SRI LANKA STANDARD 1205 : 2000

SRI LANKA STANDARD

SPECIFICATION FOR LP GAS FUEL CONTAINERS FOR CONVERSION OF AUTOMOTIVES TO BI-FUEL (PETROL-LPG) PROPULSION SYSTEMS

SRI LANKA STANDARDS INSTITUTION

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Sri Lanka Standard

SPECIFICATION FOR LP GAS FUEL CONTAINERS FOR CONVERSION OF AUTOMOTIVES TO BI-FUEL (PETROL-LPG) PROPULSION SYSTEMS

SLS 1205 : 2000

Gr. 6

SRI LANKA STANDARDS INSTITUTION
No. 17, Victoria Place,
Elvitigala Mawatha,
Colombo 08
SRI LANKA

Sri Lanka Standards are subject to periodical revision in order to accommodate the progress made by industry. Suggestions for improvement will be recorded and brought to the notice of the Committees to which the revisions are entrusted.

This standard does not purport to include all the necessary provisions of a contract.

Sri Lanka Standard

SPECIFICATION FOR LP GAS FUEL CONTAINERS FOR CONVERSION OF AUTOMOTIVES TO BI-FUEL (PETROL-LPG) PROPULSION SYSTEM

FOREWORD

This Sri Lanka Standard was approved by Technical Advisory Committee on Conversion of Automotives to Bi-fuel (Petrol-LPG) Propulsion Systems and was authorized for adoption and publication by the Council of the Sri Lanka Standards Institution on 2000-09-21.

This standard is for LPG containers with welded attachments to be used as parts of installations complying with **SLS .....*.** Certain features, e.g. attachments, require reference to **SLS .....*** and manufacturers should be familiar with this standard.

New designs and manufacturing methods are not prohibited by this standard. However it is advisable that no major variations are attempted without a thorough design verifications by an independent third party verification body acceptable to the Sri Lanka Standards Institution.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or an analysis, shall be rounded off in accordance with **CS 102**. The number of significant places retained in the rounded off value shall be the same as that of the specified value in this standard.

The Sri Lanka Standards Institution gratefully acknowledges the use of the following publications, in the preparation of this standard :

a) AS/NZS 3509 : 1996 LP gas fuel vessels for automotive use ; and

b) UN regulation No. 67

1 SCOPE

This standard specifies requirements for welded carbon steel LP gas fuel containers of total volume not greater than 500 l, and for welded stainless steel LP gas fuel containers of total volume not greater than 200 l intended for automotive installations.

NOTES

1 *SLS ..... *Specify requirements for the installation of LP gas fuel containers in automotives.*

2 *Appendix **B** provides information that may be helpful to suppliers of 'valved-up' vessels for use by an installer without pre-installation tests.*

SLS ..... ' LP Gas fuel systems for vehicle engines (under preparation)

2 REFERENCES

AS 1210	Pressure vessels
AS 1449	Wrought alloy steels - Stainless and heat-resisting steel plate sheet and strip
AS 1594	Hot-rolled steel flat products
AS 1627-4	Metal finishing - Preparation and pretreatment of surfaces Part 4 Abrasive blast cleaning
AS 2666	Pressure sensitive adhesive label stock-paper
AS 2812	Welding, brazing and cutting of metals-glossary of terms
AS 4037	Boilers and pressure vessels - Examination and testing
BS EN 287	Approval testing of welders for fusion welding
BS EN 288	Approval of welding procedures for metallic materials
SLS 978	Tensile testing of metallic materials
SLS 994	Method of bend testing of metallic materials
SLS.....*	LP Gas fuel systems for vehicle engines (under preparation)
SLS.....*	Methods of test for conversion of automotive to bi-fuel (Petrol-LPG) propulsion systems (under preparation)

3 DEFINITIONS

For the purpose of this standard the following definitions shall apply :

3.1 bi-fuel system : A system where two alternative fuels are intermittently provided for the propulsion.

3.2 capacity : The designated water capacity (total volume) of the space within the fuel container.

3.3 compartment : A structure which enclose the whole of the container and its fittings, whose purpose is to collect any gas leakage which might occur, so that it can be discharged to open air.

3.4 inspection body : For the purpose of this standard the inspection body is the regulatory authority having jurisdiction.

3.5 inspector : A person, or body, employed by an inspection body, who ensures and certifies that the inspections specified herein have been carried out and assures the fuel vessel complies with the requirements of this standard.

3.6 main longitudinal joint : A longitudinal joint in the vessel shell other than any longitudinal joint associated with the attachment of an inserted non-circular pad for openings.

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* Under preparation

3.7 **regulatory authority** : Any state regulatory authority in Sri Lanka with the jurisdiction for pressure equipment safety and includes an officer of that authority with delegated responsibility by that authority.

3.8 **sub-compartment** : A structure attached to the container, which encloses the container fittings, and whose purpose is to collect any gas leakage which might occur, so that it can be discharged to open air.

3.9 **welding procedure specification** : A documented qualified welding procedure prepared to provide direction for making production welds to the requirements of this standard.

3.10 **welding procedure test** : The making and testing of a welded joint representative of that to be used in production in order to prove the weldment is capable of providing the required properties for its intended applications.

4 DESIGNATION

Fuel containers for LP gas shall be designated according to the standard and the materials of construction as follows :

a) For welded carbon steel..... **SLS 1205 /C**
b) For welded stainless steel .....**SLS 1205 /316S***

Designation system other than specified in 4, are acceptable subject to the approval of the Sri Lanka Standards Institution.

5 REQUIREMENTS

5.1 Materials (for welded carbon steel LP gas containers)

5.1.1 *Cylindrical sections and ends*

5.1.1.1 The materials used for the manufacture of the cylindrical section and ends shall be steel as specified in **AS 1594**. However, other materials may be used provided that the container has the same safety characteristics, to be certified by the inspection body.

5.1.1.2 Rimmed steel shall not be used for arc welded components. This standard does not cover the use of temper rolled steel.

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* Designation shown for type 316 stainless steel

TABLE 1 - Some acceptable steel grades

Standard (1)	Analysis grades (2)	Structural grades (3)	Extraformable grades (4)
AS 1594	A 1016 XA 1016 XK 1016	Hd 250 Hd 300 Hd 300/1 Hd 350 Hd 400	XF 300 XF 400 XF500

5.1.1.3 The steel shall be of weldable quality and have a maximum carbon equivalent of 0.45 per cent, based on cast analysis or product analysis, where carbon equivalent (CE) is determined as follows:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad \text{per cent}$$

5.1.1.4 Mechanical testing of parent metal and welds shall be carried out in accordance with 5.5.3.

All mechanical testing shall be carried out after any heat treatment.

The resulting yield and tensile strength values shall not be less than the values used in the equations in 5.3.1 and 5.3.2.

The resulting elongation of the parent metal shall be not less than 20 per cent minus one percentage unit for each increment of 50 MPa by which the measured tensile strength exceeds 350 MPa, but in any case shall be not less than 16 per cent.

NOTE

Mechanical properties other than elongation are not specified and are a matter for agreement between steel supplier and containers manufacturer.

5.1.2 *Attachments*

Pressure - retaining and non pressure-retaining attachments shall be of steel complying with 5.1.1.

5.1.3 *Heat treatment*

Cylinders made from steel produced by using fully killed fine grain steel making practice (grain refining elements 0.010 minimum total) need not be stress relieved provided type testing shows that the desired properties are achieved without stress relieving.

If after fabrication heat treatment is considered necessary, or micro alloying (e.g. niobium, vanadium) elements or both shall be stress relieved in the temperature range 550 ^{0}C to 650 ^{0}C. Steels not containing above elements (e.g. semi-killed) shall be stress relieved in the temperature range 550 ^{0}C to 600 ^{0}C.

