SPECIFICATIONS FOR HIGH DENSITY POLYETHYLENE (HDPE) PIPES & FITTINGS FOR WATER SUPPLY APPLICATIONS

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SPECIFICATIONS FOR HIGH DENSITY POLYETHYLENE (HDPE) PIPES, FITTINGS, SPECIALS, ACCESSORIES FOR WATER SUPPLY APPLICATIONS

TABLE OF CONTENTS

2.0 TECHNICAL REQUIREMENTS FOR HIGH DENSITY POLYETHYLENE PIPES AND FITTINGS FOR WATER SUPPLY APPLICATIONS

1.0 GENERAL

1.1 Ambient Conditions

All items of materials and equipment shall be in every respect suitable for storage, installation, use and operation in the conditions of temperature and humidity appertaining in Sri Lanka.

The annual average temperature is 35^0C while the relative humidity varies generally from 70% during the day to 90% at night. The pH of potable water to be conveyed ranges from 6.5 – 7.9.

The climate of Sri Lanka is at times, hot and the sunlight is intense. Ambient temperature of up to 40^0C is possible and surfaces exposed to the sunlight may rise to even higher temperatures.

1.2 Suitability for Potable Water

Pipes and pipeline components, including their protective coatings and joint materials, that will or may come into contact with potable water shall not constitute a toxic hazard; shall not support microbial growth; shall not cause taste or odour, cloudiness or discolouration of the water and shall be approved by recognized certifying authority listed below, as being suitable for using portable water supply schemes.

- NSF International, World Headquarters, 789 N. Dixboro Road, Ann Arbor, MI 48105 USA
- Water Regulations Advisory Scheme (WRAS), Fern Close, Pen-Y-Fan Industrial Estate, Oakdale, Gwent, UK, NP11 3EH
- IAPMO Research & Testing, 5001 E, Philadelphia St., Ontario, CA 91761-USA

1.3 Definitions

The definitions given in the relevant standards which are referred to in the specification shall apply for the terms used in this specification.

1.4 Materials

Material shall be as specified in clause 2.5 of the Technical Specification.

1.5 Inspection and Testing

The Contractor shall supply, furnish and prepare the necessary test pieces and samples of all materials and supply the labour facilities and appliances for such testing as may be required to be carried out on his premises according to this specification. If there are no facilities at his own works for making the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere.

The Engineer or his representative or nominated inspection authority shall have full access to all parts of the plant that are concerned with the testing, furnishing or preparation of materials for the performance and testing of work under this Specification.

The Contractor shall furnish the Engineer or his representative or nominal inspection authority with reasonable facilities and space (without charge) for the inspection, testing and obtaining of such information, as he desires regarding the character of material in use and the progress and manner of the work.

The manufacturer shall provide results of tests conducted, in accordance with the BSEN or ISO standards given in the Specification.

1.6 Marking of Pipes, Fittings and Specials

All markings described below shall be legible and indelible unless otherwise specified.

All pipes and fittings shall be marked as specified in clause 12 of ISO 4427 - 2:2019 or clause 11 of BSEN 12201-2:2011 and as specified in the Table 1 hereof. The manufacturer's name, Identification mark, the PN rating and SDR shall be marked legibly and indelibly on the pipes together with the information shown below.

Markings shall be in such a way that it does not initiate cracks or other types of failures and that normal storage, weathering, handling, installation and use shall not affect the legibility of the markings.

During the manufacturing process, the pipe should be marked with pertinent product and process information at approximately 1m intervals along the pipe.

Specifications require at least the following information to be included.

- Manufacturer's identification or logo,
- Standard number (Specification number)
- The designation of the pipe material (PE 100).
- The dimensions (Nominal outside diameter, nominal wall thickness).
- Third party certification mark by the inspection agency approved by the Engineer.
- The Production Period (date and code).
- The Nominal Pressure (PN)
- Standard Dimension Ratio (SDR)

The marking shall be printed in the following colours:

PE 100	SDR 11	Black
	SDR 17.6	Red
	SDR 26	Yellow
	SDR 33	Orange

In addition to the markings specified above, following information shall be marked on the fittings:

- In case of a bend, bending angle and incase of unequal tee branch line size and main line size.
- Pressure rating at relevant temperature
- Standard Dimension Ratio (SDR)
- Fusion time (Seconds)
- Cooling time (minutes)
- System voltage
- Moulded-in identification and appropriate product information
- Terminal pin size of electro fusion fittings

Table 1 – Marking

Item	Diameter (mm)	Details required	Lettering Heights Details (mm)
Pipe Lengths(at intervals not more than 3m)	above 355	"NWSDB"; "WATER"(at 3m intervals) "SDR" Production Date, PN outside diameter, nominal wall thickness and other (at 3 m intervals)	50
	160 to 355 (both inclusive)	as above	25
	50 to 160	as above	10
	Below 50	as above (except "NWSDB")	05
		"NWSDB"	10
Fittings & Specials	Above 355	"NWSDB", "WATER" "SDR" , Production date, PN, outside diameter and other	25
	160 to 355 (both inclusive)	As above (except "NWSDB")	10
		"NWSDB"	25
	50 to 160	As above	10
	Below 50	As above (except "NWSDB")	05
		"NWSDB"	10

All fittings must be packed in such a way to allow instant use on site without additional cleaning. All electro-fusion fittings must be packed in transparent protective bags. The electro-fusion fittings must then be packed in carton boxes. The Contractor shall label and clearly mark all crates and boxes legibly and indelibly as specified in the notes forming a part of this Specification.

All fittings shall be marked with the corresponding item number in the Bills of Quantities or any other number specified by the Engineer. An individual data carrier card in compliance with ISO 7810 and ISO 7811 containing a magnetic strip and appropriate bar codes as well as manual setting information for data transfer purposes must be supplied with each item as appropriately.

1.7 Protection during Delivery

The Contractor shall provide methodology of protection of pipes and fittings, to the approval of the Engineer and obtain written approval prior to the pipes and fittings leaving the place of manufacture and shall maintain such protection until the items reach their destination in order to guard effectively against damage during handling, transit and storage and ingress of foreign matter inside the pipes & fittings.

All fittings shall be securely packed in crates and boxes to prevent damage during delivery. The cost of packing shall be deemed to be included in the Contract Rates and crates will not be returned.

