AMENDMENT NO. 2

TO

AIS-028 (Version - 3):

Code of Practice for use of CNG Fuel in Internal Combustion Engined Vehicles

1.0 Clause 3.1.2 :

Substitute following text for existing text.

"3.1.2 CNG fuel line and connections for use with pressures exceeding 100 kPa but less than 2.15 MPa shall be tested to a minimum burst pressure of 48 bar. The material of the flexible hose made up of synthetic rubber or composite materials like fiberglass, PTFE (Teflon) and steel braiding shall meet the requirements of SAE J30 R6 / R7 / R8 or ISO 15500 or equivalent standard, except testing on slab."

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THE AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA
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ON BEHALF OF
AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE

UNDER
CENTRAL MOTOR VEHICLE RULES – TECHNICAL STANDING COMMITTEE

SET-UP BY
MINISTRY OF ROAD TRANSPORT & HIGHWAYS
(DEPARTMENT OF ROAD TRANSPORT & HIGHWAYS)
GOVERNMENT OF INDIA

October 2011

AMENDMENT RECORD

This document contains AIS-024, AIS-028

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– **Amd. 1 to Version 3 : AIS-007 removed from the document : Effective from 02nd Aug. 2002**

– **Amendment No. 2 to AIS-024 (Version 3) : Effective from 1st June 2004**

– **Amendment No.3 to AIS-024 (Version 3) : Effective from 1st June 2004**

– **Amendment No.4 to AIS-024 (Version 3) : Effective from 1st October 2004**

– **Amendment No.5 to AIS-024 (Version 3) : Effective from 10th December 2008**

– **Amendment No.6 to AIS-024 (Version 3) : Effective from 1st December 2010**

– **Amendment No.1 to AIS-028 (Version 3) : Effective from 1st December 2010**

NOTE :

- **Amendment No. 2 to AIS-024 (Version 3) is shown in red colour underlined text.**

- **Amendment No. 3 to AIS-024 (Version 3) is shown in blue colour underlined text.**

AMENDMENT NO. 1
TO
AIS-028 (Version – 3):

Code of Practice for use of CNG Fuel in Internal Combustion Engined Vehicles

1. Clause No. 2.2.5: Refueling Interlock Device:

Substitute following text for existing text:

2.2.5 Refueling Interlock Device

Filling connections in motor vehicles shall be fitted with a system that prevents the engine starting when the dust plug or dust protection cap is removed. This system shall isolate the starting device of the vehicle. Any other system that isolates the engine starting shall be considered.

2. Clause No. 2.5:Cylinder installation, clause No. 2.5.1 (d) (vi)

Substitute following text for existing text:

(vi) Where the attachment is by means of clamping bands there shall be a positive means of resisting end loads on the cylinder by means of providing suitable end stoppers (Except for transverse mounted cylinders).

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December 2010

AIS 028:CODE OF PRACTICE FOR USE OF CNG FUEL IN INTERNAL COMBUSTION ENGINED VEHICLES

1. General

This code of practice may be called as " Code of Practice for Use of CNG fuel in Internal Combustion Engined Vehicles ". This code of practice is applicable for 2-wheeler, 3-wheeler, 4-wheeler, heavy motor vehicles and construction equipment vehicles (CEV).

1.1 Scope

1.1.1 This code of practice shall apply to the design, construction, installation, operation, maintenance, inspection, testing and fueling of compressed natural gas (CNG) systems where CNG is used either wholly or as bi-fuel for internal combustion engines. In general the Standard is directed towards vehicle installations.

1.1.2 It is not intended to cover the areas where major structural modifications are to be carried out to the vehicle (major structural modifications are those not defined in 1.1.4). Prior to commencement of such work guidance should be sought from the vehicle manufacturer.

1.1.3 Special circumstances exist for construction equipment vehicles with internal combustion engines. Accordingly a separate section is included to cover the special requirements of the construction equipment vehicles.

1.1.4 Any alterations or modification to any vehicle to install equipment shall be carried out in accordance with sound engineering practices and in compliance with Central Motor Vehicles Act 1988 and Central Motor Vehicles Rule, 1989 and their superseding amendment and notification issued thereafter. The following aspects shall be taken into consideration during alteration or modification:

Where modifications are made to:

(a) Suspension: mounting locations, geometry, ground clearance adjustment, axles and sub-axles, or steering mechanism
(b) Original fuel storage: the fuel tank assembly, fuel tank mounting, venting or filler assemblies.

NOTE – In some instances the fuel tank constitutes a structural member of the vehicle.

(c) Vehicle structure: Holes greater than 13 mm shall not be located within 40 mm of the edge of a panel, welded joint or direct load bearing point (such as a belt anchor). The only holes permitted greater than 13 mm diameter are of the installation of the filling valve or for venting purposes

(d) Braking system including the hand brake and components.
In this aspect, design guidelines supplied by vehicle manufacturers, vehicle safety standards of Indian or relevant standard, wherever applicable shall be referred.

NOTE- In case of the retrofitment, where modification types (a) (b) (c) and (d) are carried out to heavy motor vehicles these will require prior design approval from vehicle manufacturer.

1.2 **Approved equipment**
Only equipment and systems approved by the relevant Statutory Authority **/ Test Agency** shall be used.

1.2.1 This Standard is not intended to cover CNG fuel systems for the propulsion of marine craft.

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

APPROVED OR APPROVAL. Approved by or approval of the Statutory Authority.

AUTHORIZED PERSON. A person, normally an automotive workshop person, authorised by the vehicle manufacturer or the conversion kit manufacturer/kit supplier specially trained for installation, maintenance and periodic inspection of motor vehicle converted for bi-fuel or dedicated operation of internal combustion engined vehicles.

AUTOMATIC FUEL SHUT-OFF VALVE. A device such as solenoid valve for shutting off the fuel supply unless certain essential conditions exist.

COMPRESSED NATURAL GAS (CNG). A compressed gaseous fuel composed predominantly of methane (CH_4), shall be used as specified by the Government of India from time to time.

CONSTRUCTION EQUIPMENT VEHICLES. Means rubber tyred, including pneumatic tyre rubber padded or steel drum wheel mounted, self propelled, excavator, loader, back compactor roller, dumper, motor grader, mobile crane, dozer, fork lift truck, self loading concrete mixer or any other construction equipment vehicle or combination then designed for off-highway operations in mining, industrial undertaking, irrigation and general construction but modified and manufactured with “on or off” or “on and off” highway capabilities.

CYLINDER. A pressure vessel for storage of CNG for use as fuel for an internal combustion engine, approved **/ endorsed** by Department of Explosives under Gas Cylinder Rules,1981 as amended from time to time.

CYLINDER VALVE. A manually controlled shut-off valve fitted on the cylinder which can open or shut off the CNG supply and which incorporates a burst disc backed with a fusible material, approved **/ endorsed** by Department of Explosives under Gas Cylinder Rules, 1981 as amended from time to time.

DEDICATED ENGINE **(for diesel engine conversion only)**. An engine operating on gaseous fuel only.

DOWNSTREAM. Is the direction in which the stream flows.

EXCESS-FLOW VALVE. A valve normally in the open position which closes automatically in the direction of flow for which it is designed, when a predetermined flow limit is exceeded.

EXCESS PRESSURE DEVICE. An automatic pressure relieving device.

GAS-AIR MIXER. A device for introducing gaseous fuel to the induction air of the engine.

HEAVY MOTOR VEHICLE. A vehicle for either goods or passenger services as defined under the Central Motor Vehicle Rules (CMVR) as applicable.

NON-RETURN VALVE. A valve, which permits fuel flow in one direction only.

PRESSURE. Pressure refers to gauge pressure.

PRESSURE INDICATOR. A device to indicate the pressure of gas in the cylinder.

REGULATOR. A device which reduces fuel pressure to a level appropriate for the delivery to the gas-air mixer.

SERVICE FUEL LINE. The fuel line running from the storage cylinder and terminating at the regulator.

SERVICE SHUT-OFF VALVE. A manually operated shut-off valve fitted on the cylinder, which can open or shut off the CNG supply for maintenance, servicing or emergency requirements.

SHALL. The word "shall" is used to indicate a requirement that must be adopted to comply with this Standard.

SHOULD. The word "should" is used to indicate a recommended practice.

SHUT-OFF VALVE: A valve for stopping gas flow.

STATUTORY AUTHORITY. The Government Department or agency responsible for the particular aspect (See Appendix B).

UPSTREAM. Is the direction against the flow of the stream.

1.4 Special requirements

The fitment of a CNG fuel system shall be prohibited in any vehicle with a passenger compartment heating system, which draws air from the engine compartment unless the heating system is made inoperable and gas-tight to the passenger compartment.

2. CYLINDER

2.1 Design approval

2.1.1 Cylinders shall be approved **/ endorsed** by the Department of Explosives as per Gas Cylinder Rules, 1981, as amended from time to time.

2.1.2 The weight of the CNG cylinder(s) will affect the **unladen** weight of the vehicle and therefore consideration of the effect on the legal and manufacturer's rating and axle loadings should be considered.

2.1.3 In no circumstances shall the vehicle's critical load distribution affecting safety considerations be compromised.

2.1.4 Cylinders shall be re-tested as per Gas Cylinder Rules, 1981,as amended from time to time.

2.2 Fittings on cylinders and filling connection

2.2.1 Cylinder valve

Each cylinder shall have a manual cylinder shut off valve mounted directly on it capable of shutting off all gas flow from that cylinder**.** Cylinders and shut-off valve assemblies shall be approved **/ endorsed** by the Department of Explosives, as per Gas Cylinder Rules, 1981, as amended from time to time.