NOTE

Because of the possibility of critical strain grain growth in vessels it is important that individual vessels in a heat treatment batch are not heated to temperatures beyond the specified temperature range.

Normalizing of these steels can cause significant loss in their mechanical properties. Because of this, these steels shall not be subjected to normalizing treatment unless the specified properties of the material are verified by tests on a specimen subjected to a simulated heat treatment equivalent to that which the vessel is subjected.

5.2 Materials (for welded stainless steel LP gas containers)

5.2.1 *Cylindrical sections and ends*

5.2.1.1 Cast analysis

The cast analysis shall comply with the chemical composition requirements of grades 304, 316 of AS 1449 or better standard, and the maximum carbon content shall be 0.05 per cent.

The stainless steel shall be of weldable grade.

5.2.1.2 Test certificate(s)

Test certificates shall be provided by the steel supplier, and shall show the material analysis and mechanical properties for each coil.

For temper-rolled steel, tensile specimens shall be taken from both ends of each coil. All specimen for test certificate purpose shall be taken at a sufficient distance from each end of the coil to be representative of the coil.

The steel maker shall certify for each coil that the steel is free of deleterious carbides.

5.2.1.3 Mechanical testing

Mechanical testing of parent metal and welds shall be carried out in accordance with 5.2.3 and 5.5.3. The transverse tensile butt-weld specimen shall have a parallel length not less than the width plus 60 mm.

The resulting yield and tensile strength values shall be not less than the values used in the equations in 5.3.1 and 5.3.2.

The resulting elongation shall be not less than 20 per cent.

5.2.2 *Attachments*

Attachments shall be of steel complying with AS 1449 or AS 2837, The attachments and the weld metal for the attachments shall be the same grade as that used for the vessel.

NOTES

1 *The above materials for attachments are specified to ensure compatibility of welded joints with the cylindrical section and ends.*

2 *Support straps or bands shall be made from more of these grades of stainless steel.*

5.2.3 *Intergranular corrosion test*

For welded stainless steel fuel vessels the welding variables, materials, and welding procedures shall be qualified by testing a test specimen from at least one vessel randomly sampled from each batch of 200 vessels (or part thereof) as follows:

a) Test pieces shall be prepared to provide representative weld metal and heat-affected parent metal for each of the following :

   i) a T - joint of the longitudinal and a circumferential weld ;
   ii) the longitudinal joint above ;
   iii) a typical nozzle attachment ; and
   iv) a weld representative of any other attachment welds to the pressure -retaining member of the vessel, e.g. for attachment of a name plate.

   At least one of the test pieces shall be taken from the position of maximum heat input and maximum number of runs.

   NOTE
   Test pieces may be taken from vessels also used for mechanical testing or other type testing, provided that tensile failure did not occur in the zone from which a piece is taken.

b) Test specimens shall be tested in accordance with SLS .....* , Practice A, Stretcher Test (Oxalic acid Etch Test). If any grain is completely encircled with carbides then this shall be treated as a failure.

c) The welding variables, materials, and welding procedures shall be deemed acceptable with respect to intergranular corrosion only if the test piece for each of items a(i), a(ii) and a(iii) do not fail the test specified in item (b).

5.3 Design

5.3.1 *Thickness of cylindrical section*

The thickness of the cylindrical section after forming shall be not less than the greater of those calculated from the following equations, but in no case less than the value given in Table 2.

$$t = 2.5\left[\frac{D_i}{R_m}\right]^{\frac{1}{2}} \text{ and } t = \frac{2.55D_0}{2f\eta + 2.55}$$

where

t = minimum calculated thickness, in millimeters ;
D_i = inside diameter of cylindrical section, in millimetres ;
D_0 = outside diameter of cylindrical section, in millimetres ;
R_m = tensile strength for the steel in the finished condition. this shall be taken as the least value of the following ;

a) the tensile strength of the parent metal (see **7.3.3.**)
b) the transverse tensile strength of the main longitudinal joint (see**7.3.4**)
c) the tensile strength of the circumferential joint determined in accordance with **7.3.5.**
d) 700 MPa.

f = maximum permissible design strength, in megapascals
= the smaller of $\frac{R_e}{1.5}$ and $\frac{R_m}{C}$

where
R_e = yield strength from the tensile test of the parent metal (see**7.3.3**). the yield strength may be any one of the yield parameters assessed by the tensile test of the parent metal.
R_m = the value defined above

* Methods of test for conversion of automobiles to bi-fuel (Petrol -LPG) propulsion system (under preparation)

C = a factor
= 2.35 for carbon steel
= 2.5 for stainless steel
η = efficiency of the welded joint
= 0.9 or 1.0, substantiated in accordance with 7.1.2

TABLE 2 - Minimum thickness of cylindrical section

Material	Minimum thickness mm	
	Protected location	Unprotected location
(1)	(2)	(3)
Carbon steel	1.75	2.2
Stainless steel	1.50	2.2

5.3.2 *Thickness of ends*

The minimum thickness of ends after forming shall be as follows:

a) In the cylindrical portion (see Figure 1), the greater of the thickness given in (i) and (ii) below.

(i) The greater of the values calculated from the following equations :

$$t = 2.5\left[\frac{D_i}{R_m}\right]^{\frac{1}{2}} \text{ and } t = \frac{2.55D_0}{2f\eta + 2.55}$$

where t, D_i, D_0, R_m, ,f and η have the meanings given in Clause 5.3.1.

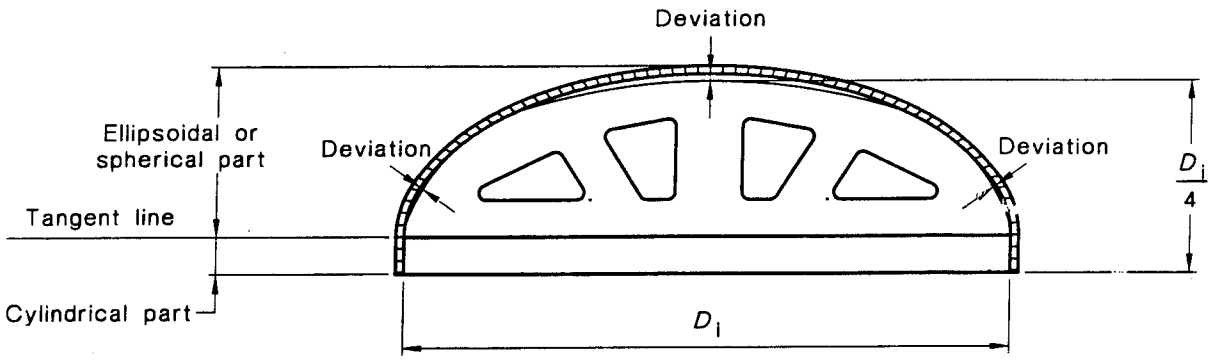
(ii) In accordance with Table 2.

b) In the spherical or ellipsoidal portion the minimum thickness at any thinned section shall be not less than the greater of the thicknesses given in (i) and (ii) below :

(i) 90 per cent of the thickness established in (a) above.
(ii) In accordance with Table 2.

NOTE

Parts described as 'ends' may include portions of the 'shell' e.g. where a shell has one or more knuckles formed into it to extend into the end(s).



NOTE

This Figure illustrates true ellipsoidal internal template of 2 to 1 ratio at the surface in position.

FIGURE 1 - True ellipsoidal internal template

5.4 Construction /Fabrication

5.4.1 *Form of ends*

Ends shall be concave to pressure, and shall have either spherical or ellipsoidal form.

The ellipsoidal form shall be of no more than 2 to 1 ratio at the internal surface, i.e. the internal height of the ends is not less than 25 per cent of the internal diameter.