The manufacturer shall provide necessary details to the shipping line on precautions to be taken during loading/unloading, handling & transport of the pipes & fittings and other components, in the sea. Manufacturer shall provide to the purchaser a set of recommendations of manufacturer for handling, loading, unloading, transporting and storing of polyethylene pipes and fittings.

1.8 Storing, Handling and Hauling of Pipes, Fittings and Specials

All materials shall be stored in an approved location and in such a manner as to preserve their quality and condition as recommended by the manufacturer.

All materials should be carefully inspected at the time of delivery and any defective material set aside before accepting the delivery into stores. Any such defects should be notified to the manufacturer immediately.

Materials and components shall be handled in such a manner as to avoid any damage or contamination and in accordance with all applicable manufacturers recommendations.

1.8.1 General Principles

The recommendations for handling and storage of HDPE pipes shall have greater care in the handling of HDPE pipe coils too shall have greater care as of pipes of similar wall thickness.

Polyethylene is a tough resilient material which is relatively light and easy to handle although it is prone to damage through scoring by sharp objects. Therefore careful handling is always required and the dragging of straight pipe and coils should be avoided.

The maximum allowable depth of scoring of the external surface of the pipe is 5% of the wall thickness. Pipes and fittings showing obvious defects or excessive scoring should be withdrawn, clearly identified as unsuitable and, where appropriate, returned to the source of supply.

The general properties of polyethylene are unaffected by low ambient temperatures but, having very smooth surfaces, the pipes and fittings become slippery in wet or frosty weather. Particular attention should be given to effective securing and storage under such conditions. Extra care should also be taken when handling large diameter prefabricated fittings during very cold weather.

The packaging of pipes by the manufacturer is normally consistent with the requirement to prevent damage and to comply with safety considerations. Usually pipes are delivered strapped into convenient bundles or banded coils. Fittings are normally supplied in separate cartons together with any associated small items, such as bolts and gaskets.

As far as practicable the protective packaging (pallets, strapping, bags etc.) should be kept intact until the material is required for use. The temporary capping or plugging of pipe ends is recommended.

Pipes and fittings likely to be stored outside should be covered by a tarpaulin or black polyethylene sheeting to prevent ultra violet degradation from sunlight. Electro fusion fittings should be stored under cover and in their protective packaging.

For hygiene purposes, the pipe ends must be protected from the ingress of dirt/water etc. This protection should be carefully disposed of following use.

1.8.2 Transport and Delivery

For transporting bulk loads, vehicles should be provided with a clean flat bed, free from nails or other projections, which may cause damage. If high sided lorries are used, special care must be taken to prevent slippage or excessive bowing of the pipes and extra protection given at all sharp edges.

Care should be taken to avoid positioning pipes and fittings near or adjacent to exhaust systems or other heat sources and to avoid possible contamination from materials such as lubricating or hydraulic oils, gaseous, solvent and other aggressive chemicals.

Metal chains or slings should not be brought into direct contact with the material. Webbed slings of polypropylene or nylon are recommended. Straight pipes should be fully supported and bound together. Pipes must not rest on the integral socket, if one is incorporated.

When transporting 'pupped' fittings, these should not be loaded in a way that it could distort the pupped end.

Both vertical and horizontal deliveries of coiled pipes are permissible, although in the case of horizontal transportation special notification may be required for highway authorities in respect of wide load regulations.

Following the quality control inspection and testing, caps or plugs are to be provided to protect the jointing surfaces during transportation and storage. The finished and protected pipes are then carefully packed into manageable units (bundles or coils) prepared for shipments.

1.8.3 Off Loading

1.8.3.1 Bundled Pipes

When lifting by crane, non metallic wide band slings or ropes should be used, and for pipe lengths greater than 6m, load spreading beams of a length at least equivalent to one quarter of the length of the pipe or bundle pack should be employed.

Chains or end hooks should not be used. Care should be taken to avoid damage to pipes and pipe ends during lifting, particularly those pipes with couplers.

Some bending should be allowed for in the middle of the lift when loading and unloading pipes and, because of this, lifting points should always be well spread and evenly spaced.

Standard bundle packs, 6m long, may be handled by fork lift trucks but due allowance should be made for the flexible nature of the pipes in the positioning of the forks and the raising of the load.

Bundle packs greater than 6m long should be handled either by a side loader with a minimum of four supporting forks, or by a crane using a spreader beam and suitable slings. Individual pipes may be and led in the same way. Off-loading on site may be made easier by using skid timbers and rope slings.

1.8.3.2 Coiled Pipes

Pipe coils shall be transported inside containers from place of manufacture. Manufacturer/ Contractor shall ensure that coils of pipes are not exposed to direct sunlight at any place, during transit. Contractor shall deliver the pipe containers in closed condition to site stores as directed and only inside the site warehouse, the containers shall be opened for inspection. Contractor in coordination with the Engineer shall make arrangements for customs clearance if imported, when the containers are brought to site warehouse.

Reinforced adhesive tape at least 50 mm wide should be used for banding. Complete coils are secured by outer and intermediate bands and individual layers are also independently secured. These should not be removed until the pipe is required for actual use.

Pipe less than 63 mm in diameter should be moved and uncoiled using an approved dispensing trailer.

Before unstrapping pipe form the coil or drum, both pipe ends must be firmly mechanically restrained. The band securing the outer end of the pipe should be removed first and the movement of the free end carefully controlled. This removal should be followed with those securing successive layers. No more bands should be removed than necessary to release the length of pipe immediately required. After sufficient pipe has been cut from the coil the protective end cap must be replaced on the remainder. The outer end of the pipe should be suitably re-marked as such.

When removed form the coil or drum, the pipe will be oval and curved. The extent of ovality and curvature will depend upon the temperature, SDR rating, pipe diameter, coil diameter and material type. Although both ovality and curvature will reduce naturally with time, special hardware is available to facilitate handling and jointing.
(refer the fig. 1 in Annex - VI hereof, showing the proper handling methods for coils)

1.8.3.3 Fittings

Hooks should not be used to lift fittings which are generally supplied in cardboard boxes or polyethylene bags.

1.8.3.4 Storage at Depot

Materials of different polymer manufacture should be kept separately and clearly identified.