2.2.2 Filling Connection

The filling connection shall be of the NZS/NGV-1 or any other type as specified by the Government of India from time to time
The basic dimensions for NZS type are as given in Appendix D and recommended sizes of NGV – 1 type of filling connection are SAE 9/16" and 7/8". However, the vehicle manufacturer / kit installer may seek the guidance from The Gas Authority of India Ltd. / Ministry of Petroleum and Natural Gas about the use of specific type of NGV – 1 nozzle.

2.2.3 The NZS type filling connection shall be provided with a captive dust plug and NGV-1 type filling connection shall be provided with dust protection cap.

2.2.4 Position of filling connection

The filling connection shall be located in suitably protected and ventilated location, usually the engine compartment, and shall comply with the following:

(a) The filling connection is made and filling is supervised from outside the vehicle. The filling connection may be made only if the method of access to it from outside does not result in the opening of a vapour path to the interior of the vehicle, thereby negating the effectiveness of a compartment or sub-compartment.

(b) The filling connection is protected by being located in a recess below the surface of a body panel, or by being located so that equivalent protection is provided by the construction of the vehicle.

(c) The filling connection shall be attached to motor vehicle in such a manner as to resist, without permanent deformation of the mounting attachment, a proof load of 50 kgf applied in the forward and reverse directions of travel of the vehicle.

The proof load shall be applied by full engagement of the filling connection and shall be representative of attempted movement of the vehicle while refueling.

(d) The filling operation can be carried out without requiring the operator to lie or crawl under the vehicle or be otherwise subjected to inconvenience, discomfort or hazard.

2.2.5 Refueling Interlock Device

Filling connections in motor vehicles shall be fitted with a system that prevents the engine starting when the dust plug or dust protection cap is removed. This system shall isolate the starting device of the vehicle.

2.2.6. Non-return valve

There shall be a non-return valve fitted on the refueling line to prevent the return flow of gas from the cylinder to the filling connection. The non-return valve shall be located as close to the filling connection as it is practicable.

2.2.7 Excess flow valve

A device may be fitted in the fuel line preferably at the outlet of the cylinder valve which prevents the total contents of the cylinder from discharging to atmosphere in the event of rupture to any part of the fuel line or components.

2.3 **Location, Ventilation and Mounting of Cylinders**

2.3.1 Cylinders, Fittings and Pipe work

2.3.1.1 Cylinder shall be mounted in a protected location inside the perimeter of the vehicle. Cylinders shall not be located so that the vehicle driving characteristics are adversely affected.

2.3.1.2 For externally mounted cylinders:

In no case shall cylinder valves be positioned less than 200 mm from the extremities of the vehicle unless they are protected to minimize the possibility of damage due to collision, overturning or other accident.

Where the operation of the vehicle is such, that the **cylinder** will be subjected to impact damage from loose metal or other objects being thrown up from the road, effective shielding against these shall be provided.

2.3.1.3 The cylinder shall be situated and vented so that any gas escaping due to leakage from the cylinder valve shall not enter the vehicle passenger compartment or driver space.

2.3.1.4 The clearance between the cylinder the exhaust shall not be less than 75 mm.

2.3.1.5 For Heavy Motor Vehicles Only

2.3.1.5.1 In the case of heavy motor vehicles, the number of cylinders likely to be required will be of sufficient weight to affect the legal maximum vehicle weight constraints. The effects of the chosen position of the cylinders on the following criteria must be assessed, and if necessary, a reduction in the allowable payload of the vehicle under study be considered.

(a) The original manufacturer's maximum design axle loadings.
(b) The maximum allowable axle loadings.
(c) The maximum gross vehicle weight and/or gross combination weight allowed by the original manufacturer.

A number of alternative cylinder mounting positions may have to be considered in order to minimize the effects mentioned above. The effects of removing or replacing existing diesel fuel tanks on weight distribution of the vehicle should also be taken into account in the above calculations.

NOTE- Vulnerability of cylinders and fittings to damage during loading and unloading of the vehicle or load shift or spillage shall be taken into account.

2.3.2

(a) **Cylinder shall not be fitted in any position behind the driver seat (seat adjusted to rear most position), which will hinder the driver seat adjustment unless specifically approved by the testing agency.**

(b) **Cylinder shall not be fitted in a position beneath the vehicle that decreases the effective ground clearance.**

(c) **In case of heavy vehicles (bus having more than 3.5 GVW), for fitment of cylinders on roof, the strength of roof shall be validated by testing agency based on design calculation provided by vehicle manufacturer / kit manufacturer / kit supplier.**

(Refer to fig. 1 for 4-wheeler below 3.5 tonnes GVW)

2.3.3 Vehicle mounted cylinders

2.3.3.1 A cylinder installed in a vehicle shall be permanently mounted and filled in that position.

2.3.3.2 Cylinder location ground clearance

Cylinders shall be located in accordance with all the following requirements:

(a) The vehicle mass for determining ground clearance shall be the laden mass, including permanent non-standard attachments to the vehicle with all fuel, water and oil containers full.
(b) Cylinders installed between and behind axles shall not be lower than the lowest of the following points and surfaces forward of the **cylinder** (refer figure 1 for 4-wheeler below 3.5 tonnes and figure 2 for 4-wheeler and above exceeding 3.5 tonnes GVW):
    (i) The lowest structural component of the body
    (ii) The lowest structural component of the frame or sub-frame, if any
    (iii) The lowest point of the engine
    (iv) The lowest point on the transmission (including the clutch housing or torque converter housing as applicable) but excluding differential housings.
    (v) The original fuel tank or tanks and or brackets
    (vi) Approach and departure clearances shall be below planes defined in figure 2 (for 4-wheeler and above exceeding 3.5 tonnes GVW).
    NOTE- Suspension spring U bolts are not classified as structural components.

(vii) In any case the lowest point of the cylinders shall not be lower than a horizontal line taken at the lowest point of the front and rear wheel rims (line AB in figure 2) (for 4-wheeler and above exceeding 3.5 tonnes GVW).

(c) Ramp angle (for 4-wheeler below 3.5 tonnes GVW)
The cylinder(s) shall not be lower than a point defined by a ramp angle of 17 deg. (Refer Appendix F for calculation).

To calculate ramp angle the following measurements shall be taken (refer fig. 1):

(i) A plane through the centre line point of road contact of the front wheel (B), sloping upward to contact the lowest structural point of the vehicle midway between the axles (A) (line AB in fig 1); and

(ii) A plane sloping from point (A) defined in (i) downward to the centre line point of road contact of the foremost rear axle wheel (C) (line AC in Fig. 1).

(d) Departure angle (for 4-wheeler below 3.5 tonnes GVW)
(i) The cylinders shall lie within an area C-D in fig. 1.
(ii) When calculating departure angle the measurement shall be taken along angular plane tangential to the centre line point of road contact of the rear most axle wheel sloping upward and outward to the extremity of the permanent body work or original equipment bumper bar whichever is the lower**.**

(e) All clearances shall be measured to the bottom of the cylinder or to the lowest fitting, support or attachment on the cylinder or cylinder housing, whichever is lowest.

2.3.4 Internal cylinders

Where a cylinder is located within the body shell of a vehicle, either:

(a) The whole body of the cylinder together with its attached components and fittings shall be enclosed in a compartment; or

(b) The valves and pipe connections associated with or attached to the cylinder shall be enclosed in a localized sub-compartment, which is attached to the cylinder and vented to the atmosphere.

Provision shall be made for ready access to the cylinder valve in all installation arrangements.

NOTE - The luggage boot of a car is not considered to be acceptable as a cylinder compartment under (a) above, because of difficulties concerning effectiveness of sealing, the maintenance of ventilation openings, and the presence of electrical equipment in most boots.

2.4 Construction of compartments and sub-compartments

2.4.1 A cylinder compartment or sub-compartment shall comply with the following requirements:

(a) Construction shall be such that any gas which might leak from any fittings, component or piping, can not pass to any other enclosed compartment, passenger space or luggage space of the vehicle

(b) When a sub-compartment has been subjected to hydrostatic internal pressure of 30 kPa applied for 5 min, sealing materials or gaskets shall not be displaced or otherwise lose integrity during the test.

(c) Hatches, covers, or construction joints, which may need to be opened or dismantled during maintenance or inspection shall be capable of being opened at least 10 times without adverse effects on durability. Hinges and locking devices of hatches and covers shall be designed to prevent the dislodgment of the hatch or cover when in the closed and locked position.

(d) The construction shall be such that when subjected to a pushing force of 60 kgf applied at any point on any external face of the sub-compartment, any resultant damage shall not be of a nature to permit gas leakage in the event of pressure testing as in (b) above. The pushing force shall be applied by a measuring instrument having a flat circular face of 20 mm diameter.

(e) It shall be possible to operate the cylinder service shut-off valve in the installed position. The valve may be arranged so that it can be operated from some internal area of the vehicle provided that the sealing of the compartment or sub-compartment shell is maintained by one of the following means, as appropriate:

  (i) If a valve actuating device passes through the shell a gas-tight seal shall be provided.

  (ii) If the actuating handle is wholly within the shell, access shall be a gas-tight captive hatch. The design shall not need tools to open the hatch.

(f) A compartment or sub-compartment shall not contain ignition sources or electrical equipment or wiring unless it is intrinsically safe.