A template of true form shall be used internally or externally to check the deviation from the true form. Any deviation measured perpendicular to the surface shall not exceed 1.25 per cent of the nominal external diameter of the container (see Figure 1)

5.4.2 *Pressure retaining joints*

5.4.2.1 General

The main longitudinal joint and circumferential joints shall be of welded construction by a machine process using automatic feed and guidance mechanisms. Other equivalent automatic processes, with the exception of resistance welding, may be used.

The main longitudinal joint and circumferential joints shall be made with welding variables verified by type testing in accordance with A.1 of Appendix A , and where welding procedures are changed, these shall be re-verified by further type testing in accordance with A.1 of Appendix A. The weld metal shall be compatible with the vessel material.

Misalignment of mating butt edges shall not exceed the following percentages of the nominal vessel thickness.

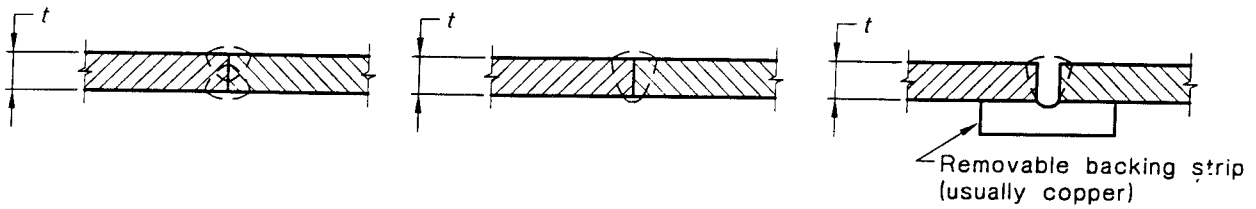
a) 15 per cent for square butt joint ; and
b) 25 per cent for Joggle-butt joint.

5.4.2.2 Main longitudinal joint

The main longitudinal joint shall be a full penetration butt weld. There shall be not more than one main longitudinal joint. Acceptable main longitudinal butt joints are as follows:

a) Double welded, close square [see Figure 2 (a)] ;
b) Single welded, close square [see Figure 2 (b)] ; and
c) Single welded, open square, with removable backing strip [see Figure 2(c)].

Where a backing strip is used, it shall be non-ferrous and shall be removed after welding.



(a) Double welded close square **(b) Single welded close square** **(c) Single welded open square**

FIGURE 2 - Same acceptable types of main butt longitudinal joint

5.4.2.3 Circumferential joints

There shall be not more than two circumferential joints. A circumsterential joint shall not lie in the hatched zone illustrated in Figure 3.

Some acceptable circumferential joints are as follows :

a) Butt joint (full penetration) as specified in 5.4.2.2 or with a retained backing strip ; and

b) Joggle-butt joint (full penetration) of the proportions given in Figure 4 with one member offset to form an integral internal backing strip.

Circumferential joggle-butt joint members shall be made with a uniform press fit at the weld root, and the offset shall be smooth and symmetrical without notches.

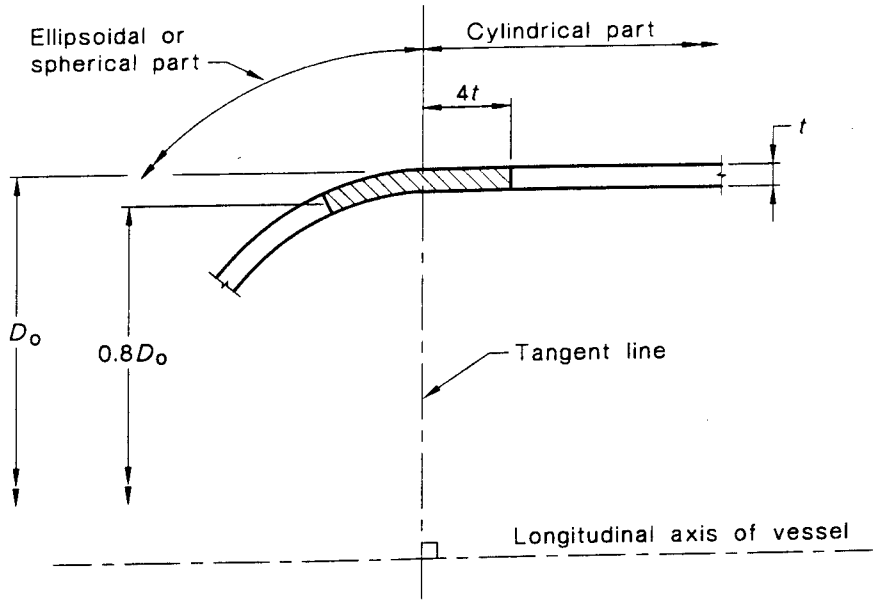


FIGURE 3 - Prohibited zone for circumferential joints

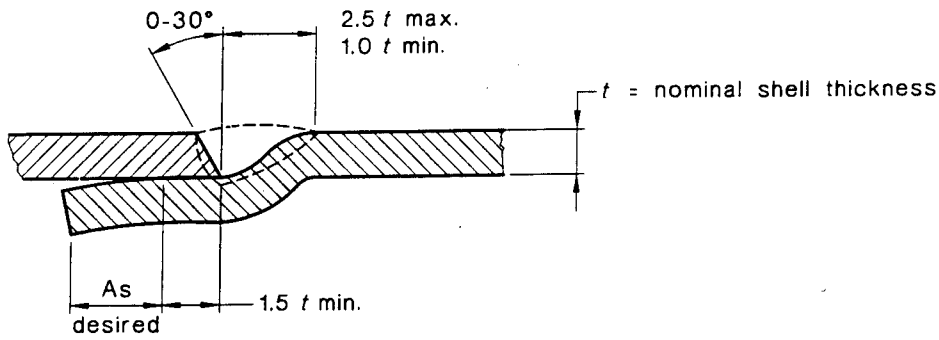


FIGURE 4 - Circumferential joggle-butt joint

5.4.3 *Openings*

Openings shall be provided for connections required in accordance with SLS ..... * Some acceptable types of connections are as follows :

a) Type for threaded connections (see Figure 5) ; and
b) Type for studded connections (see Figure 6).

NOTE

5.6 specifies that where an opening is for fitment of a studded multivalve connection certain markings are to be applied.

Connections of types other than given in Figures 5 and 6 shall comply with the requirements for openings specified in AS 1210 except that, where inserted non-circular pads for openings are to be provided, the following requirements shall apply :

a) Welds for attachment of the connection or pad to the shell shall be full penetration types.
b) The design of the connection or pad shall be verified by type testing in accordance with A.1 of Appendix A.

NOTE

This standard provides only for connections that can be considered to have sufficient reinforcement to allow ligament efficiencies to be disregarded.

c) Corners before welding shall be of not less than 6 mm radius.

Threads shall be clean cut, even, without checks and cut to gauge.

Threads and thread lengths for threaded connections shall be American National Gas Taper (NGT) in accordance with ANSI/CGA V-1.

The diameter of an opening in an end shall not exceed 50 per cent of the outside diameter of the vessel. The edge of any reinforced opening, or the edge of any reinforcement or welding thereto shall be not closer to the outside circumference of the end than 10 per cent of the outside diameter of the vessel, measured perpendicularly to the axis of the end.

The height of branches, bosses, adaptors, or similar pressure-retaining parts shall be not greater than 25 mm, measured radially from the external profile of the shell to the highest point of the part, as shown in Figures 5 and 6.