Blue polyethylene pipe should preferably be stored under cover and protected from direct sunlight until required for use. Where storage facilities necessitate the material to be exposed externally, suitable good protective sheeting should be used.

All pipe stacks should be made on sufficiently firm, leveled ground and free from stone to support the weight of the pipes and any necessary lifting equipment. Stacking heights should be kept to a minimum and without exceeding the manufacturer's

recommendation and adequate space allocated for lifting machinery to manoeuvre (more carefully and often with difficulty) without causing accidental damage.

For safety and the convenience of handling, the stacking height for bundles should not be more than 3 metres. To prevent possible deformation of the pipes, bundles must be stored timber to timber.

The Bidder shall make arrangements to stack wrapped/bagged coils neatly on robust pallets (free from projections), in Central Stores, conforming to the following maximum stack heights.

- 7 coils for 20 mm diameter pipe
- 6 coils for 25 mm diameter pipe
- 5 coils for 32 mm diameter pipe
- 4 coils for 50 mm diameter pipe
- 3 coils for 63 mm diameter pipe
- 2 coils for 90 mm diameter pipe
- 1 coils for 110 mm diameter pipe
- 1 coils for 125 mm diameter pipe
- 1 coils for 180 mm diameter pipe

Forklift trucks shall not be used to load and unload pipes except where coils are neatly stacked on pallets or coils and are provided with slings.

For similar reasons, pipe coils should be stored flat and the number of coils per stack should be limited to;

Where individual pipe lengths are stacked in pyramidal fashion, deformation may occur in the lower layers, particularly in warm weather. Such stacks should therefore be no more than 1 metre high. Socketed pipes should be stacked with the sockets at alternate ends and with the sockets protruding to avoid uneven stacking which may permanently distort the pipes.

Polyethylene fittings should be stored under cover, preferably on racking and in the manufacturer's protective wrapping or cartons which should be kept intact until the fitting is required for use.

At all times pipes and fittings should be stored away from exhaust outlets and all other high temperature sources. Care should also be taken to avoid contact with lubricating or hydraulic oils, gasoline, solvents and other aggressive chemicals.

All special tools and equipment associated with the jointing of HDPE pipes and fittings should be stored separately and securely until they are required for use. The heating

faces of fusion tools should be kept in a position where the surfaces are protected from scratching or other damage. Tools incorporating cutting edges should likewise be protected from damage that could cause poor joint preparation.

1.9 Packing of Bolts, Joint Rings and Gaskets

Bolts of the same length and size (and their accompanying nuts and washers) shall be packed together in boxes not exceeding 100 kg. gross weight.

Joint rings and gaskets shall be packed in boxes and separate packages shall be provided for each size and description of ring or gasket.

Each box and package therein shall be clearly labeled stating the number, size and description of the contents.

1.10 Manufacturer's Certificate

The Contractor shall supply to the Engineer a certificate stating that each item supplied has been subjected to the tests laid down herein and conforms in all respects to this Specification or such other Specification which has been submitted to and approved by the Engineer.

1.11 Quality and Workmanship

All pipes, fittings and accessories shall be manufactured in compliance with the ISO 9001 : 2015 quality management system standards for the manufacturing factory. In addition to product quality control tests the manufacturers also must perform and satisfy long term type tests to demonstrate long term performance of pipe as detailed in relevant standards. Quality Management System Certification should be from an organization which is a member of International Accreditation Forum (IAF) having the scope of the accreditation for HDPE pipes and fittings to issue such certification and the manufacturer shall have this certification valid during the supply and delivery of the materials. Document evidence regarding accreditation together with the scope of certification should be provided.

1.11.1 Quality Assurance (Q/A) at Manufacturer's Works

The manufacturer shall operate a quality assurance scheme to the ISO 9001: 2015 and on award of order shall submit a copy of his quality assurance guidelines, as issued to his production works sections. This shall include the following items, detailing the frequency of quality assurance checking.

a. Raw Materials

i. Vetting and recording of certificates provided by the raw material manufacturer (s).

ii. Chemical testing of raw material and frequency of tests.

b. Pipe Manufacture (for each pipe diameter)

i. Checking of extrusion compound temperature at the extruder (state the temperature) and state its consequence on quality.

ii. Temperature of water bath/sprayed water cooling system on extruded pipe.

iii. Maintenance of pull force on extruded pipe.

i. Procedure for resumption of production after an interruption on the production line (e.g. power failures, change of pipe production batches, etc.)

ii. Hourly production records.

iii. Frequency of calibration of testing equipments

iv. Inspection of stock yards (visually) and packing methods.

2.0 TECHNICAL REQUIREMENTS FOR HIGH DENSITY POLYETHYLENE (HDPE) PIPES, FITTINGS, SPECIALS AND ACCESSORIES FOR WATER SUPPLY APPLICATIONS

2.1 Scope

This specification covers polyethylene pipes and associated fittings for the use of cold drinking water.

2.2 Reference Standards

ISO 4427-1:2019	Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) – Part 1: General
ISO 4427-2:2019	Part 2- Pipes
ISO 4427-3:2019	Part 3- Fittings
ISO 4427-5:2019	Part 5- Fitness for purpose of the system
EN12201-1:2011	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). Part 1- General
EN12201-2:2011	Part 2- Pipes
EN12201-3:2011	Part 3- Fittings
EN12201-4:2011	Part 4- Valves
EN12201-5:2011	Part 5- Fitness for purpose of the system
EN ISO 1167-1:2006	Thermoplastics pipes for the conveyance of fluids. Determination of the resistance to internal pressures. General Method.
EN ISO 1167-2:2006	Thermoplastic pipes for the conveyance of fluids. Determination of the resistance to internal pressures. Preparation of pipe pieces.
EN 1092-2:1997	Flanges & their joints circular flanges for pipes, valves, fittings & accessories PN designated Cast iron flanges
EN 1515:2000	Flanges & their joints, bolting, selection of bolting
EN 1514-2:2014	Flanges and their joints. Gaskets for PN-designated flanges. Spiral wound gaskets for use with steel flanges
EN ISO 12162:2009	Thermoplastics materials for pipes and fittings for pressure applications. Classification, designation and design coefficient
DIN 16963 1-15 series	Pipes joints and elements for high Density Polyethylene (PE) pressure pipe lines.