NOTE – Items (b), (c) and (d) are intended to be the basis of approval for proof of design**.**

2.4.2 Ventilation

One or more vents to the outside of the vehicle shall be provided, the aggregate area of which is not less than 550 mm^2 for vehicles other than 2- &3-wheeler and 250 mm2 for 2- & 3-wheelers. The vents shall be so located as to exhaust any gas, which may accumulate in the compartment or sub-compartment to atmosphere and shall exit not less than 75 mm from an exhaust pipe or other heat source. (Refer also to 2.4.3 (c)). Holes for venting shall be positioned not less than 40 mm from the edge of a panel or a welded joint or direct load bearing point (refer also to 1.1.4(c)).

2.4.3 Ducting

2.4.3.1 All piping or hoses that pass through an enclosed area of the vehicle shall be within a conduit gas-tight from the vehicle interior, vented unobstructed to outside atmosphere and protected from external damage and shall comply with the following requirements:

(a) The ducting shall be as short as practicable.

(b) The connections shall be mechanically clamped and shall not depend on adhesives or sealing compounds to retain them in place. Protection in the form of a gasket shall be provided to prevent damage to the ducting material by the clamping device.

(c) The material of the conduit used for ducting shall be sufficiently strong to resist mechanical damage, preserve venting integrity, protect the piping or hose within it, shall not support combustion and shall meet the following minimum criteria:

(i) The conduit shall withstand an internal pressure of 30 kPa.

(ii) The conduit shall not suffer sufficient damage to permit leakage when tested by applying a 60 kgf static force applied through 20 mm diameter, in the following manner.
(1) Applied to a free length of conduit (minimum length of 500 mm).
(2) With the conduit connection clamped up in position the force then applied 5 mm from the end of this coupling so as to place the connection in tension.

(iii) Flammability. The material shall conform to SAE J 369a class SE/NBR

(iv) Presence of resistance to ultraviolet degradation agent shall be confirmed.

NOTE – Item (c) shall be the basis of approval for proof of design of the conduit.

2.4.3.2 Pliable material
A sub-compartment may be constructed of pliable material attached to the cylinder so that the cylinder valve, piping and connections are contained within the sub-compartment. The pliable material shall meet the requirements of this clause and shall be clearly marked accordingly.

2.4.3.3 Where the sub-compartment is removed to initiate repairs or at the periodic inspection special attention shall be given to the inspection of the material to ensure that no degradation of material has taken place. Any sub-compartment showing signs of degradation shall be replaced.

2.4.3.4 The cylinder valve actuating device position shall be clearly identified and shall have provided adequate material to allow closing of the valve without damage to the sub-compartment sealing.

2.4.3.5 The pliable sub-compartment shall be shielded or installed in a protected location to prevent damage, from unsecured objects and abrasion and:

(a) The material shall be sufficiently strong to resist mechanical damage, preserve venting integrity, shall not support combustion and shall meet the following minimum criteria:
(i) Resistance to cold cracking. The material shall withstand a bend of 180º applied within 0.5 seconds around a 6 mm diameter former at temperature of –35ºC without cracking.
(ii) Flammability. The material shall conform to SAE J369a class SE/NBR.
(iii) Presence of resistance to ultraviolet degradation agent shall be confirmed.

NOTE – Item (a) shall be the basis of approval for proof of design.

2.5 Cylinder(s) installation
(For Construction Equipment Vehicles refer clause (9))

2.5.1 **Attachment to vehicle (refer also to 2.5.1(e))**
Cylinders shall be securely attached to the vehicle to prevent slipping, rotating and jarring loose, in accordance with the following requirements:

(a) The method of attachment shall not cause undue stresses or wear in the cylinder shell;

(b) The mounting method shall not significantly weaken the vehicle structure, and reinforcement shall be added where necessary to ensure compliance with (c) below. An air gap of not less than 5 mm shall be provided between the cylinder and vehicle structure;

(c) The force necessary to separate the cylinder from the vehicle shall not be less than 20 times the mass of the full cylinder in any direction.

The strength of the anchorages may be established by static test (forces directed through the centre of mass of the cylinder).

(d) In the absence of testing or where calculations are impracticable, the following design requirements shall apply:

(i) There shall be at least 4 points of attachment to the vehicle structure. The spacing between these shall be sufficient to ensure the stability of the cylinder.

(ii) Where a cylinder is anchored to steel sheet metal the sheet metal shall be reinforced by a plate of not less than 3600 mm^2 and a thickness of not less than 2.5 mm or appropriate thickness supported by the calculation or test report. It is preferred that a round washer be used but where a square plate is fitted the corners shall be radiused. Any such reinforcement plate/washer shall be contoured to the shape of the sheet metal or chassis rail.

Table 1

Cylinder size (water capacity in ltrs.) Over, up to and including L	Band dimensions – Minimum nominal size (mm)	Bolt or stud diameter for strap or flange mountings minimum nominal size (mm)
0 -30	30 x 2	10
30-100	30x3	10
100 150	50 x 6	12
Above 150	Specific design required	--

(iii) Where anchorage bolts pass through a hollow section, provision shall be made to prevent collapse of that section under load.

(iv) Anchorage bolts or studs shall have a diameter not less than that shown in table 1 and shall conform to strength grade 8.8, IS:1364 or equivalent ISO:4014 with nuts to IS:1364 or ISO:4032.

(v) Where clamping bands are used, at least two steel bands per cylinder shall be provided, the dimensions, of which shall not be less than those in table 1.

To prevent possibility of external corrosion where clamping bands are used a non-moisture retaining hard rubber or equivalent material shall be provided on the inner side of the bands. Similar adequate protection to the cylinder shall also be provided wherever the cylinder rests against other metal objects such as the mounting frame.

(vi) Where the attachment is by means of clamping bands there shall be a positive means of resisting end loads on the cylinder by means of providing suitable end stoppers.

(vii) Screwed fasteners or clamping devices shall either be inherently resistant to loosening or be locked or pinned after tightening.

(e) The chassis of heavy motor vehicles can be subjected to considerable torsional and bending deflections even under normal operating conditions. Mounting of cylinders to chassis rails must take these deflections into account and the cylinder mounting method chosen must not unduly prevent these deflections occurring.

In addition, many chassis manufacturers specifically prohibit the welding of attachment points to their chassis members and in some cases also prohibit the drilling of additional mounting holes in the chassis members. For any proposed chassis modification due consideration must be given to the particular chassis manufacturer's restrictions with respect to welding, drilling and sealing of existing holes. Advice on these matters can be obtained from the chassis manufacturer.

2.5.2 Cylinder manifolding
Where more than one cylinders is fitted to a vehicle it is preferable the cylinders be manifolded together in such a way that all can be simultaneously filled from any fill point on the vehicle. Each cylinder shall retain its required individual **cylinder** valve**.**

2.5.3 More than one cylinder
Specific design may be required for the mounting attachment. Refer also 1.1.4.

2.5.4 Cylinder identification markings should be capable of being read when in the installed position.

2.6 Shielding

2.6.1 Cylinders shall be installed to ensure that valves and connections on cylinders shall be protected to minimize the possibility of damage due to accidental contact with stationary objects or from loose objects thrown up from the road. Valves shall be protected to minimize the possibility of damage due to collision, overturning, or other accident. Parts of the vehicle may be used to provide such protection to valves and fittings.

3. CNG FUEL LINE

3.1 CNG fuel line - pressure exceeding 100 kPa (high pressure fuel line)

3.1.1 Rigid piping and connections for use with pressures exceeding 2.15 MPa shall be steel piping for use with CNG, shall have a minimum burst test pressure of 70 MPa and effectively protected against corrosion for 24 hours in accordance with ASTM B 117 or equivalent.

3.1.2 CNG fuel line and connections for use with pressures exceeding 100 kPa but less than 2.15 MPa shall be tested to a minimum burst pressure of 48 bar. The material of the flexible hose shall meet the requirements of SAE J30 R6 / R7 / R8 or **ISO 15500 or** equivalent **standard, except testing on slab**.

3.1.3 Flexible hose exceeding 2.15 MPa
Flexible hose shall meet the following requirements.

3.1.3.1
Flexible hose shall meet SAE 100R1 (except impulse loading test **and testing on slab**) or equivalent. Each flexible hose assembly shall be permanently and clearly

marked with the manufacturer's name and trademark, type, size and design working pressure. It shall be identifiable as being suitable for CNG use either by marking it with "CNG" or with a specification mark.

3.1.3.2 Ageing Test

When hose is aged for 72 hrs at 125 ± 2 deg C and then tested in accordance with IS:3400 for the tensile strength and elongation at break of the lining and cover shall not vary from the corresponding pre-determined unaged values by more than 40%.

3.1.3.3 Installation

3.1.3.3.1 The hose shall be supplied and fitted as a fully made up assembly and proof tested to not less than 27.5 MPa with fittings attached prior to installation.

3.1.3.3.2 In addition to the requirements of 3.1.5 of this Standard, flexible hose shall be installed in accordance with the following requirements:

(The exception being the flexible hose used between the towed and towing vehicle)

(a) The bend radius of the hose shall not be less than 35 mm or the manufacturer's recommended specifications.
(b) Flexible hose shall be secured to the chassis frame or vehicle body by clips, secured at not more than 300 mm apart and shall be fitted prior to and after each bend.
(c) Such clips shall be of sufficient resilience and secured to the vehicle in such a manner so as to prevent lateral movement and damage to the hose and not work loose.
(d) The hose shall be located as far away as practicable from the exhaust system. In no case shall it be closer than 100 mm. Where the hose is situated between 100 mm and 200 mm from the exhaust, shielding shall be provided which shall take the form of one piece of sheet metal located midway between the exhaust and fuel line.

