (for SI engines) and E1 (for CI engines) for testing of Marine Application Engines. The cycle details are mentioned in Table – I and II below.

2.3 Qualification criteria: When tested on the respectively applicable cycles as mentioned in clause 2.2, the alternate fuel kit fitted engine shall be qualified in the engine performance and emissions test if it meets the following criteria:

2.3.1 Performance characteristics: The net power produced by the engine fitted with alternate fuel kit shall not be less than 95% of the power observed for the same engine in baseline condition.

2.3.2 Emission characteristics: The weighted emissions [CO, HC, NO_x, CO₂ & PM (only on case of CI engine)] of the engine fitted with kit (in gm/kWh) when tested on the cycles mentioned in clause 2 shall be either same or better than the emissions of the engine in baseline condition. i.e, the weighted emission test results obtained in the alternate fuel kit fitted engine shall be lower or equal to the results of the engine as obtained during the baseline test.

Table – I
Applicable Cycle (for Spark Ignition Engines): E4

Mode Number	1	2	3	4	5
Speed, ^a %	100	80	60	40	idle
Torque, %	100	71.6	46.5	25.3	0
Weighing Factor	0.06	0.14	0.15	0.25	0.40

*Note: a is the declared Rated Speed

Table – II
Applicable Cycle (for Diesel Engines): E1

Mode Number	1	2	3	4	5
Speed, %	Rated Speed		Intermediate Speed		idle
Torque, %	100	75	75	50	0
Weighing Factor	0.08	0.11	0.19	0.32	0.3