BS 7874:1998	Method of test for microbiological deterioration of elastomeric seals for joints in pipe work and pipes.
BSEN 681-1:1996	Elastomeric seals, material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber.
BS 6920-1:2014	Suitability of non-metallic materials and products for use in contact with water intended for human consumption with regard to their effect on the quality of the water. Specification
ISO 12176-1:2012	Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems – Part 1 : Butt Fusion.
ISO 12176-2:2008	– Part 2 : Electrofusion.
PD CEN/TS 12201-7:2014	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). Guidance for the assessment of conformity
ISO 6259-1:2015	Thermoplastics pipes — Determination of tensile properties — Part 1: General test method
ISO 6964:2019	Polyolefin pipes and fittings — Determination of carbon black content by calcination and pyrolysis — Test method
ISO 1133-1:2011	Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method
ISO 2505:2005	Thermoplastics pipes — Longitudinal reversion — Test method and parameters
ISO 9001: 2015	Quality management system

2.3 Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

2.4 Classification

2.4.1 The terms PE 100 are a classification developed in line with a decision taken at CEN/TC 155, the European Technical Committee drafting plastics piping system standards for polyethylene products for water supply.

2.4.2 According to this classification, as detailed in ISO 12162:2009' material has a Minimum Required Strength (MRS) value of 8 Mpa and PE 100 has a MRS value of 10 Mpa. The international Standards Organization (ISO) technical procedure ISO 9080: 2012 identifies these MRS values derived from the 50 year extrapolated 97.5% Lower Confidence Limit (LCL) failure stress.

2.5 Materials

Pipes and fittings shall be manufactured by using polyethylene as main raw material. The raw material used in manufacturing process shall be of reputed suppliers and comply with the following characteristics tabulated in Table 2 in Annex I, except Carbon black content (black compound).

All pipes & fittings shall be manufactured of blue colour compounds and shall comply to the Technical Specification hereof.

Required manufacturing pressure class due to temperature correction

For imported HDPE Pipes and fittings manufacturer shall calculate the required manufacturing pressure class for the required pressure class specified in the Bills of Quantities based on the temperature in Sri Lanka. Relevant factors shall be obtained from Annex A of EN 12201 -1:2011or ISO 4427 Part -1:2019.

Manufacturing Pressure = PN/f_T

The continuous allowable operating pressure (PFA) is derived from the following formula

$PFA = f_T \times f_A \times PN$

Where,

f_T = Co-efficient according to Table A-1

f_A = derating factor related to the application (for the conveyance of water, the maximum value of $f_A = 1$)

PN = nominal pressure (Specified pressure class in the Bills of Quantities)

Accordingly, manufacturer shall supply higher pressure class pipes & fittings based on the above calculation.

2.5.1 Non-metallic Materials

All non-metallic materials supplied shall be in conformity with the BS 6920 Part 1:2014 to BS 6920 –Part 2 and Part3:2000, BS EN 15768:2015; suitability of non metallic materials products for use in contact with water intended for human consumption with regard to their effect on the quality of water or approved equivalent publication, as a recognized certifying authority having passed full tests of effect on water quality under the requirements for the testing of non-metallic materials for use in contact with potable water.

2.5.2 Pipes

Polyethylene pipes shall be flexible and in pipe form or coil form complying with standards given in the reference standards in the document. Pipe jointing methods shall be as follows.

Jointing Methods

1. Electro-fusion – Temperature, time, alignment
2. Butt-fusion – Temperature, time, alignment
3. compression – Gaskets

2.5.3 Fittings

Polyethylene fittings shall be manufactured by injection moulding, factory welding or formed in the factory complying with the standards referred in the document.

Fittings shall be suitable either for electrofusion or butt welding as specified in the Bill of quantities. All dimensions of electro fusion fittings must be fusible with one fusion machine.

Diameters upto 32mm shall be manufactured using injection moulded only.

2.5.3.1 Types of pipe fittings

The following types of fittings shall comply to EN 12201-3:2011/ ISO 4427-3:2019

a) Spigot fittings
b) Electro-fusion fittings and
c) Mechanical fittings and joints

2.5.3.1.1 Spigot Fittings

Spigot fittings fall under two clauses as shown below.

Class	Description
Moulded	Injection moulded fittings
Fabricated	Fitting which are assembled using butt-fusion joints

2.5.3.1.2 Electro-fusion Fittings

Electro-fusion fittings shall be injection moulded fittings made of HDPE but incorporating integral heating element(s) to enable fusion jointing with HDPE pipes.

2.5.3.1.3 Mechanical Joints and Fittings

i. General

Metal and plastic fittings available for use with PE pipe are:

- Polymeric coated Flanged and other adaptors
- Mechanical type couplers c/w restrainer

The materials and constituent elements used in making the fitting (including elastomers, greases and any metal parts) shall be as resistant to the external and internal environments as the other elements of the piping system and shall have a life expectancy under the following conditions as least equal to that of the PE pipe conforming to EN 12201:2011 or ISO 4427 :2019 with which they are intended to be used:

a) During storage :
b) Under the effect of the fluids being conveyed :
c) Taking account of the service environment and operating conditions.

The requirements for the level of material performance for non-polyethylene parts shall be at least as stringent as that of the PE pipe systems.

All mechanical joints and fittings shall be of approved types designed specifically for PE pipe system. They shall be supplied with all necessary coupling, rings, nuts, bolts, washers, rubber rings/sealing gaskets and restrainers/stiffeners.

All mechanical joints, fittings and systems shall conform to the requirements specified in BS EN 12201-5:2011/ISO 4427-5:2019 of Table below as applicable.