3.1.3.4 Inspection

3.1.3.4.1 At the time of periodic inspection, the hose shall be inspected for twists, kinks and damage or abrasions to the cover, which expose the wire. The hose shall be condemned on detection of any one of these defects.

3.1.3.4.2 At no time shall flexible hose be placed back into service after removal from the vehicle, the exception being flexible hose designed for and used between the towed and towing vehicle.

3.1.4 Joints and connections

3.1.4.1 Every joint or connective filling in rigid high pressure fuel line shall be tested for minimum test pressure of 70 MPa without leakage or failure.

3.1.4.2 The number of joints and connections shall be the minimum for the inclusion of all components.

3.1.4.3 Joints or connections in a CNG fuel line shall be in accessible positions **for easy inspection**.

3.1.4.4 Connection means shall provide positive retention of the fuel line in the fitting (e.g. by double inverted flaring of the tube end).

3.1.5 Securing and location

3.1.5.1 High pressure piping and hoses in vehicles shall comply with the following:

(a) No CNG fuel line inside the part of any vehicle occupied by the driver or passenger shall be outside the sealed and vented enclosure (except as provided for in 2.4.3)
(b) All CNG fuel lines shall be positioned for protection from the possibility of damage by impact, accident or loose objects thrown by the vehicle wheels/tyres. Parts of the vehicle may be used to provide such protection.
(c) CNG fuel lines shall not be located inside box sections or in other inaccessible locations nor shall they be installed in any location, which is not adequately protected from sources of heat, abrasion, or from impact.
(d) Use of the drive shaft tunnel for fuel line location is not desirable or recommended. If such routing is the only possible practicable method of installation, the fuel line must be positioned along the lower corner of the tunnel with the underside of the fuel line not more than 15 mm above the intersection with the floor pan. The fuel line should follow this route for the shortest distance possible. The fuel line shall have a minimum clearance of 40 mm with the drive shaft under all operating conditions. This method is not applicable to vehicles where the open axle shaft passes through a tunnel.
(e) Use of the wheel arch for fuel line location is not desirable or recommended.
(f) Fuel lines shall follow the shortest practical route taking into account the requirements of 3.3.2.
(g) Rigid fuel lines shall be effectively secured to the chassis frame or vehicle body by clips spaced not more than 300 mm apart for 2 and 3 wheeler and 600 mm apart for other vehicles. In order to prevent the possibility of fretting corrosion or erosion of the fuel line cushioning must be provided to protect the fuel line from both the chassis/body and the clips themselves. Suitable grommets must be provided where the fuel line passes through any body panel.
(h) Manifolds used in multi-cylinder applications shall be installed in a protected location. Manifold branch pipelines shall be sufficiently flexible to prevent damage to the lines, valves and fittings due to vibration, expansion or contraction.
(i) In no case shall the clearance between the exhaust system and the fuel line be less than 75 mm.
(j) Fuel lines shall not be installed where any part will be permanently hidden from sight or can not be inspected or easily replaced (except as provided for in 2.4.3).

3.2 CNG fuel line - pressure not exceeding 100 kPa (low pressure fuel line)

3.2.1 All CNG fuel lines for use for service pressure not exceeding 100 kPa (low pressure hose) shall comply with the following:

(a) Such low pressure fuel line shall be of flexible material complying with SAE J30R6/R7/R8 or ISO 15500 or equivalent. Low pressure fuel line shall withstand 5 times the maximum pressure likely to be encountered in service and shall comply with 3.1.5.1(a) to (f) inclusive and (j).

(b) Joints and connections for low pressure fuel lines shall be suitable for use with CNG and capable of sustaining 5 times the maximum pressure likely to be encountered in service, and shall comply with 3.1.4.2 and 3.1.4.3.

3.3 Flexibility

3.3.1 Low pressure hose shall be of sufficient length to accommodate engine movement.

3.3.2 High pressure fuel line shall be installed so as to accommodate any relative movement between chassis/body and fuel system components or temperature variations in the fuel line.

3.3.3 All runs of rigid fuel line piping between any two components shall be installed with a 'pigtail' or U bend to provide this essential flexibility (Refer 3.3.2).

3.4 Trailers and semi-trailers

The fuel supply line between cylinders and an engine shall not pass between a towed and a towing vehicle unless the following conditions are satisfied:

3.4.1 Low pressure transfer of CNG:

(a) The cylinder pressure shall be reduced to value not greater than 2.15 MPa by use of a primary regulator placed upstream of the towing connection. All such equipment should be recommended for this application by the equipment manufacturer.
(b) All components downstream of the primary regulator must be protected against pressure rise due to failure of any other component by the use of a relief valve which will prevent the pressure experienced downstream of the primary regulator from rising above 3.3 MPa.
(c) CNG fuel line connecting the towed and towing vehicle shall be flexible hose and shall meet the requirements of SAE 100R1.
(d) The flexible fuel line shall be arranged and installed so that the free movement of the hose between towed vehicle and the breakaway coupling shall be minimum required to accommodate all possible movement with the towing coupling engaged.
(e) A breakaway coupling shall be provided within the connection of the flexible hose between towed and towing vehicle and the rigid fuel line installed on the towing vehicle.
The coupling shall be attached to the towing vehicle in such a manner so as not to impede its operation and shall resist, without permanent deformation of the attachment, a proof load of 50 kgf in the forward and reverse direction of travel of the vehicle.
(f) Hose couplings shall be of the failsafe or dry type having internal valves which prevent the loss of fuel when breakaway occurs or when the coupling is undone.
(g) The fuel line upstream of the breakaway coupling must be protected by an accessible manually operated isolating valve. If cylinders are present on a towing vehicle an accessible manually operated isolating valve shall also be fitted on the towing vehicle.

NOTE – The allowable amount of free movement of hose between the towing and towed vehicle shall be such as to minimize whipping of the hose should the hose be severed.

3.4.2 High pressure transfer of CNG (Refer fig.3):

Where high pressure CNG is transferred between the towing and towed vehicle 3.4.1 (c), (d), and (g) shall apply along with the following clauses:

(a) A quick-connect coupling shall be provided within the connection of the flexible hose between towed and towing vehicle and the rigid fuel line installed on the towing vehicle.
(b) For any tractor unit provided with CNG storage cylinders, the system shall have installed on the tractor as close as practicable to the coupling a check valve to prevent flow of gas from the cylinders on the tractor through the coupling.
(c) The system shall have installed on the trailer downstream and as close as possible to the quick connect coupling, a manual venting valve, having 3 ports. The valve shall be fitted in such a way that in one position the flow of gas from the cylinders through the excess flow valve will be permitted while in the other position the fuel line from the cylinders is isolated and the line through the coupling, is vented to atmosphere. A permanent label shall be provided "MANUAL VENTING VALVE" in such a way as to clearly indicate the position and function of the valve.
(d) The manual venting valve is to be operated before the disconnection of the coupling thus releasing pressure from the coupling and fuel line between the check valve in the line of the towing vehicle and the manual venting valve. This venting operation is to be conducted in an open, well ventilated space at least 15 meters from any naked flames or other source of ignition.
(e) A plate shall be permanently attached to the fuel line next to the coupling and shall be marked as follows: "DANGER: NO SMOKING. PRIOR TO UNCOUPLING, RELEASE LINE PRESSURE AT MANUAL VENTING VALVE."

NOTE – The allowable amount of free movement of hose between the towing and towed vehicle shall be such as to minimize whipping of the hose should the hose be severed.

4 CNG CONTROL EQUIPMENT

4.1 Definition

4.1.1 The CNG fuel control equipment includes all the equipment necessary to convert CNG at high pressure at the cylinder to CNG air mixer for supply to the engine.

In case of heavy motor vehicle, engine control equipment includes all the equipment used to convert a compression ignition engine to run on a gaseous fuel. This includes devices such as fuel provision and control device, the ignition system (if one is used), the speed and/or load governing device (if any), and any engine protection devices such as temperature and pressure alarms, and knock detection systems.

4.2 Control Equipment

4.2.1 Filter

At the termination of every CNG service fuel line immediately prior to any regulator component there shall be fitted a properly designed filter capable of removing all particulate matter from the fuel that could cause malfunction of such regulator components.

4.2.2 CNG shut-off valve

4.2.2.1 This valve shall shut-off fuel supply to the engine when activated by the fuel change over control on bi-fuel fuel operation and by the ignition switch on single fuel operation. Normally this is a regulator component but in any case it shall be located downstream of the filter.

This valve shall automatically shut-off the fuel supply to the engine unless the following conditions are satisfied:

(a) The ignition is on;
(b) The engine is turning;

4.2.2.2 Service shut-off valve

A service shut-off valve shall be installed in the high pressure line between the cylinder valve and any other valve or component within the engine compartment and as close as practicable to the Regulator, however it is acceptable to install the valve at the refueling point. It shall be possible to readily operate the valve in the installed position at all times in particular during the refueling operation. A permanent label shall be provided 'CNG service shut-off valve' or similar wording to positively indicate its purpose and a positive indication of "Closed" and "Open" positions of the valve shall be clearly marked.

4.2.3 Regulator system

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

(a) It is securely mounted as far as practical from the extremities of the vehicle
(b) It is mounted securely and as close to the engine carburettor position as convenient.
(c) It is easily accessible for routine maintenance, adjustment and inspection.
(d) 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.
(e) It is reasonably protected from impact in a collision.
(f) It allows sufficient free movement of all hoses.
(g) 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.
(h) Where possible, the regulator should be at lower level than top of the radiator, as insufficient water may cause freezing. (Refer also Appendix E for precautions against freezing).