* LP Gas fuel systems for vehicle engines (under preparation)

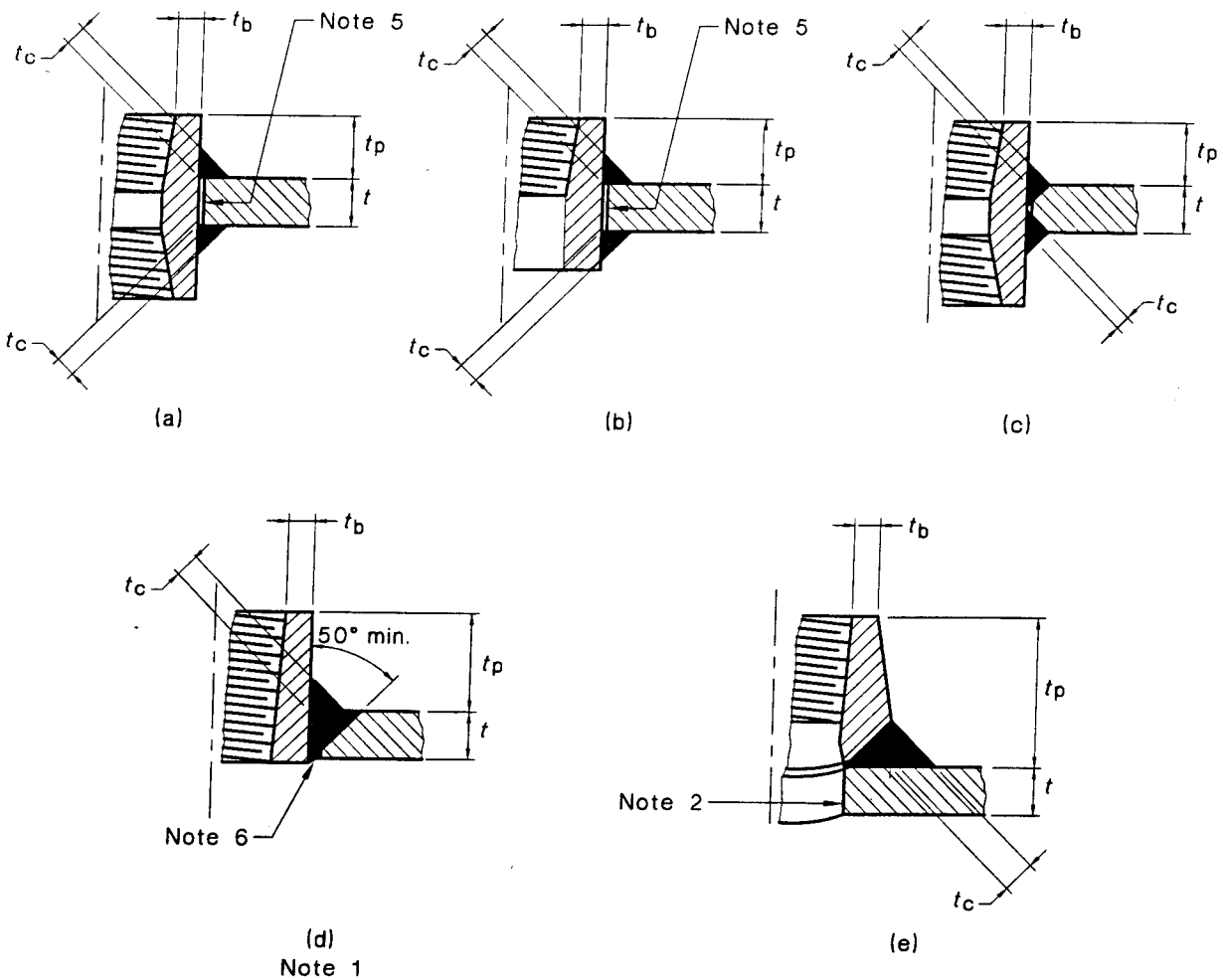


FIGURE 5 - Some acceptable types of welded attachment of threaded connections (see Figure 6 for notes)

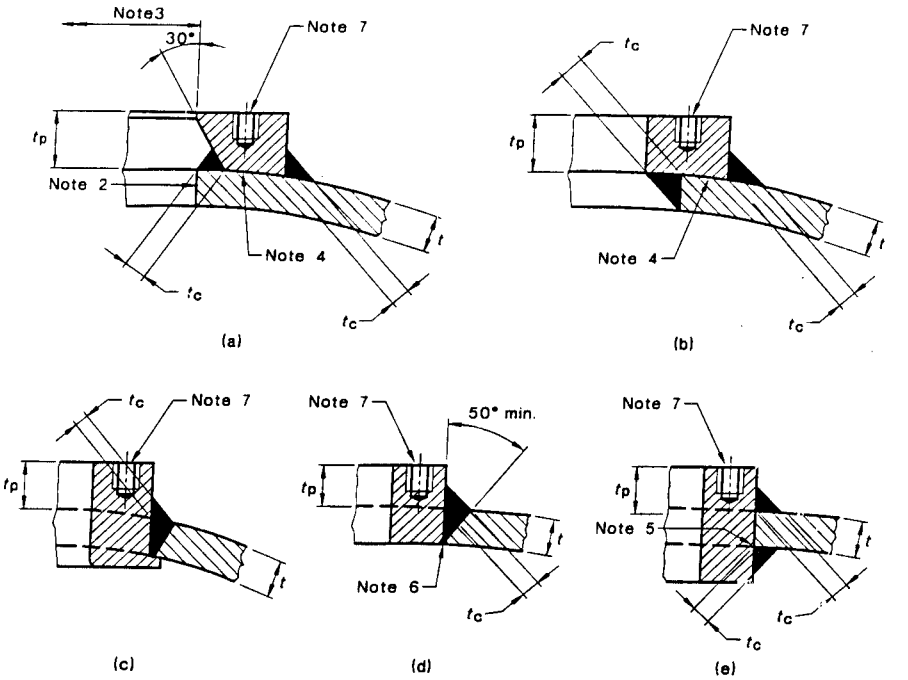


FIGURE 6 - Some acceptable types of studded connections

Notes to Figures 5 and 6

1 t = *nominal thickness of shell wall, in millimetres.*
$t_c \geq 0.7t$, $0.7t_c$ *(where applicable), or 6 mm, whichever is least.*
$t_p \leq 25$ *mm*
t_c = *0.5 (nominal OD of connection - maximum major diameter of thread), in millimetres.*

2 *The shell plate is to be examined visually to ensure there are no laminations at the hole [see Figures* ***5 (e)*** *and* ***6 (a)****].*

3 *The bore is to be sufficient to provide adequate access for sound deposition of the internal fillet. [see Figure* ***6 (a)****].*

4 *Full contact required between connection and shell; telltale hole may be necessary. [see Figure* ***6 (a)*** *and* ***6 (b)****]..*

5 *Root gap not to exceed t/2. [see Figure* ***5 (a)*** *and* ***5 (b)****].*

6 *Welded where necessary. [see Figures* ***5 (d)*** *and* ***6 (d)****].*

7 *There is to be not less than 3 mm of metal under any tapped hole. [see Figure* ***6(a)****,* ***6(b)****, 6(c),* ***6 (d)****, and* ***6 (e)****].*

5.4.4 *Attachment*

5.4.4.1 General attachments shall be provided as required in accordance with SLS.....*. Attachments shall be clear of longitudinal and circumferential joints and shall not prevent inspection of a pressure-retaining joint. Intermittent contact between an attachment and the vessel is permitted, i.e. by scalloped contact or attachment by ears, except where leak containment is a function of the joint.

* LP Gas fuel systems for vehicles engines (under preparation)

Non-pressure-retaining joints for joining of attachments directly to a pressure-retaining part shall be made by arc welding.

Joint shall be designed to prevent crevice corrosion, and shall be continuously welded at all points of contact with a pressure-retaining part.