Characteristics for fitness for purpose of the joint, fitting of system

Characteristics	**Test Method**
Hydrostatic strength at room temperature	EN ISO 1167-3:2007
Peel decohesion test PE electrofusion assemblies of nominal outside diameter $\geq$ 90mm	ISO 13954:1997 ISO 13955:1997
Resistance to tensile force	ISO 13953:2001
Mechanical Joints	
Leak tightness under internal pressure including end thrust	EN ISO 3458:2015
Leak tightness under internal pressure when subjected to bending	EN ISO 3503:2015
Plastics piping systems, Elastomeric sealing rings type joints and mechanical joints for	EN ISO 3459:2015

thermoplastic pressure piping for leak tightness under external hydrostatic pressure	
Resistance to pull out under constant longitudinal force	EN ISO 3501:2015

2.5.3.2 Compression Fittings, Nuts for PE Pipes

Couplings, flange adaptors etc shall be compatible with the pipes specified in item 2.5.2 hereof; together with following;

- All bodies shall be injection moulded from recognized top quality poly propylene.
- Bodies shall be coloured black
- Bodies must have moulded in manufacturer identification, material and series information and dimension of the outside pipe diameter.
- All male and female threads shall be injection moulded to the ISO 7/1 standards.
- Nuts must have UV resistance of grade 8 of ASTM D2585.

2.5.3.3 Joint Rings

The physical properties of elastomeric joint rings shall comply with Table 2 of EN 681-1:1996 or ISO 4633:2015. The joint rings shall also comply with the relevant provisions in BS 7874-1:1998 for effects on water quality and resistance to microbiological deterioration.

Joint rings shall be supplied by the pipe manufacturer.

Each joint ring shall be marked clearly and durably in accordance with the following information in a manner that does not interfere with the sealing function of the ring, in complying with clause 10 of EN 681-1:1996 or clause 9 of ISO 4633:2015.

a). The nominal size

b). Manufacturer's identification

c). BS or ISO standard with seal type designation

d). Abbreviation for the elastomer

2.5.3.4 Flanges

All flanges dimensionally shall be in accordance with EN 1092-2:1997 (Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges) and EN 1515-1:2000 Flanges and their joints Bolting. The screw threads in the pipes and fittings shall be complying with ISO Metric Screw Threads (ISO 7-1:1994 and ISO 7-2:2000).

2.5.3.5 Flange Joints for Pipes and Pipeline Fittings

Flanges for pipes and pipeline fittings shall unless otherwise stated comply with EN 1092: Part 2: 1997. Flanges shall be of PN16 nominal pressure rating and shall be raised faced, unless otherwise stated.

Flanges in accordance with EN545, ISO2531 are dimensionally compatible with EN1092-2:1997.

Flanged joints shall be complete with all nuts, bolts, gaskets and two washers per bolt.

The flanges of all fittings shall be integrally cast. The flanges of flanged pipes shall either be integrally cast or screwed or factory welded unless otherwise stated. 'Factory welded' means that the flanges are welded to the pipes at the point of manufacture under factory conditions with inspection agency certification.

The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, including where connections are required to pipe work and valves associated with pumping plant and inlet/outlet pipe work at service reservoirs or other structures.

2.5.3.6 Steel Flange Converter

Steel Flange Converter shall be made out of polyethylene and shall conform to the EN 12201-3:2011 & EN 12201-5:2011 or ISO 4427:2019 specification for mechanical fittings and joints including flanges for polyethylene pipes for conveyance of cold potable water for the size range 90-1000 mm inclusive made of metal or plastics or a combination of both.

2.5.3.7 Gaskets for Flanged Joints

Gaskets for flanged pipe joints shall be of the inside bolt circle type and the dimensions shall comply with EN 1514-2:2014 (Flanges and their joints. Gaskets for PN-designated flanges. Spiral wound gaskets for use with steel flanges)

The Gasket material shall be EPDM and shall be of average hardness of 65-75.

The Gaskets shall be supplied by the manufacturer and shall suit for PN 16 flanges unless otherwise stated.

Each gasket shall be marked clearly and durably in accordance with the following information in a manner that does not interfere with the sealing function of the gasket, in complying with clause 10 of EN 681-1:1996.

a). The nominal size
b). Manufacturers identification
c). The number of the BS or BSEN with seal type designation.
d). Abbreviation for the elastomer

2.5.3.8 Nuts, Bolts and Washers

The nuts, bolts and washers for flanged joints shall be of high tensile steel and shall comply with EN 14399-1:2015.

The bolting shall comply with the relevant provisions of EN 1092-2:1997.

The Bolt lengths shall be sufficient to ensure that nuts are full threaded when tightened in their final position with two threads showing.

Two washers per each bolt shall be supplied for providing under the head of the bolt and under the nut.

The bolts and nuts shall be hexagonal and shall be in accordance with BS 4190:2014 ISO metric black hexagon bolts, screws and nuts, Specification, the bolts, studs, nuts and washers used shall be made of stainless steel or hot-dipped galvanized carbon steel coated with fusion bonded epoxy powder or polyamide 11 to the finished thickness of coating between 75 mm and 125 mm according to WIS 4-52-03-1994. Cold applied high solid epoxy shall be used to repair the damaged coatings on the bolts and nuts after fastening.

2.5.4 Testing

Testing shall be carried out fully in accordance with the requirements of ISO 4427 :2019 and DIN 8075 (2011-12)- (Polyethylene (PE) pipes PE 100 - General quality requirements, testing)or equivalent standard acceptable to the purchaser.

Test parameters of physical and mechanical characteristics for pipes & fittings shall be as indicated in Table 3, 4, 5, 6 in Annex II.

2.6 Dimensions of Pipes and Fittings

Dimension of standard pipes shall conform to the following standards.

ISO 4427:2019	Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE)
EN 12201:2011	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE)
EN ISO 1167-1:2006	Thermoplastics pipes for the conveyance of fluids. Determination of the resistance to internal pressures. General Method.
EN ISO 1167-2:2006	Thermoplastic pipes for the conveyance of fluids. Determination of the resistance to internal pressures. Preparation of pipe pieces.
BS ISO 4065 – 1996	Thermoplastic pipes – universal wall thickness table
ISO 11922 – 1:1997	Thermoplastic pipes for the conveyance of fluid - Dimensions & tolerances – Part I metric series

Standard lengths of a straight pipe shall be 12 m.

Dimensions of fittings shall conform to the following standards.

EN 12201-3:2011	Plastic piping System for Water Supply – Polyethylene (PE) 3 - Fittings
ISO 4427:2019	Plastic piping System for Water Supply – Polyethylene (PE) 3 - Fittings
DIN 16963 1-15 series	Pipes joints and elements for high Density Polyethylene (PE) pressure pipe lines.