4.2.3.2
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.

4.2.4 The gas air mixer

4.2.4.1 There shall be installed in the air intake immediately prior to the mixer, a backfire deflector to arrest flash back, which shall meet the requirements of Appendix G of this standard.

In case of heavy motor vehicle, there shall be installed in the air intake prior to the mixer a backfire deflector (original air filter acceptable). In turbo charged applications where rigid piping is fitted from the turbo charger to the intake manifold a pressure relief valve shall be fitted as close as practicable to the intake manifold. Where a volume of gas/air mixer, due to turbo charging or inter/after coolers is contained downstream of the mixer, special precautions will need to be applied to avoid damage to components downstream of the mixer due to backfire.

Vehicle manufacturer / kit manufacturer / kit supplier shall submit test report or certificate complying with the above requirement**. It is not necessary to carry out the test if declaration is submitted.**

4.2.4.2 The mixer shall be securely mounted and when remotely fitted shall be suitably bracketed to support its own weight and applied working forces.

4.2.4.3 There shall be no air filter element fitted downstream of the gas air mixer.

4.2.5 Bi- fuel /Dedicated fuel system

4.2.5.1

(a) Bi- fuel type. A bi-fuel system is defined as a system equipped to operate with either on CNG or some other fuel e.g. petrol.
(b) Dedicated fuel type. A dedicated system is defined as a system equipped to operate wholly on CNG.

4.2.5.2 For bi-fuel type

4.2.5.2.1 A shut-off device shall be installed in the bi-fuel fuel system. This device shall shut-off the optional fuel supply to the engine when this fuel is not required.

4.2.5.2.2 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 carburettor. The valve shall be mounted securely so that its weight is not taken on any part of the carburettor or fuel lines.

4.2.5.2.3 Where the shut-off device is mounted remotely from the engine, flexible hose shall be used of sufficient length 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.

4.2.5.3. 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 carburettor on vehicles equipped with bi- fuel systems for the use of petrol and gaseous fuel. The relief device need not be installed on fuel pumps containing a bypass relief device as original equipment.

4.2.5.4 Fuel selection control
A fuel selection control shall be provided which shall have at least three positions, clearly marked for the selection of each of the two fuels. The selection control shall be placed within easy reach of the driver or operator. For vehicles fitted with electronic fuel injection, a two- position switch is acceptable.

4.2.6 Installation

4.2.6.1 The CNG control equipment shall be:

(a) Installed in positions that are accessible for routine inspection, maintenance ad adjustment.
(b) Mounted securely and reasonably protected from damage in a collision.
(c) Remote from the vehicle engine exhaust system or protected therefrom by a metal shield.
(d) No closer than is avoidable and practicable to any electrical equipment capable of sparking.

4.3 Electrical wiring

4.3.1 All wiring shall be properly installed, taped, clipped or contained in a loom along its length.

4.3.2 Wiring cables shall comply with the requirements of JIS C 3406 or equivalent standard, **for only conductor resistance test; spark and immersion test to withstand voltage.**. The kit supplier / kit manufacturer or vehicle manufacturer shall submit test certificate / test report complying with above requirements.

4.3.3 The electrical circuit shall be provided with a current limiting device. This equipment or fuse shall be dedicated to the CNG fuel system.

NOTE – Where fuses are used they should be sized to conform such that 110% of rated current of the circuit – shall not fuse **within 60 minutes** and at 135% of the rated current of the circuit, it shall fuse **within 60 seconds**.

A circuit breaker meeting this criteria is acceptable.

4.3.4 Connectors and terminals

4.3.4.1 Connectors and terminals shall be insulated to prevent accidental earthing during operations or routine servicing.

4.4 Pressure indicator

4.4.1 A pressure indicator to indicate pressure in the CNG gas cylinder shall be fitted in an easily visible position to service personnel at the regulator or fill point preferably within the engine compartment.

4.4.2 A supplementary gauge or electronic gauge may be placed in the driver's compartment provided any gauge shall be gas isolated from the cylinder or piping to prevent gas leaking into the compartment.

5 COMPLIANCE PLATE

5.1 Compliance plate
There shall be installed near the filling connection and be clearly visible to the re-fueler a compliance plate displaying the following information:

COMPLIANCE PLATE

- CNG Cylinder Identification Number(s)
- Date of Installation
- Water Capacity **(litre)** of the Total Installation
- Date of the Last Retest
- Vehicle Registration/Identification No.

  The CNG installation complies with the safety requirements of AIS 028
- Installed by

6. LABELS

6.1 Identification labels

6.1.1 Vehicles using a CNG system shall be labeled as follows:
Labels conforming with the specification given in 6.1.2 of this Standard shall be affixed in a vertical position as close to the vehicle number plate as practical or on the left side of the front & rear safety glass and shall ensure visibility from the front and rear sides.

6.1.2 The label shall be in position at all times, shall be in good condition, and the shape, colouring and lettering shall be easily identifiable.

6.1.3 Label shall be coloured white and sized 80 mm x 80 mm square. Label shall have on them the text "CNG" in a central position not less than 20 mm high, coloured black. The label shall have a black border 1 mm wide, 5 mm inside the outer edge and running parallel to it. The 80 mm dimension is measured from the outer edge. (Refer Appendix C for drawing).

7 INSPECTION, TESTING AND COMMISSIONING(FOR INSTALLER)

7.1 Commissioning

Prior to initial use, an inspection of the CNG system and components shall be carried out by, or under the supervision of an Authorized Person/Installer, who shall also carry out a complete examination to ensure the system complies with all relevant sections of this Standard and any other statutory requirements as specified by the Central Government.

7.1.1 Initial inspection **and installation certificate**

The system shall be leak tested as detailed in 7.2 of this Part of this Standard. The installation shall be inspected for compliance with this Standard and all components shall be checked for operational performance. In the case of bi-fuel fuel installations, the ability for the vehicle to operate on the optional fuel shall also be tested.

When the system conforms to this standard, an installation certificate, as per Annexure VI of AIS 024, signed by authorized person / installer shall be issued to the owner of the vehicle.

For CNG buses, checklist as per Annexure VII of AIS 024 shall be duly filled and complied for carrying out third pary inspection. This checklist is for third party inspection of fully built CNG buses before registration.

7.1.2 **Periodic** Inspection /**preventive maintenance**

7.1.2.1 The **cylinder**, piping and all components of the system shall be examined by an installer for corrosion, deterioration and for any modification affecting compliance with this Standard, at least once in a year or incase of malfunction or accident. The inspection shall include leak testing under 7.2 of this Part of this Standard.

Every CNG bus manufacturer / installer shall incorporate periodic inspection schedules in the operation and owner's manuals.

7.1.2.2 When the system has been inspected and any defects remedied and the system conforms to this Standard to the satisfaction of the installer, a **checklist as per Appendix A (in case of buses it shall be as per Annexure VII of AIS 024) of this Standard** shall be issued to the owner of the vehicle.

7.2 Leak testing

7.2.1 Initial test
At the time of commissioning, the complete pressure system shall be subjected to a pressure test of 20 ± 1 MPa by using CNG or a gas inert to CNG such as nitrogen.

Procedure
(a) With boot or cylinder compartment open and vapour sealing removed from cylinder valve area, and cylinder valve closed slowly pressurize the system.

WARNING. The system must not be subjected to a shock loading as insecure fittings could blow out with dangerous results, and burst discs could rupture.

(b) Leak test lines, fittings and components using a non-corrosive foaming agent and when leak free

(c) Open cylinder valve, pressurize cylinder and check for leaks at valve and cylinder neck.

(d) When the system is passed leak free seal venting area.

7.2.2 Gas tightness of compartments and sub-compartments

7.2.2.1 The compartment and sub-compartment shall be tested at the time of commissioning and subsequently at each periodic inspection to ensure that it is gas tight to the vehicle interior by blowing tracer gas into the compartment or sub-compartment and testing the surrounding atmosphere for gas leakage with a gas detector. Passages between the compartment and outside air, e.g. ventilation provisions, or an access hatch or door in the case of a permanently in-built compartment, should be sealed during testing. Any leakage should be rectified, and testing repeated.

7.2.2.2 Should the compartment or sub-compartment fail the above tests, corrective action shall be taken and the tests repeated until they comply with the test requirements.

NOTE – It may be permissible to check such a compartment or sub-compartment before installation of the fuel system, provided that nothing in the subsequent installation procedure will negate the validity of the test.

7.2.3 Where CNG is used for testing the following precautions shall be observed:

(a) Testing shall be carried out under adequately vented conditions.

(b) Testing shall be carried out at least 5 m from any open flame or other source of ignition.

7.2.4 The operation of the equipment and controls shall also be tested with CNG under normal working conditions to prove satisfactory performance of the entire system and a further leak test shall be carried out using a non-corrosive foaming agent.

7.2.5 A BCF fire extinguisher and dry powder fire extinguisher to meet IS: 2171 and each of 2 kg shall be kept ready within a safe distance. If ignition occurs the service valve should be closed and the extinguisher(s) used to quell any fire, which may continue.

8 GARAGING AND REPAIR (FOR INSTALLER)

8.1 Garaging and repairing of CNG fueled vehicles

8.1.1 Vehicles fueled with CNG may be stored or serviced and repaired inside garages provided that the following conditions are observed:

(a) There shall be no leaks in the fuel system

(b) Such vehicles shall not be parked within 3 m of any sources of ignition

(c) CNG fueled vehicles being repaired in garages, unless the fuel is required for engine operation, shall have the cylinder shut-off valve closed and the CNG

fuel in the service line exhausted by running the engine or depressurizing the line in a well-ventilated area

(d) Vehicles undergoing repairs involving welding or the application of heat, to any part within 1 m of the cylinder, shall have the cylinder removed or shielded from the source of heat.