Name plates and doubling plates shall comply with **5.4.4.6.**

NOTE

*SLS .... * specify the requirement for protection of the valves and connections, and for provision of leak containment from fittings, depending on the fuel vessel installation.*

5.4.4.2 Valve protecting attachments

There shall be provision for valve protection, either by a permanently attached valve guard or permanent attachments to which the valve protection is to be affixed. The throat thickness of welds for the provision of valve protection shall be not greater than the shell thickness.

Each vessel shall incorporate physical protection for its attached components. The protection provision shall be attached to the vessel in such a manner as would require the use of cutting implements or a unique tool for its removal, and shall be capable of withstanding, without permanent deformation, a static load of 150 kg applied from any direction to any position on the guard through a 75 mm square applicator plate. The protection guard shall be arranged so that no component will project beyond it (piping through the guard excepted).

Attachments to the vessel shall be tested by bending back by hammer blows, until they lie against the vessel surface. Any tearing or cracking of the pressure-retaining portion shall be cause for rejection of the design or process.

Any valve guard shall be of such dimensions as will ensure that the valve(s) fitted to the vessel lie wholly within the guard.

5.4.4.3 Mounting attachment

Mounting attachments shall not be welded directly to the shell. Where permanent attachments are provided they shall be attached to doubler pads which are not thinner than the shell or by other means which shall avoid point loading on the pressure container. The design and construction of mounting attachments shall be such that, when tested by bending back, no tearing or cracking of the pressure-retaining portion occurs. The mounting attachments shall comply with the strength requirements of SLS..... *

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* LP Gas fuel systems for vehicles engines (under preparation)

5.4.4.4 Welding to attachments

Welding carried out on attachments shall be completed prior to heat treatment (where required) and pressure testing or shall be not less than 20 mm from the junction of the attachment and the vessel. During such welding operations, satisfactory precautions shall be taken to ensure that naked flame, excess heat, or arcing does not come into contact with the pressure-retaining portion of the vessel.

5.4.4.5 Internal attachments

Internal attachments, e.g. liquid eductor tubes, shall be attached by continuous welding or equivalent process suitable for the application. The method of attachment shall give strength equivalent to that specified for mounting attachments.

5.4.5.6 Name plates and doubling pads

Name plates and doubling pads that follow the form of the pressure shell shall be welded to the vessel around their full periphery, and may require a telltale hole that is sealed by a soft and durable plug before the vessel is dispatched.

5.4.5 *Welding*

5.4.5.1 Supervision of welding

All welding shall be supervised by a person with appropriate training or experience for the form of construction and process of welding. The supervisor shall be a certified welding supervisor in accordance with AS 1796 or shall be otherwise acceptable to the inspection body.

5.4.5.2 Competence of welder

Each welder engaged in the welding of fuel vessels shall be competent in the task. Welder should be suitably trained and experienced and have passed a welder qualification test for the welding procedure being used.

Suitable training and experience can be achieved by appropriate certification in accordance with EN 287 or other industry based training.

5.4.5.3 Welding procedures

A written procedure shall be used which specifies limits on all welding parameters. The procedure shall include requirements for welded repairs.

5.4.5.4 Repair of welds

Unacceptable welding imperfections shall be removed and be rewelded in accordance with a qualified procedure, or the vessel shall be condemned. Any section repaired by welding shall be re-inspected in accordance with 7.1.6 and 7.2.

A circumferential joint found by spot radiography to contain an unacceptable imperfection shall have the entire joint radiographed and all unacceptable imperfections repaired by cutting out and re-welding, or the entire joint shall be cut out and welded.

Not more than two attempts shall be made to repair any one section of weld. Repaired welds shall be radiographed in accordance with 7.1.6 as appropriate.

Postweld heat treatment of carbon steel vessels shall follow any repair welding except that heat treatment is not considered necessary following minor repair welding of pinholes exposed by the leakage test where the depth of weld metal removed is not greater than half the shell thickness, and the length does not exceed 12 mm.

5.4.6 *Surface coating and colour*

The surface coating shall provide corrosion protection not inferior to following :

a) Base coat of any inhibited type primer applied to the surface prepared by abrasive blasting to not less than Class 2 in accordance with AS 1627.4 ; and

b) Top coat of high grade paint, sufficient to give a total dry film thickness of not less than 25 μm.

The colour of the finished vessel shall be of a light colour, preferably white or silver grey.

NOTES

1 *Silver grey is taken to include the colour obtained by application of Aluminium paint consisting of a suitable paint vehicle in which powdered leafing aluminium pigment is dispersed, and also that colour obtained by clean galvanizing of the surface of cylinder.*

2 *The colour is specified only to minimize heat intake of the vessel and not for identification of the contents.*

6 MARKING

Each fuel vessel shall carry permanent and legible marking applied by the manufacturer including all of the following information :

a) Manufacturer's mark ;

b) Owner's mark (where applicable).

c) Serial number ;

d) Designation of the vessel (see 4) ;

e) The water capacity, in litres (see 3.1) being the minimum design capacity ;

f) Test pressure, in megapascals ;

g) Date of original pressure test (month and year) and the period of validity ;

h) An orientation mark where such a mark is part of the manufacturer's specification ;

j) Where the vessel has a thickness of the cylindrical part less than 2.2 mm or the vessel is constructed of grade 304 stainless steel, the following marking :
THIS VESSEL SHALL BE INSTALLED WITHIN A COMPARTMENT INSIDE THE VEHICLE.

k) Design registration/notification number ; and

l) The identification mark of the inspection body.

NOTES

1 *See SLS ..... * for provisions on visibility of markings on fuel vessels in the installed position.*

2 *Markings may be on an attached plate, but to facilitate tracing of the origin of a fuel vessel at least the serial number and manufacturer's mark be stamped on a permanent attachment to the vessel, and these same markings be on any plate attached by other than welding. It is also desirable that markings on any attached plate withstand a fire.*

3 *Other type of marking that is acceptable to the Sri Lanka Standards Institution can be used by manufacturer.*

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* Methods of test for conversion of automotives to bi-fuel (Petrol-LPG) propulsion systems.(under preparation)

A vessel with a studded multivalve connection shall carry marking to identify the model of multivalve for which the opening is designed. An adhesive label is an acceptable means of identifying the model of multivalve.

NOTE

AS 2666 specifies paper for pressure sensitive adhesive label stock.

7. INSPECTION AND TESTING

7.1 Radiographic examination

7.1.1 *Personnel and operator requirements*

Personnel responsible for the radiographic examination, interpretation, evaluation for compliance and reporting shall have qualifications and experience acceptance to the inspection body.

7.1.2 *Frequency and extent*

The frequencies and extent of radiographic examination shall be as follows :

a) Main longitudinal weld, where the value used for efficiency of the welded joint is 1.0 (see 5.3.1) ; all of the main longitudinal weld of every vessel and 50 mm of the circumferential weld(s) in each direction from the intersection ;

b) Main longitudinal weld. where the value used for efficiency of the welded joint is 0.9 (see 5.3.1) ; 150 mm of each end of the longitudinal weld shall be radiographed on one vessel from each 50 (or part thereof) consecutively welded vessels, and as specified in item (d) ;

c) Circumferential weld(s) 100 mm of each circumferential weld of one vessel randomly taken from each 2000 (or part thereof) consecutively circumferentially welded vessels, and as specified in item (d).

Where there is an intersection of the circumferential weld and longitudinal weld. the radiograph of the circumferential weld shall be at the junction ;

NOTE

Radiography of the circumferential and longitudinal welds may be simultaneous.

d) On re-commencement of welding operations following a shutdown exceeding four hours; the extent of radiographic examination specified in items (b) or (c) as appropriate, applied to one vessel from the first five vessels produced on re-starting operations ; and

e) Attachment welding that is for a non-circular inserted pad and is substantially parallel to the longitudinal axis of the vessel ; the entire length of the longitudinal portion(s) of weld(s) at the same frequency specified for the main longitudinal weld [see items (a) and (b)] on the barrel section.