2.7 Method of Manufacturing of Pipes & Fittings

2.7.1 Manufacturing of HDPE Pipes and Fittings

2.7.1.1 The contractor shall submit full details of manufacturing process that he intended to use with the bid. The Material Quality Certificates shall be from one of the **Independent Testing Agencies,** which is indicated in the Condition of Contract, shall be provided by the contractor.

Base Polymer Compound position, antioxidants, rework material and colour shall be in accordance with WIS 4-32-15, BS 3412:1992 and EN ISO 12162:2009.

2.7.2 Production Quality Control

2.7.2.1 The manufacture of HDPE pipe is a continuous processing which necessitates strict and accurate control of both materials and plant to achieve the required quality. A range of quality control tests pressures in the relevant standards should be applied within the scope of a quality assurance in accordance with ISO 9001: 2015.

These control procedures shall include:

- Quality testing of raw materials, i.e. base compound.
- Checks on the uniformity and consistency of the granules
- control of processing parameters in terms of temperature, pressure, flow rates, haul off speed and energy input
- visual inspection of the pipes to check general appearance, dimensional compliance and any indication of inclusions or processing flaws in pipe barrels and jointing ends,
- production short term tests, to identify any variations in the plant function.

2.7.2.3 Essential short-term quality control tests and procedures are described in the relevant Water Industry Specifications include the following

- appearance and surface condition
- dimensions
- thermal stability
- elongation at break
- hydrostatic pressure test at 80^0 C
- short term pressure test

2.7.3 Product Type Tests

2.7.3.1 In addition to 'production quality control' tests, there are a number of important longer-term "Type Tests" that must be undertaken to demonstrate the long-term performance of the pipe. These tests are also required whenever there is any change in such parameters as formulation, size, classification or processing technique.

2.7.3.2 These "Type Tests" are again detailed in the relevant specifications and include the following:

- effect on water quality
- resistance to weathering
- long term hydrostatic pressure testing
- resistance to fracture on impact tensile strength,
- elongation and weld test

2.7.3.3 Perhaps the most fundamental Type Test is the long term hydrostatic test which is a standard means of predicting the long-term performance of the pipe. In this test, samples are subjected different circumferential (hoop) stresses by pressurization and the subsequent time to pressure is recorded. The individual results are plotted as a log stress versus log time graph. They are then subjected to regression analysis to obtain an extrapolated 50 year stress level.

2.7.3.4 It is worth bearing in mind that the above requirements for long-term performance levels are minimum values and manufacturers usually ensure that their products can comfortably meet these standards, i.e. the pipes have an additional factor of safety built into them to cover any manufacturing variables.

2.8 Tolerances

Tolerances on wall thickness & weight, and length shall be in accordance with ISO 4427:2019 or EN 12201:2011.

The tolerances on flange thickness, flange diameter and bolt holes in polyethylene Steel flange converters to be used of connecting different type of material shall conform to EN 1092-2:1997.

2.9 Final Acceptance at site

All pipes, fittings, valves and accessories shall conform to the specification at site. Engineer shall carryout necessary inspections at site prior to final acceptance.

2.10 Specification for Butt Fusion Welding Machine

i. Machine shall be hydraulically operated and suitable for welding of HDPE pipes.

ii. Machine shall consist of self –aligning frame and compact dimensions, to be suitable for working on narrow roads.

iii. Machine shall comprised of four clamps in lightweight alloy of which the third one is easily adjustable in order to weld special pieces, and the automatic disconnecting devices to detach the pipes the heating mirror at the end of heating time.

iv. Heating mirror shall be silver stone coated with electronic thermostat and separate thermometer in order to continuously check the temperature of the heating mirror. Operating electricity requirement of the heating mirror shall be 220±10 V 50Hz.

Also it shall include removable electric facing tool complete with reducing gear, double cutting edged blades, safety micro switch all which allow the engine to start only in operating position.

i. An electrically operated mechanical block device avoiding dislocation during the facing operation. Operating electricity requirement shall be 220±10, 50Hz.

ii. A support for facing tool and heating mirror suitable to carry the two part and to hold them when it is not in use.

iii. Hydraulic double throw pump with precision pressure gauge (class 1.0-100 bar scale and 100mm face to easy reading) incorporates a device which maintains pre-set line pressure even when motor is not running. Allows continuous pressure adjustments and features flexible hoses with quick disconnect dry-lock couplings. Mounted in a tough protective frame, with two transport handles. Operating electricity requirement is 220±10 50Hz.

iv. Light weight aluminium reducing inserts (8 inserts per set including 6 inserts for pipes and 2 inserts for fittings) sizes 200,225,250,280,315,355,400,450mm.

v. Upper fitting clamp 500mm for short fittings.

vi. Stub end device with size range 200 to 500 mm.

vii. A Generator of adequate capacity.

viii. A 2 year warranty to cover all the equipments offered.

ANNEX I

Table 2 – Characteristics of the PE compound as granules

Characteristics	Requirements [a]	Test parameters		Test method
		Parameter	Value	
Compound density	> 930 kg/m [b]	Test temperature Number of Samples	23^0C shall conform to ISO 1183:1 or ISO 1183:2	ISO 1183-1:2019or ISO 1183-2:2019
Carbon black content [c]	(2.0 to 2. 5)% by mass	Shall conform to ISO 6964		ISO 6964:2019
Carbon black dispersion [c]	grade ≤ 3 Rating of dispersion A1,A2,A3, or B	Preparation of test pieces [d]	Free	ISO 18553:2002
		Number of test pieces [b]	Shall conform to ISO 18553	
Pigment dispersion [e]	grade ≤ 3 Rating of dispersion A1,A2,A3, or B	Preparation of test pieces [d]	Free	ISO 18553:2002
		Number of test pieces [b]	Shall conform to ISO 18553	
Water content [f]	≤300 mg/kg (Equivalent to <0.03% by mass)	Number of test pieces [b]	1	ISO 15512:2019
Volatile content	≤350 mg/kg	Number of test pieces [b]	1	EN 12099:1997
Oxidation induction time (Thermal stability)	≥ 20 min	Test temperature [g]	210 ^{0}C	ISO 11357-6:2018
		Number of test pieces [b]	3	
		Test atmosphere	Oxygen	
Melt mass-flow rate (MFR) for PE40	0, 2 ≤ MFR≤ 1,4 g/10 min[h] Maximum deviation of ± 20% of the nominated value	Loading mass	2,16kg	ISO 1133-1:2011
		Test temperature	190^0C	
		Time	10min	
		Number of test pieces [b]	shall confirm to ISO 1133:1	
Melt mass-flow rate (MFR) for PE80 and PE 100	0, 2 ≤ MFR≤ 1,4 g/10 min[h,i] Maximum deviation of ± 20% of the nominated value	Loading mass	5kg	ISO 1133-1:2011
		Test temperature	190^0C	
		Time	10min	
		Number of test pieces [b]	shall confirm to ISO 1133:1	

[a] Conformity to these requirements shall be proved by the compound producer.