8.2 Repair Operation

8.2.1 Repair operation involving heat shall be carried out with due regard to fire safety.

8.2.2 Damaged fuel lines shall not be repaired; in all cases they shall be replaced.

8.2.3 Welding, brazing and the application of heat shall not be carried out on any part of the cylinder subsequent to manufacture.

8.2.4 When a vehicle is involved in an accident causing damage to part of all of the CNG fuel system or where any part of the system necessitates removal to allow for the repair of the vehicle the system shall, after re-assembly or repair, be tested in accordance with 7.2 and **a checklist as per Appendix A of this standard be** issued. If applicable the requirements of 8.3.2 shall also be met.

8.3 Scrapping

8.3.1 A vehicle, which is about to be scrapped, shall have its cylinder removed prior to disposal.

8.3.2 Where the cylinder has been subjected to impact or fire damage the cylinder shall be inspected and re-tested by the owner of the vehicle as per Gas Cylinder Rules,1981, as amended from time to time.

NOTE – There will always be combustible gas in the cylinder until it has been cleared of all traces of flammable vapour or gas.

9 CONSTRUCTION EQUIPMENT VEHICLES (SPECIAL EQUIREMENTS)

9.1 General

9.1.1 This section covers the special requirements of Construction Equipment Vehicles.

9.1.2 CNG fuel system installation on Construction Equipment Vehicles shall comply with the requirements of this Standard subject to the allowable variation detailed in this section.

9.1.3 Clauses of this Standard which are not applicable to Construction Equipment Vehicles and which are not clearly identifiable as such are as follows:

Clause 2.3	Location and ventilation of cylinders.
Clause 2.4	Construction of compartments and sub-compartments (for internally mounted cylinders refer clauses 2.4.1 and 2.4.2).
Clause 2.5	Cylinder installation
Clause 3.1.5	Securing and location – (except paragraphs (a) to (f) inclusive and (j)).

9.2 Cylinders and fittings, location and mounting

9.2.1 Location

9.2.1.1 A fuel cylinder shall be so located as to minimize the possibility of damage to the cylinder or its fittings and it shall not be located so that it adversely affects driving characteristics of the Construction Equipment Vehicles.

9.2.1.2 A cylinder shall not be fitted in any internal location when a suitable external location is available.

9.2.1.3 A cylinder and its fittings shall not extend beyond the plan form of the vehicle.

9.2.2 Clearance

A fuel cylinder shall be installed with as much ground clearance as is practicable, but never less than the minimum ground clearance of the vehicle in the vicinity of the cylinder. This minimum clearance shall be measured to the bottom of the cylinder or the lowest cylinder fitting.

9.2.3 Protection
Valves and connections on cylinders shall be protected to minimize the possibility of damage due to accidental contact with stationary objects or from loose objects thrown up from the road. Valves shall be protected to minimize the possibility of damage due to collision, overturning or other accident. Parts of the vehicle may be used to provide such protection to valves and fittings.

9.2.4 Shielding
A fuel cylinder shall be shielded if necessary, against direct heat radiation from the engine and exhaust systems.

9.2.5 Mounting

A fuel cylinder shall be secured in place on the Construction Equipment Vehicles so as to meet the requirements of a loading test.

9.2.6 Load test

9.2.6.1 A CNG cylinder shall be secured in place on the Construction Equipment Vehicles in a manner capable of withstanding, without visible permanent deformation, loadings in any direction equal to 10 times the filled weight of the cylinder.

9.2.6.2 For this test, the cylinder is to be empty of fuel and is to be secured in the manner covered by the manufacturer's instruction. Loadings are to be applied in any convenient manner capable of being measured by gauges or weights.

9.3 Fuel system

9.3.1 Components

All fuel system components shall be fastened to the Construction Equipment Vehicle to minimize the possibility of loosening due to vibration.

9.3.2 Securing and shielding

Fuel lines shall be supported to prevent chafing and to maintain at least 50 mm clearance from exhaust and electrical system parts. Refer 3.1.5 paragraphs (a) to (f) inclusive and (j).

9.4 Shielding – Temperature/pressure tests

9.4.1 The materials employed in the construction of Construction Equipment Vehicles shall not be damaged by the temperatures attained during normal operation under the conditions of maximum rated load and under conditions of maximum overload maintained for a short period of time. The maximum temperature rise on the surface of any combustible material of electrical insulation shall not exceed 150 °C.

9.4.2 The test period shall be that required to establish equilibrium conditions for temperature rise and pressure determinations, but shall be continued for not less than 2 hours; except that a tractor shall be operated an additional 1 minute period against a bumping post or other obstruction, thereby causing the wheels to slip and the tractor to exert maximum draw bar pull in effect. During this additional 1minute period, the rise in surface temperatures shall not exceed the limits specified.

APPENDIX A

CHECKLIST FOR INSTALLATION

A1
This checklist is a guide for the installer when carrying out the inspection prior to issuing installation Certificate. Reference to relevant clauses in this Standard and guidelines issued by Central Government from time to time should be made where appropriate.

(a) Cylinder:
Approved by DOE
Validity of Certificate
Free from corrosion
Mounted securely and inside vehicle parameter
Mounting points free from corrosion and fractures
Shielded and valves protected where necessary
5 mm clearance between cylinder to vehicle components provided
Ground clearance correct

(b) Valves:
Cylinder valve operating correctly
Burst disc fitted

(c) Filling connection:
Refueling connection made external to vehicle interior
Captive dust plug fitted
Meets proof loading of 50 kgf

(d) Refueling interlock:
Operation correct

(e) Non-return valve:
Operation correct free from bypass leakage

(f) Leak test:
All valves and fittings leak free

(g) Vapour sealing:
Gas tight

(h) Ducting:
Free from damage and secure to outlets

(i) Pliable sub-compartment:
Ease of operation of cylinder valve satisfactory
Position identified

(j) Fuel line:
Free from damage and corrosion
Secured to vehicle
Protected and shielded where necessary

(k) Joints and connections:
Leak free

(l) CNG shut off valve/solenoid valve:
Mounting secure
Operation correct
Leak free

(m) Service shut off valve:
Operation satisfactory
Mounted securely
Leak free
Identified and operation clearly marked

(n) Regulator:
Mounting secure
No gas bypass after engine has stopped turning
Shielded where necessary
Leak free

(o) Control equipment:
Approved type

(p) Gas air mixer:
Securely mounted
Backfire deflector where applicable

(q) Bi-fuel shut-off device:
Operation correct
Petrol lock off where fitted is mounted securely
Petrol hose secure joints leak free and free from cracks
Sufficient flexibility for engine movement
Bypass device fitted where applicable

(r) Electrical wiring:
Current limiting device fitted
Connections secure
Terminals insulated to prevent shorting
Wiring taped and clipped securely

(s) Compliance Plate:
Installed and carries correct markings

(t) Identification labels:
Located front and rear of vehicle

APPENDIX B

STATUTORY AUTHORITY APPROVAL

B1 The type of component in question and its use determine the Statutory Authority Approval in respect of CNG fuel system components. The Statutory areas of responsibility are:

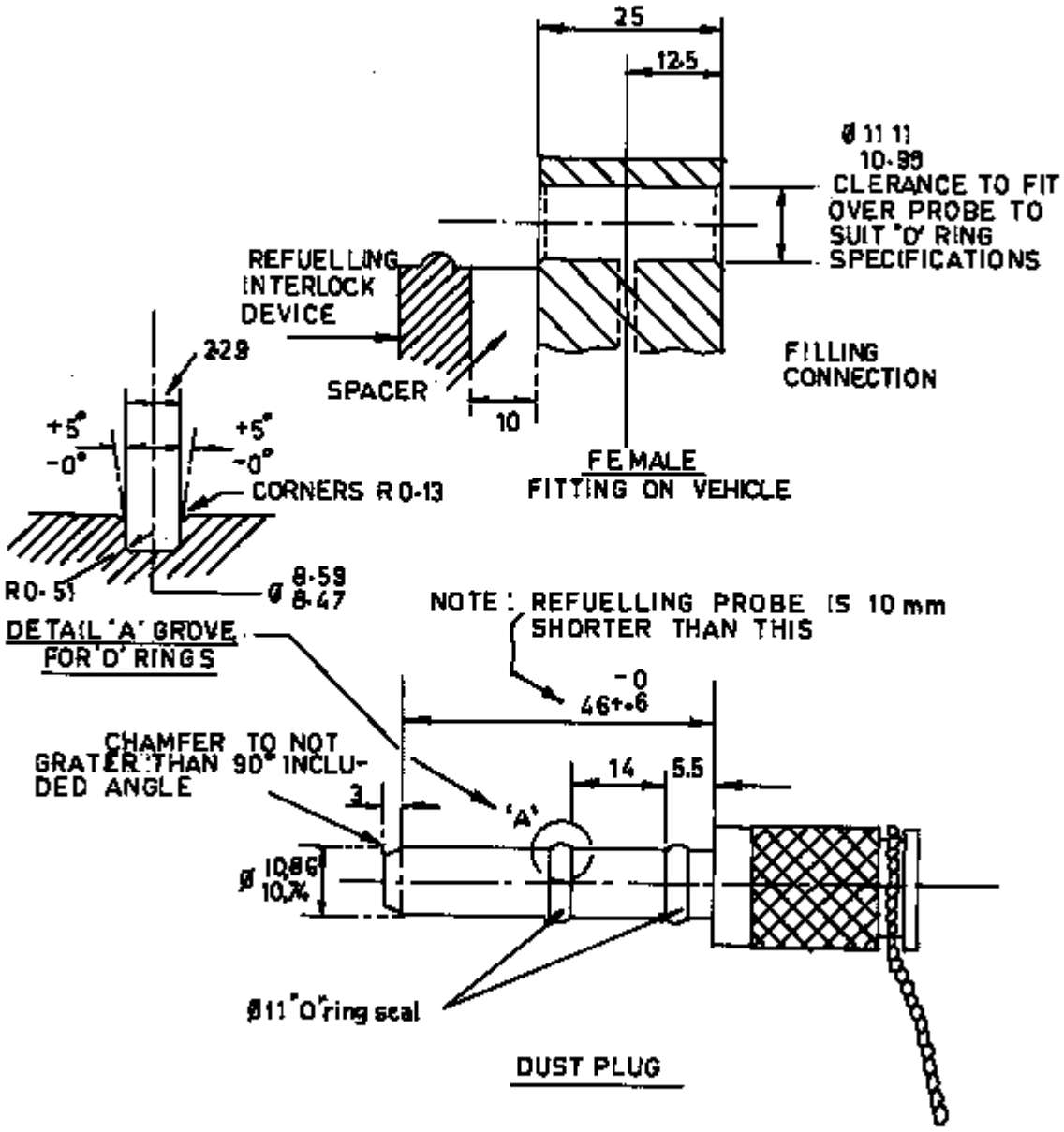
Government Agency	Statutory powers	Scope of application
B 1.1 **Ministry of Road Transport and Highways**, Government of India.	Central Motor Vehicle Act, 1988 (CMVA) Central Motor Vehicle Rules, 1989 (CMVR)	All CNG kit components (excluding CNG cylinder & its valve(s)) and systems used for the purpose of propelling a motor vehicle on road.
B 1.2 Department of Explosives, Government of India	Gas Cylinder Rules,1981	CNG cylinder with valves and **their** accessories.