7.1.3 *Methods and sensitivity*

Radiographic examination shall be carried out as follows :

a) Where there is adequate access to the inside of the vessel, Method XR1/S or XR2/S of SLS..... * shall be carried out as appropriate ;

b) Where there is not adequate access to the inside of the vessel, Method XR1/DWS or XR2/DWS of SLS..... * shall be carried out as appropriate; and

c) Sensitivity shall be such as will ensure that the IQI wire number specified in Table 3 is visible.

TABLE 3 - IQI wire number

Joint	Wire number (Note 1)			
	Single weld thickness (Note 2) mm			
	≤ 3.5	> 3.5 ≤ 4.7	> 4.7 ≤ 6.3	> 6.3
(1)	(2)	(3)	(4)	(5)
Longitudinal	16	15	14	See AS 4037
Circumferential	15	14	13	See AS 4037

NOTES

1 *The wire number refers to those specified in* ***AS 2177.2.***

2 *The single weld thickness is taken to equal the nominal thickness of the plate plus allowable reinforcement on each side but excluding any joggle. Allowable reinforcement is taken to be 1 mm each side for up to 3 mm nominal shell thickness, and 1.5 mm each side for nominal shell thickness of 3 mm and up to 6 mm.*

* Methods of test for conversion of automotives to bi-fuel (Petrol-LPG) propulsion systems.(under preparation)

7.1.4 *Acceptance standards*

The weld shall fully penetrate the root, and any section of weld showing any of the following imperfections, as defined in AS 2812, shall not be acceptable :

a) Cracks, lack of fusion or lack of penetration ;

b) Linear slag inclusion or localized porosity, i.e. separated from an adjacent pore by 25 mm or more, having a length of greater than *tl* 3 ;

c) Group of slag inclusions or porosity in alignment having an aggregate length greater than *t* in a weld length of 12*t* and where such defects are not separated by at least 6*D* of acceptable weld metal, and any isolated slag inclusion or porosity within a group having a length greater than *t* / 3 ;

d) Uniform porosity including any clustered porosity having a total projected area on the radiographic film greater than 1.50*t* mm measured over 150 mm length of weld ; and

e) Clustered porosity in any length of weld equal to 25 mm or 2*t*, whichever is the smaller, and which exceeds 4 times the limit permitted for uniform porosity.

NOTES

1 *Porosity charts for some of the above imperfections are provided in AS 4037, although most of these charts are for thicknesses greater than would apply for the vessels covered by this standard. The porosity charts provided in gas cylinder standards published prior to 1982 are considered not to be suitable.*

2 *In the above requirements, t = thickness of the weld, and D = the dimension of the largest imperfection in a group.*

7.1.5 *Treatment of imperfections disclosed by radiographic examination*

Imperfections as specified in 7.1.4 and disclosed by radiographic examination shall required the subject vessel to be deemed unacceptable. Vessels which are deemed unacceptable shall be condemned, or be repaired in accordance with 5.4.5.3.

Where a vessel deemed unacceptable represents a batch, the entire batch shall be deemed unacceptable or radiographic examination shall be carried out on the weld(s) under consideration of two additional vessels. These two vessels shall be from the group of vessels consecutively welded from not more than 20 earlier and not more than 20 later than the failed test piece.

The batch shall then be assessed as follows :

a) Where the additional radiographic examination of both vessels discloses no imperfections as specified in 7.1.4 that batch shall be deemed to comply with the requirements for radiographic examination ; and

b) Where the additional radiographic examination discloses any imperfections as specified in 7.1.4 those vessels shall be deemed unacceptable and radiographic examination shall be carried out on all the weld(s) (other than welds for attachments) under consideration of all remaining vessels of that batch, or all remaining vessels shall be deemed unacceptable.

7.1.6 *Radiography of repairs*

Joints or sections of joints rewelded or repaired to remove defects specified in 7.1.4 shall be radiographed. Each radiograph shall include the identification symbol R1 or R2 to denote that a first or second weld repair has been carried out in the length of weld represented by that radiograph.

7.2 Visual inspection

7.2.1 *Welded cylindrical section and unassembled ends*

The welded cylindrical section, and unassembled ends, shall have examined and complied with the following :

a) Thickness, which shall be in accordance with 5.3.1 or 5.3.2 as appropriate ;

b) Internal and external surfaces, which shall be free from detrimental scoring, gathering, and local irregularities ; and

c) Welds, which shall not have cracks, incomplete penetration, lack of fusion, root concavity, sagging, excess misalignment (see 5.4.2) or intermittent undercut exceeding a depth of 0.2 mm. The surface of the weld(s) along and across the joint shall be reasonably smooth and free from sharp irregularities, grooves, or depressions, and shall merge smoothly into the plate surface.

Defective components shall not be acceptable. Unacceptable welding imperfections may be rectified in accordance with the requirements of the inspector and 5.4.5.4.

7.2.2 *Finished fuel vessels*

Finished fuel vessels shall have the following examined :

a) External surfaces, which shall not have detrimental scoring, gathering or local irregularities ;

b) Circularity, which shall not deviate from a true diameter by more than 1 per cent of the mean external diameter ; and

c) Welds, which shall comply with the requirements of **5.4.2** or **5.4.3** as appropriate, and **7.2.1 (c)**. For stainless steel vessels, welds on the external surface shall not have scale, Excessive welding scale including welding heat scale may cause pitting corrosion when the vessel is in service.

Defective vessels shall not be acceptable. Unacceptable welding imperfections may be rectified in accordance with the requirements of the inspector and **5.4.5.4.**

7.3 Mechanical tests

7.3.1 *General*

When determined in accordance with the requirements of this **7.3.1** the yield strength, tensile strength and total elongation values shall comply with the requirements of **5.1.1.4** and **5.2.1.3** as appropriate.

When the required test results are not achieved, retests may be carried out in accordance with **7.3.8.**

7.3.2 *Test specimens*

Test specimens shall be representative of the material, the manufacturing process, the heat treatment process and any other process that may alter the materials properties.

At least one vessel randomly sampled following any heat treatment but prior to or after pressure testing from each batch of 200 vessels (or part thereof) shall be used to provide the test specimens required.

Test specimens, other than from inserted non-circular pad openings for which additional bend tests are required, shall be taken from locations indicated in Appendix C for the particular vessel construction.

NOTES

1 *For test sample purposes 'batch' means vessels made consecutively from the same steel heat, by the same process and production run, heat-treated by the same process, and with the same welding control settings.*

2 *The required test specimens may also be obtained from test coupons attached to the sections being welded to allow continuous welding of the joint.*

7.3.3 *Tensile tests of parent metal*

The following properties of the parent metal shall be assessed in accordance with SLS 978.

a) Yield strength ;

b) Tensile strength ; and

c) Total elongation.

The test piece shall comply with the dimensions of the 12.5 nominal width test piece for a test piece of rectangular cross-section (reduced section and parallel sided) of SLS 978 (i.e. 50 mm nominal gauge length) and shall be prepared in accordance with that Standard.

7.3.4 *Transverse tensile test of main longitudinal joint*

The main longitudinal joint shall be tested in accordance with SLS ..... * with weld reinforcement retained or dressed off, as appropriate. The test piece shall be straightened by a gradual application of force and not by blows. The tensile strength obtained shall be not less than the minimum tensile strength used in the design calculations of **7.3.1** and **7.3.2.**

* Methods of test for conversion of automotives to bi-fuel (Petrol-LPG) propulsion systems. (under preparation)

7.3.5 *Tensile test of a circumferential joint*

Where the welding procedure for any circumferential joint differs from the procedure for the main longitudinal joint, or where there is no main longitudinal joint, a circumferential joint shall be tested in accordance with **SLS .....*** .