[b] The number of test pieces given indicates the number required to establish a value for the characteristic described in the table 1. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan. Guidance on assessment of conformity can be found in CEN/TS 12201-7(^{2}).

[c] Only for black compound.

[d] In case of dispute, the test pieces shall be prepared by microtome method.

[e] Only applicable for non-black compound.

[f] Only applicable if the measured volatile content is not in conformity with its specified requirement. In case of despite, the requirement for water content shall apply. As an alternative method, ISO 760 may be used. The requirement applies to the compound producer at the stage of compound manufacturing and to the compound user at the stage of processing (if the water content exceeds the limit, drying is required prior to use).

[g] The test may be carried out at 200 ^{0}C or 220 ^{0}C provided that a clear correlation has been established. In case of dispute, the reference temperature shall be 210 ^{0}C.

[h] Nominated value given by the compound manufacturers.

[i] Materials of nominated value 0.15 ≤ MFR < 0.20 can be introduced, in such case attention is drawn to the fusion compatibility. The lowest MFR value resulting from the maximum lower deviation of the nominated value should be not less than 0.15.

ANNEX II

Table 3 - Physical Characteristics of PE Pipes

Characteristics requirements	Requirements	Test parameters		Test method
Elongation at break for $e \leq 5$mm	$\geq$ 350%	Test piece shape Test speed Number of test pieces [a]	Type 2 100 mm/min shall confirm to ISO 6259-1:2015	ISO 6259-1:2015 and ISO 6259-3:2015
Elongation at break For 5 mm $< e \leq$ 12 mm	$\geq$ 350%	Test piece shape Test speed Number of test pieces [a]	Type 1 [b] 50 mm/min shall confirm to ISO 6259-1:2015	ISO 6259-1:2015 and ISO 6259-3:2015
Elongation at break for $e \geq$ 12 mm	$\geq$ 350%	Test piece shape Test speed Number of test pieces [a]	Type 1 [b] 25 mm/min shall confirm to ISO 6259-1:2015	ISO 6259-1:2015 and ISO 6259-3:2015
		OR		
		Test piece shape Test speed Number of test pieces [a]	Type 3 [b] 10 mm/min shall confirm to EN ISO 6259-1:2015	
Longitudinal reversion[c]	$\leq$3 % No effect on surface	Length of pipe[d] and number of test pieces Test temperature: PE 80, PE 100 Time	According to ISO 2505 110 $\pm$ 2 ^{0}C See ISO 2505	ISO 2505:2005
Melt mass-flow rate MFR for PE 40	Change of MFR by processing $\pm$ 20% [e]	Load Test temperature Time Number of test pieces [a]	2.16 kg 190^{0}C 10 min shall confirm to ISO 1133:2011	ISO 1133-1:2011
Melt mass-flow rate MFR for PE 100	Change of MFR by processing + 20% [c]	Load Test temperature Time Number of test pieces [a]	5 kg 190^{0}C 10 min shall confirm to ISO 1133:1999	ISO 1133-1:2011
Oxidation induction time	$\geq$ 20 min	Test temperature Test environment Number of test pieces [a, d]	200^{0}C [f] Oxygen 3	ISO 11357-6:2018
Effect on water quality	National regulations apply			

[a] The number of test pieces given indicates the quantity required to establish a value for the characteristic described in this table. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan.

[b] Where practical, machined type 2 test pieces may be used for pipe wall thickness $\leq$ 25 mm. The test may be terminated when the requirement is met, without continuing until the rupture of the test piece.

[c] Only applicable for pipes with thickness $\leq$ 16mm

[d] For pipes with an outside diameter >200mm, longitudinally cut segments may be used.

[e] Value as measured on the pipe relative to the value measured on the compound used.

[f] Test may be carried out as an indirect test at 210^{0}C or 220 ^{0}C provided that there is clear correlation has been established. In case of dispute, the test temperature shall be 200^{0}C.

[g] Samples are to be taken from the inner wall surface.

ANNEX III

Table 4 - Mechanical Characteristics of PE Pipes

Characteristics requirements	Requirements	Test parameters		Test method
		Parameters	Value	
Hydrostatic strength at 20^0C	No failure of any test pieces during test period	End caps Conditioning period Number of test pieces [b] Type of test Test temperature Test period Circumferential (hoop) stress for : PE 100	Type a) [a] According to ISO 1167-1:2006 3 Water-in-water[d] 20^0C 100 h 12,0 MPa	ISO 1167-1[b]:2006 ISO 1167-2:2006
Hydrostatic strength at 80^0C	No failure of any test pieces during test period	End caps Conditioning period Number of test pieces [c] Type of test Test temperature Test period Circumferential (hoop) stress for : PE 100	Type a) [a] According to ISO 1167-1:2006 3 Water-in-water[d] 80^0C 165 h [c] 5,4 MPa	ISO 1167-1[f]:2006 ISO 1167-2:2006
Hydrostatic strength at 80^0C	No failure during test period of any test pieces	End caps Conditioning period Number of test pieces [b] Type of test Test temperature Test period Circumferential (hoop) stress for : for PE 100	Type a) [a] According to ISO 1167-1:2006 3 Water-in-water[d] 80^0C 1000 h [c] 5,0 MPa	ISO 1167-1[b]:2006 ISO 1167-2:2006

NOTE The characteristic resistance to slow crack growth is dealt with in ISO 4427-1 as a material property measured in the form of pipe

[a] Type b) end caps may be used for batch release tests for diameters > 500 mm.

[b] The test shall be realized on basis of measured dimensions (OD and thickness), in accordance with ISO 1167-1:2006, 7.2.