APPENDIX C

LABEL

APPENDIX D

FILLING CONNECTION AND DUST PLUG



DUST PLUG C N G VEHICLE FILLING SYSTEM

APPENDIX E

FREEZING CONDITIONS AND CORROSIVE CONDITIONS

E1
Where Regulator heat is drawn from the engine cooling water, care should be taken to ensure that the water does not freeze in the Regulator during cold weather. Expansion of the water on freezing can cause serious damage to the pressure regulator assembly.

E2
Most CNG Regulators are made from non-ferrous alloys, which can suffer pinhole corrosion under certain conditions. If this is allowed to take place CNG can be admitted to the cooling water system where it will pressurize the radiator and cause a potential hazard. It is important, therefore, to have an effective anticorrosion additive present in the cooling water.

E3
It is important to ensure that the coolant additive and the dilutant ratio comply fully with the engine manufacturer’s requirements.

APPENDIX F

TABLE FOR USE WITH CLAUSE 2.3.3.2 AND FIG. 1.ZONES OF CLEARANCE

Wheel base mm	Clearance height at 17° ramp angle (point A of fig. 1) mm
1800	134
1900	142
2000	149
2100	157
2200	164
2300	172
2400	179
2500	187
2600	194
2700	202
2800	209
2900	216
3000	224
3100	231
3200	239
3300	246
3400	254
3500	261
3600	270
3700	276
3800	284
3900	291
4000	298
4100	306
4200	313
4300	321
4400	328
4500	336
4600	343
4700	351
4800	358
4900	366
5000	373

NOTE – If wheel base measurement falls between any of the figures shown above then the next highest figure is to apply.

APPENDIX G

BACKFIRE – DEFLECTOR TESTS

1) A backfire deflector under backfire conditions shall contain a visible flame front within its confines and shall not be displaced, physically damaged or distorted, or show evidence of burning or smoldering of internal parts. If the deflector is of the oil-bath type, it shall be free of any overflow or discharge permitting accumulation of oil on electrical, hot-engine or exhaust system parts.

2) A complete industrial truck / vehicle is to be used for this test. Tests are not required on backfire deflectors employed diesel engines.

3) The backfire deflector (air cleaner, oil-bath or dry element type) and connecting hose are to be removed from the engine. The spark timing is to be advanced (approximately 8 degrees) and the spark plug leads are to be interchanged to obtain sharp backfires under the following conditions. The engine is to be alternately raced and idled and the ignition switch is to be operated to alternately energize and de-energize the ignition system. During the test, the intensity of the backfire and the issuance and extent of the accompanying flame are to be noted.

4) The backfire deflector (air cleaner) is then to be installed on the truck in the intended location. An oil-bath type deflector (air cleaner) is to be filled to the marked “full level-line” of the bowl. Paper is to be placed beneath the intake orifices of an oil-bath type and over adjacent surfaces of parts likely to be affected by accumulations of oil.

5) The engine is then to be operated in the several manners determined in the preliminary test to provide for the most severe backfire conditions. At least ten and not more than twenty backfires are to be produced.

6) Observations for containment of flame are to be made under semi-darkened conditions by at least two observers. No visible flame is to be in evidence at any time during the tests. In the tests of an oil-bath type, paper is not to show evidence of oil deposits in the form of droplets.

7) A dry-type filter element is to be tested in the above manner, then removed and then subjected to five consecutive washing and drying cycles. Washing is to consist of immersion in plain water together with sufficient agitation to remove bulk material adhering to the outside surface. The test element is then to be remounted as intended in operation, and the backfire test is to be repeated.

8) The side of the filter media normally exposed to backfire is then to be subjected to a flame source of sufficient intensity to cause the media to burn or glow. The flame source is then to be removed and an acceptable filter media is not to continue to burn or smolder.

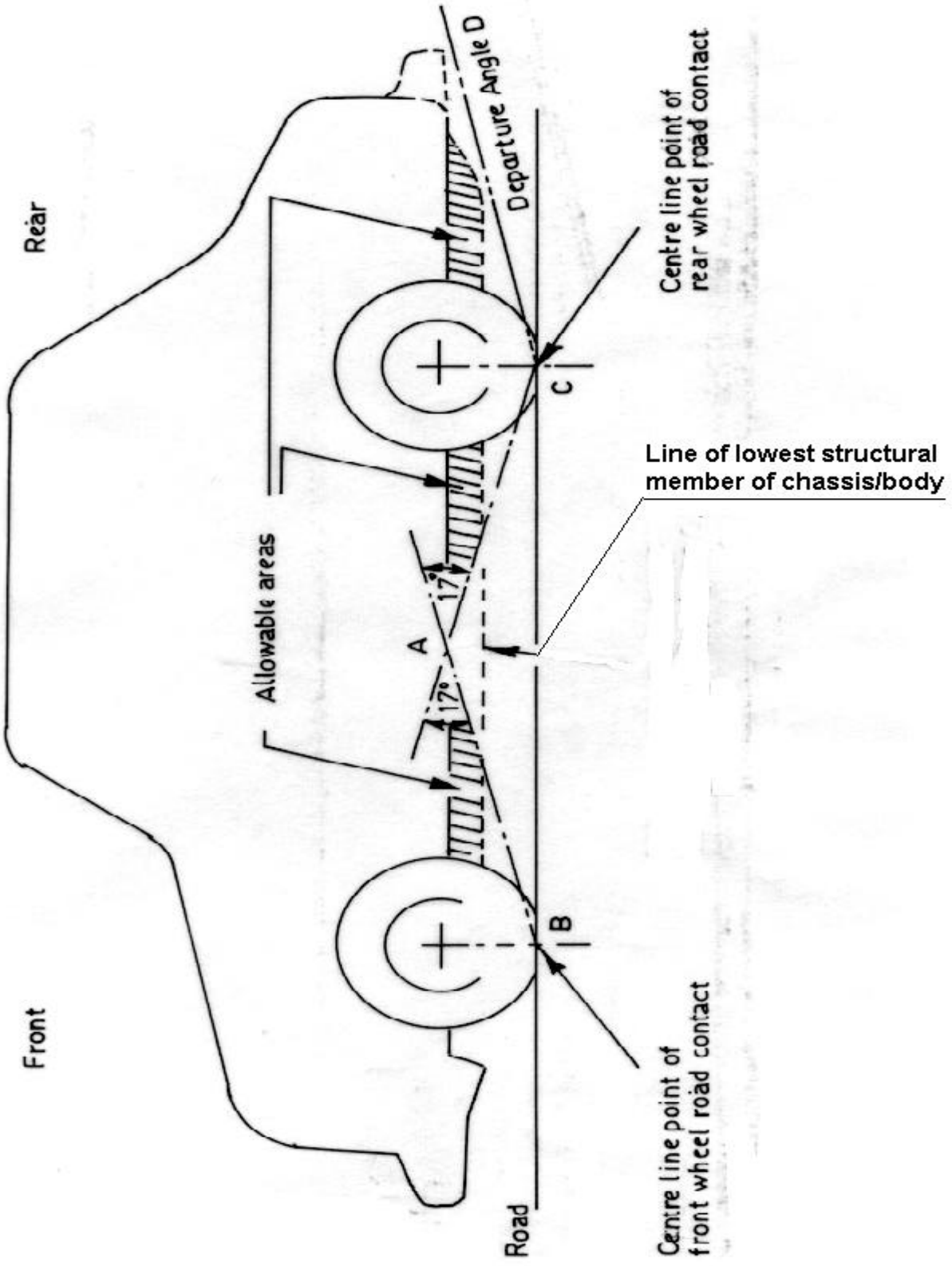

Rear
Front
Departure Angle D
Centre line point of rear wheel road contact
Line of lowest structural member of chassis/body
Allowable areas
17°
12°
A
B
C
Road
Centre line point of front wheel road contact