NOTE

The welding procedure for the circumferential joint is considered to be different from the welding procedure of the longitudinal joint if any of the following items in the procedure specification differ.

a) Welding process, position, current, voltage or speed ; or

b) Welding wire diameter and classification ; or

c) Flux type.

The tensile test value shall be not less than that value used for in **5.3.1** where there are two circumferential joints, the test specimens shall be taken from alternately positioned joints on successive sampled vessels.

7.3.6 *Bend test(s) of longitudinal joints*

The main longitudinal weld shall be tested in accordance with **SLS .....** * with weld reinforcement removed and with the root of the weld of a single-sided weld in tension. the diameter of the former shall be equal to four times the specimen thickness, and the bend shall be continued until the limbs of the specimen are parallel. For a double-sided weld, the test shall be applied for each side of the weld with the weld reinforcement removed on both sides. The bend test dimensions shall be in accordance with the requirements of face and root bend test specimens for the transverse guided bend test of **SLS..... *.** The test shall be passed if no cracks or unacceptable imperfections that exceed 3 mm in length become apparent on the convex surface.

Any attachment weld or a non-circular inserted pad, where more than 20 mm of weld is substantially parallel to the longitudinal axis of the vessel, shall be tested as follows :

a) At least one test specimen shall be taken from each long edge of the attachment. Where weld length permits, one additional test specimen shall be taken from each long edge at spacing to be representative of all substantially parallel sections of the weld :

b) The width of the bend test piece shall be not less than 30 mm ; and

c) Testing shall be completed by bending the test piece to an angle of 90 degrees, without use of a former. The root of the weld shall be located so that it is in tension.

* Methods of test for conversion of automotives to bi-fuel (Petrol-LPG) propulsion systems.(under preparation)

7.3.7 *Bend test of circumferential joint*

The test shall be in accordance with SLS ..... * with the root of the weld in tension, and the diameter of the former equal to four times the specimen thickness.

Where there are two circumferential joints, the test specimens shall be taken from alternate joints on successive sampled cylinders. The test shall be passed if no cracks or unacceptable imperfections that exceed 4 mm in length become apparent on the convex surface.

7.3.8 Retests of mechanical properties

If any piece fails a test for mechanical properties, that test may be repeated on test specimens taken from each of two further vessels taken from the batch represented. These two vessels shall be from the group of vessels consecutively welded from not more than 20 earlier and not more than 20 later than the failed test piece. If both test pieces pass the repeated test, the batch represented shall be deemed to comply with the requirement(s) of the test. If either test piece fails, the batch shall be rejected, or if appropriate re-heat treated prior to further tests.

Following any re-heat treatment, mechanical properties shall be determined by tests in accordance with 7.3.1 except that at least two vessels randomly taken from the remainder of the batch under test shall be used to provide test specimens (to represent each of the two vessels) as required by 7.3.3 to 7.3.7. If any piece fails a test, the entire batch shall be rejected and each vessel shall be rendered unusable.

7.4 Pressure tests

7.4.1 *General*

Every vessel shall be proof-tested and leakage-tested, and that testing shall be carried out after completion of all forming, welding and heat treatment operations, and before application of any surface coating. Any vessel that leaks or develops a visible bulge at any point shall be rejected and rendered unusable, except that leaking welds may be repaired as specifically provided in 5.4.5.4.

7.4.2 *Proof test*

The proof test shall be carried out as per SLS .....* .

NOTE

The proof test of fuel vessels is traditionally by hydrostatic means, but it is not intended that this standard prohibit pneumatic testing. Pneumatic testing has particular hazards, and shall be carried out in accordance with AS 4037.

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* Methods of test for conversion of automotives to bi-fuel (Petrol-LPG) propulsion systems. (under preparation)

The pressure shall be raised to the test pressure of 3.3 MPa under safe and proper control. and shall be maintained for not less than 30 s.

7.4.3 *Leakage test*

Every vessel shall be leakage-tested after satisfactory completion of the pressure test specified in 7.4.2 and prior to any surface coating. Each fuel vessel shall be tested for leakage by immersion in a liquid or by other suitable means acceptable to the inspection body while subjected to an internal air pressure of 2.3 ± 0.05 MPa. When the fuel vessel has contained moisture, the test shall follow positive internal drying.

NOTE

*Where the vessel manufacturer supplies the vessel complete with fittings, this test may be concurrent with the test for overall integrity of the vessel and fittings specified in SLS..... *.*

7.5 Overall quality control

Production vessels shall be of equivalent quality to the vessels which passed type tests. The geometry, materials, processes, weld quality, shape and size, and other features affection performance shall be equivalent to the features on successfully type-tested vessels.

If any of the above features are changed in a manner that may affect performance, the type tests shall be repeated (see Appendix A).

8 RECORD AND TEST CERTIFICATES

The fuel vessel manufacturer shall prepare a suitable certificate, a copy of which shall be retained by the manufacturer for not less than 11 years except that where it is known a fuel vessel has been rendered unusable the certificate need no longer be retained. The following data shall be recorded. and the certificate shall be signed by the authorized inspector:

NOTE

One certificate may be used to record data for a series of fuel vessels manufactured under identical conditions by the same manufacturer, provided that the serial number of each fuel vessel is listed.

a) The serial number (s) of vessel (s) represented in this certificate ;

b) Identification of material and certificate of analysis covering the strip, plate or sheet from which the particular fuel vessels were made ;

* Methods of test for conversion of automotives to bi-fuel (Petrol-LPG) propulsion systems. (under preparation)

c) Result of tensile test on the parent metal ;

d) Results on the tensile tests on the welded joint ;

e) Results of the bend tests on the welded joints ;

f) The designed water capacity, in litres to three significant figures, any rounding being to **CS 102** ;

g) Results of the pressure test ;

h) The tests performed and date and results of type tests ;

j) Minimum design thickness ;

k) Results of any radiographic examination of the weld ; and

l) The thread form of screwed openings.

9 DESPATCH

Vessels shall be despatched free of internal foreign materials, with all openings sealed to prevent the ingress of airborne moisture and foreign materials.

NOTE

Appendix ***B*** *provides guidance on tests and procedures for vessels supplied valved-up and suitable for installation in accordance with* ***SLS*** ..... * *without further pre-installation testing.*

* LP Gas fuel systems for vehicle engines (under preparation)

APPENDIX A

TYPE TESTS

A.1 GENERAL

Type tests shall be carried out

a) for each new design ; or

b) for any previously type-tested vessel where weld variables (see Note 1), the materials (see Note 2), or other significant change in design or fabrication procedures have been made necessitating re-verification.

The test vessels completely finished with all markings (see **5.6**) shall be randomly selected from the first 50 vessels manufactured (being of one batch) and shall be subjected to the following tests :

a) A stretch test on one vessel in accordance with **A.2.** If the vessel fails the test the design shall be rejected, except that two further vessels selected at random from the batch may be stretch-tested. If either additional vessel fails to pass the test, the design shall be rejected and every vessel to that design shall be rejected and rendered unusable. If both vessels pass the test, the design shall be deemed to have passed this test ;

b) A hoop stress test on one vessel in accordance with **A.3.** If the vessel fails the test the design shall be rejected, except that two further vessels selected at random from the batch may be tested. If either additional vessel fails to pass the test, the design shall be rejected and every vessel to that design shall be rejected and rendered unusable. If both vessels pass the test, the design shall be deemed to have passed this test ;

c) Pulsation tests on each of three vessels in accordance with **A.4** ;

d) Where the vessel incorporates non-circular connections or inserted non-circular pads for openings, an external load test on one vessel in accordance with **A.5** ; and

e) Where the vessel incorporates fittings which in the 'as installed' state protrude more than 35 mm beyond the profile of the shell external surface, a hammer test in accordance with B.3(c).