Figure 1

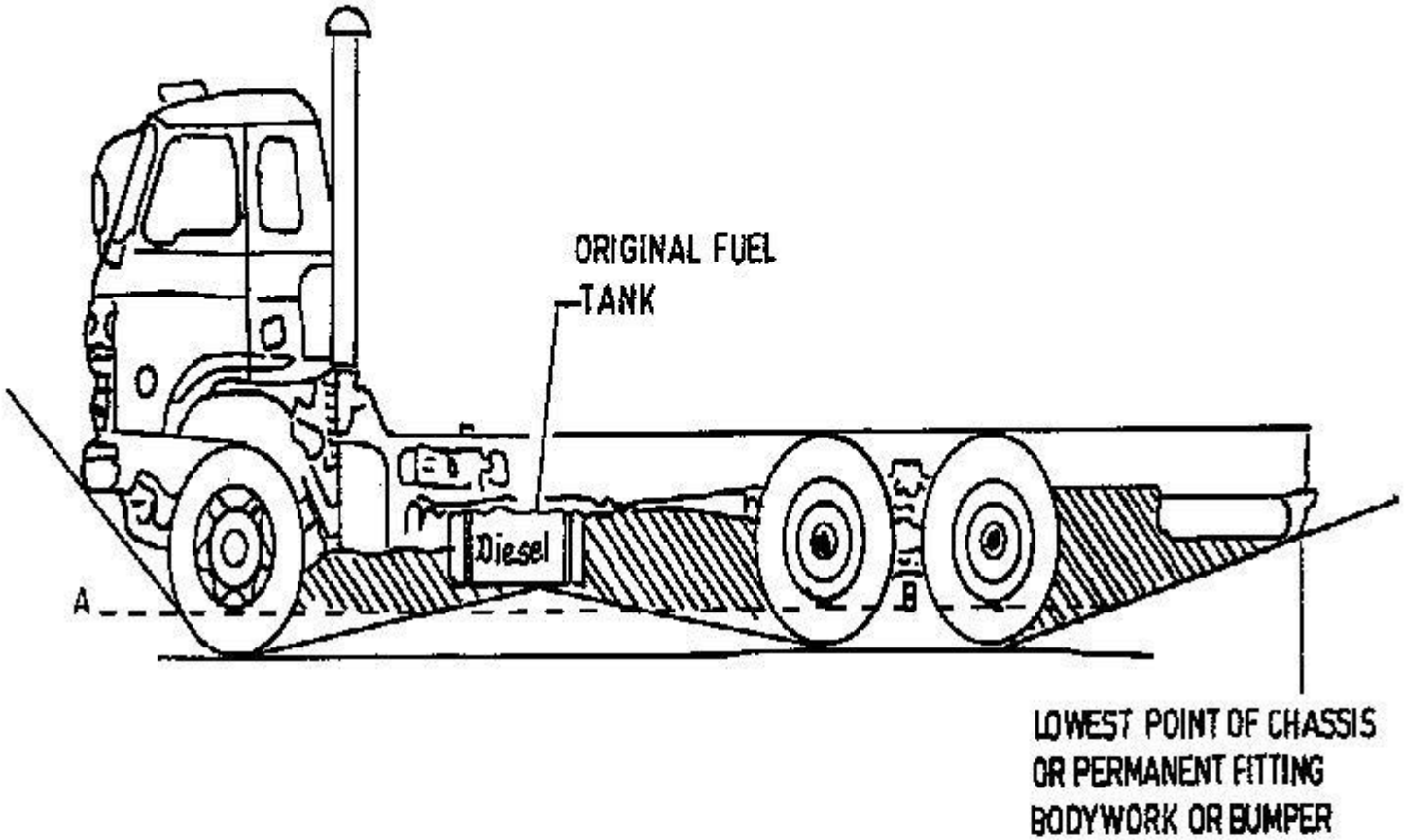


FIG: 2 TYPICAL POSITION OF ORIGINAL FUEL STORAGE TANK GROUND CLEARANCE

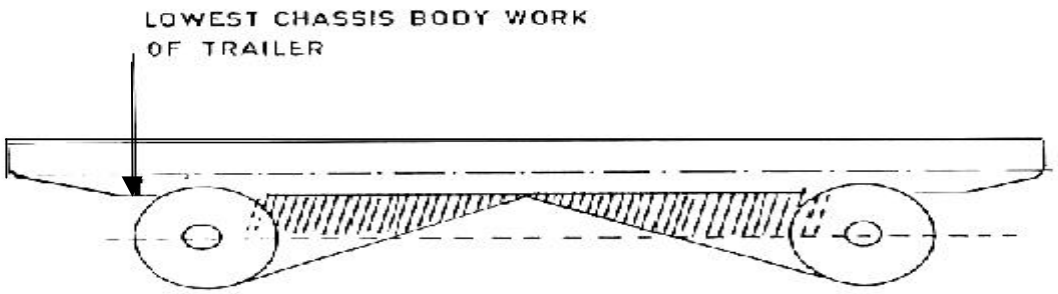


FIG. 3 TRAILER MOUNTING OF CYLINDERS GROUND CLEARANCE

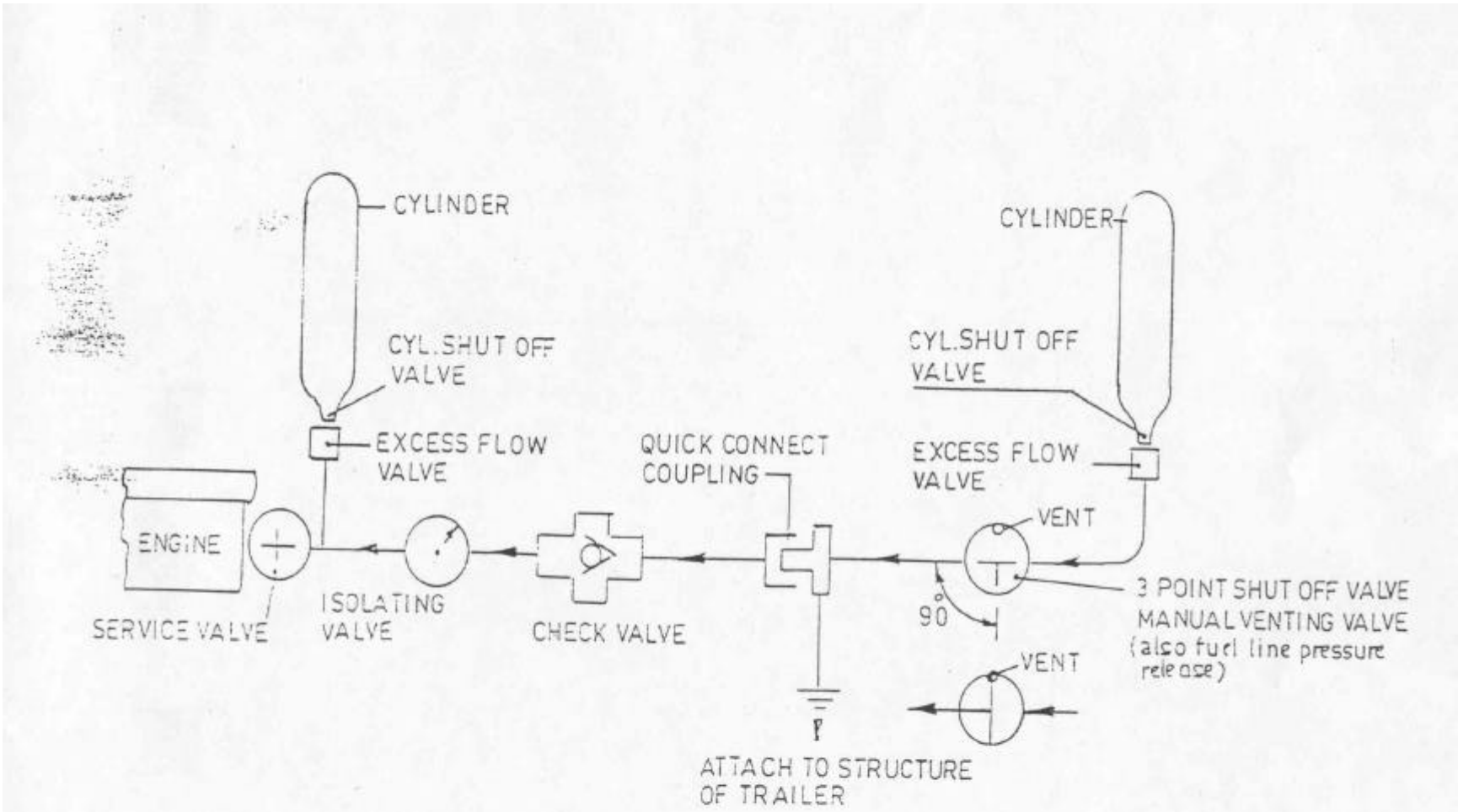


FIG: 4 DIAGRAMMATIC ARRANGEMENT OF VALVING IN FUEL LINE BETWEEN TRAILER MOUNTED CYLINDERS, TRACTOR MOUNTED CYLINDERS & ENGINE IN HIGH PRESSURE TRANSFER.