If a vessel fails any of the type tests for design, the design shall be rejected except that additional type tests at the discretion of the inspection body may be carried out to verify the design. If the vessel fails any test to verify welding variables, those weld settings shall not be acceptable.

At least one of the three most recent pulsation-tested vessels shall be retained by the manufacturer to provide evidence for compliance with 7.5. Other vessels subjected to type testing shall be rendered unusable on completion of the tests.

NOTES

1 *Clause 5.4.2.1 specifies re-verification of a welding procedure by type testing where the welding procedure changed.*

2 *An increase in carbon content of 0.01 per cent or greater of stainless steel used in a verified design could cause the weld-heat-affected zones to become susceptible to inter granular corrosion without change in welding variables. Carbon content of stainless steel is a verifiable parameter for each vessel batch. Verification may be by reference to the steelmaker's certificate.*

A.2 STRETCH TEST

The vessel shall be hudrostatically stretch-tested in accordance with the stretch test requirements specified in SLS.....* . The vessel shall not have been subjected to any internal pressure exceeding 3.0 MPa subsequent to any final heat treatment or re-heat treatment provided for in 7.3.8 and 5.1.3. The test pressure of 3.3 MPa shall be maintained for not less than 30 s before any stretch is measured. Any vessel which leaks, develops a visible bulge, or suffers a permanent increase of internal volume greater than 1 000 of the original internal volume shall be rejected and rendered unusable, except as specifically provided under 5.4.5.4.

NOTE

Where the internal design is such as will allow air to be trapped when the vessel is filled with water, e.g. by internal bosses it is recommended that the water jacket method be used to carry out stretch test, or special arrangements be made to vent all trapped air.

A.3 HOOP STRESS TEST

The vessel shall be hudrostatically pressurized until rupture occurs. The pressure immediately before rupture is such that the nominal hoop stress as calculated by the following equation is not less than 95 per cent of the minimum tensile strength (R_m) used in 5.3.1.

$$f_b = \frac{P_b \, D_i}{2t^1}$$

* Methods of test for conversion of automotives to bi-fuel (Petrol-LPG) propulsion systems. (under preparation)

where

f_b = nominal hoop stress, in megapascals

P_b = hydrostatic pressure at which rupture occurs, or at which $f_b \geq 0.95\, R_m$ in megapascals

D_i = nominal internal diameter of vessel, in millimetres

t^1 = minimum manufacturing thickness as specified on the drawing (including corrosion allowance if any) of the wall of the fuel vessel, in millimetres.

The vessel shall be considered to fail the test if on rupture the vessel fragments, or if the nominal hoop stress (f_b) does not equal or exceed 95 per cent of the tensile strength (R_m) used in 5.3.1.

A.4 PULSATION TEST

The maximum and minimum wall thickness for each vessel to be tested shall be determined prior to the test.

The vessel shall be in the condition ready for installation (i.e heat treated if applicable, pressure tested, all attachments on, and any grit blasting or similar surface treatment, as appropriate, completed) and shall be subjected to 10 000 cycles of fluid pressurization at a frequency not exceeding 0.25 Hz. The difference between maximum and minimum pressure shall be not less than 2.64 MPa and the minimum pressure shall not exceed 0.33 MPa. the fluid used shall be a non-corrosive liquid, and if necessary shall be cooled to ensure that the outside surface of the fuel vessel does not exceed 50 ^{0}C.

The vessel shall be considered to fail the test if a leak, bulging, cracking or other defects indicative of the onset of failure occurs, Inspection for defects shall be by visual means, or where specified by the inspection body, by destructive or non-destructive methods.

A.5 NON-CIRCULAR INSERTED PAD TEST

The vessel shall be subjected to deformation so that the inserted pad is displaced towards the longitudinal axis of the vessel by a distance not less the 25 per cent of the external diameter of the vessel shell. The deformation may be carried out with the interior of the vessel open to the atmosphere. on completion of the deformation , the vessel shall be pressurized to an internal air pressure of 0.35 Mpa nominal. where a vessel has leakage resulting from deformation of the welds, the design shall be deemed to have failed this test.

APPENDIX B

INFORMATION ON TESTS AND FITTINGS FOR CONTAINER SUBASSEMBLIES TO BE SUPPLIED TO AN INSTALLER
(Normative)

B.1 GENERAL

SLS .....* specify that certain tests be carried out before an LP Gas fuel installation is commissioned in a vehicle. Vessel manufacturers may desire to supply vessels to an installer as a valved-up package. The manufacturer may therefore desire to carry out some of the tests that would otherwise need to be carried out by the installer (see Clause **7.4.3**).

NOTE

SLS..... states that any leakage test is invalidated if the joint tested is subsequently dismantled.*

B.2 TESTS

Tests on the container subassembly are specified in **SLS .....***

B.3 FITTINGS

Valves, gauges and subcompartments may be supplied already fitted by the vessel manufacturer, or may be fitted by the installer.

Fittings (other than subcompartments but including multivalves) shall

a) be of a type, number location and size complying with **SLS .....*** and be a type specifically described as suitable by the valve or vessel manufacturer, and be acceptable to the inspection body, for the particular vessel ;

b) be of a design and construction such that, when fitted to the vessel and subjected to impact conditions, any fracturing or distortion of the fitting will not result in leakage that is uncontrolled or in excess of the maximum flow permitted by the excess flow valve ;

c) not protrude more than 35 mm from the pressure-retaining portion of the vessel, except where the vessel manufacturer has demonstrated to the satisfaction of the inspection body that, when the fitting is tested to failure by application of impacts to the protruding portion, leakage will not result exceeding that specified in (b) ; and

d) Where so specified in SLS .....* be internal to the vessel.

The safety valve (which shall not be fitted with an excess flow valve) shall be protected from collision damage by being within the perimeter of the vessel or within a welded boss.

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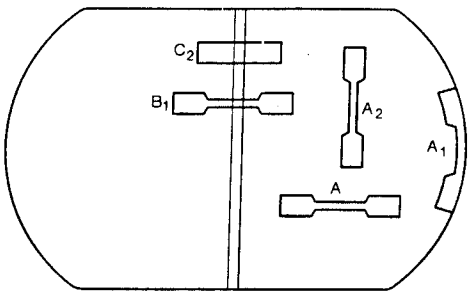
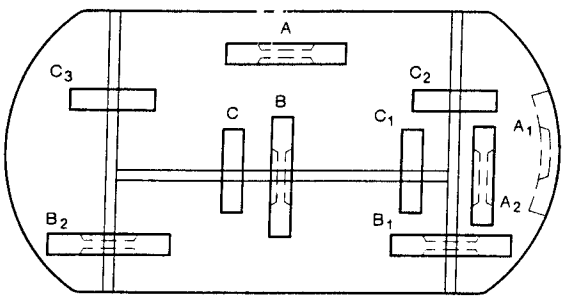
* LP Gas fuel systems for vehicle engines (under preparation)

APPENDIX C
LOCATION OF TEST SPECIMENS CUT FROM VESSEL
(Normative)



(a) Large 2-piece vessel



(b) 3-piece vessel

LEGEND :

A	Cylindrical parent metal tensile specimen
A_1	End parent metal tensile specimen
A_2	Additional parent metal tensile specimen (for stainless vessels only)
B	Transverse longitudinal weld specimen
B_1	Transverse circumferential weld specimen
B_2	Transverse circumferential weld specimen on second vessel
C	Longitudinal weld bend specimen
C_1	Second longitudinal weld bend specimen for double sided weld
C_2	Circumferential weld bend specimen
C_3	Circumferential weld bend specimen on second vessel

NOTE

Duplicated test specimens may need to be taken to qualify each heat or batch of material used for fabrication of the vessels represented.

FIGURE 7 - Location of test specimens

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