[c] The number of test pieces given indicate the quantity required to establish a value for the characteristic described in this table. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan

[d] For d_n >1000mm, the test can also be performed water –in-air. In case of dispute, water in water shall be used

[e] Premature ductile failures are not taken into account. For retest procedure , apply 8.3

[f] The test shall be realized on basis of nominal dimensions (OD and thickness), in accordance with ISO 1167-1:2006, 7.3.

ANNEX IV

Table 5 - Physical Characteristics of PE Fittings

Characteristics requirements	Requirements	Test parameters		Test method
		Parameters	Value	
Oxidation induction time (Thermal stability)	≥ 20 min	Test temperature	200^0 C [b]	ISO 11357-6:2018
		Number of test pieces [a]	3	
		Test environment	Oxygen	
Melt mass-flow rate (MFR)	After processing maximum deviation of ±20% of the value measured on the batch used to manufacture the fitting	Loading mass	5 kg	ISO 1133-1:2011
		Test temperature	190^0 C	
		Time	10 min	
		Number of test pieces [a]	Shall conform to ISO 1133-1 :2011	

[a] The number of test pieces given indicate the quantity required to establish a value for the characteristic described in table 7. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan. Guidance on assessment of conformity can be found in CEN/TS 12201-7. (Reference [2] in the Bibliography).

[c] Test may be carried out as an indirect test at 210^0C or 220^0C provided that there is clear correlation to the results at 200^0C : in cases of dispute the reference temperature shall be 200^0C.

ANNEX V

Table 6 - Mechanical Characteristics of PE Fittings

Characteristics	Requirements	Test parameters			Test method
		Parameters		Value	
Hydrostatic strength (20^0C, 100 h)	No failure during test period of any test piece	End caps		Type A of ISO 1167-1:2006	ISO 1167-1:2006 and ISO 1167-4:2007
		Orientation		Free	
		Conditioning time		Shall conform to ISO 1167-1:2006	
		Number of test pieces [a]		3	
		Type of test [b]		Water-in-water	
		Circumferential (hoop) stress in pipe [c] for :	PE 80	10,0 MPa	
			PE 100	12,0 MPa	
		Test period		100 h	
		Test temperature		20^0C	
Hydrostatic strength (80^0C, 165 h)	No failure during test period of any test piece[d]	End caps		Type A of ISO 1167-1:2006	ISO 1167-1:2006 and ISO 1167-4:2007
		Orientation		Free	
		Conditioning time		Shall conform to ISO 1167-1:2006	
		Number of test pieces [a]		3	
		Type of test [b]		Water-in-water	
		Circumferential (hoop) stress in pipe [c] for :	PE 80	4,5 MPa	
			PE 100	5,4 MPa	
		Test period		165 h	
		Test temperature		80^0C	

NOTE Each assembly shall be prepared from components (pipes and fittings) of the same pressure class.

[a] The number of test pieces given indicate the number required to establish a value for the characteristic described in Table 4. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan. Guidance on assessment of conformity can be found in CEN/TS 12201-7. (See Reference [2] in the Bibliography).

[b] Alternatively, for d_n > 450 mm, the test can also be performed in air. In case of dispute, water-in-water test shall be used. For fitting type (B) d_n > 450mm, alternative testing is allowed (e.g. pressurization through saddle outlet).

[c] The test pressure shall be calculated using the design standard dimension ratio (SDR) of the fitting.

[d] Only brittle failures shall be taken into account. If a ductile failure occurs before 165 h, the test can be repeated according to 8.4.

[e] Longest length of brittle failure in any of the test samples.

[f] Test sample can be mechanically reduced in wall thickness for testing purpose of large diameter fittings by keeping a minimum of 15 mm wall thickness of each component.

[g] Alternatively, for fittings type (B) d_n > 450mm, this characteristic can be checked by the strip-bend test according to ISO 21751. (See Reference [7] in the Bibliography).

[h] Applicable to d_n 90 mm and above.

Table 6 – *(Continued)*

Characteristics	Requirements	Test parameters			Test method
		Parameters		Value	
Hydrostatic strength (80^0C, 100 h)	No failure during test period of any test piece	End caps		Type A of ISO 1167-1:2006	ISO 1167-1:2006 and ISO 1167-4:2007
		Orientation		Free	
		Conditioning time		Shall conform to ISO 1167-1:2006	
		Number of test pieces [a]		3	
		Type of test [b]		Water-in-water	
		Circumferential (hoop) stress in pipe [c] for :	PE 80	4,0 MPa	
			PE 100	5,0 MPa	
		Test period		1000 h	
		Test temperature		80^0C	
Decohesive resistance (A)	Length of initiation rupture $\leq L_2/3$ in brittle failure [e]	Test temperature Number of test pieces [a,f]		23^0C Shall conform to ISO 13954:1997 and ISO 13955:1997	ISO 13954:1997 ISO 13955:1997
Evaluation of ductility of fusion joint interface (B)[g]	Surface of repture Ld $\leq$ 50% and Ad $\leq$ 25%, brittle – failure	Test temperature Number of test pieces [a,f]		23^0C Shall conform to ISO 13956:2010	ISO 13956:2010
Tensile strength for butt fusion (C)[h]	Test to failure: Ductile – pass Brittle – fail	Test temperature Number of test pieces [a,f]		23^0C Shall conform to ISO 13953:2001	ISO 13953:2001
Impact resistance (B: Tapping tees only)	No failure, no leakage	Test temperature Falling height Mass of the striker Number of test pieces [a]		0^0C 2m 2,5kg 1	ISO 13957:1997

NOTE Each assembly shall be prepared from components (pipes and fittings) of the same pressure class.

[a] The number of test pieces given indicate the number required to establish a value for the characteristic described in Table 4. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan. Guidance on assessment of conformity can be found in CEN/TS 12201-7. (See Reference [2] in the Bibliography).

[b] Alternatively, for $d_n > 450$ mm, the test can also be performed in air. In case of dispute, water-in-water test shall be used. For fitting type (B) $d_n > 450$mm, alternative testing is allowed (e.g. pressurization through saddle outlet).

[c] The test pressure shall be calculated using the design standard dimension ratio (SDR) of the fitting.

[d] Only brittle failures shall be taken into account. If a ductile failure occurs before 165 h, the test can be repeated according to 8.4.

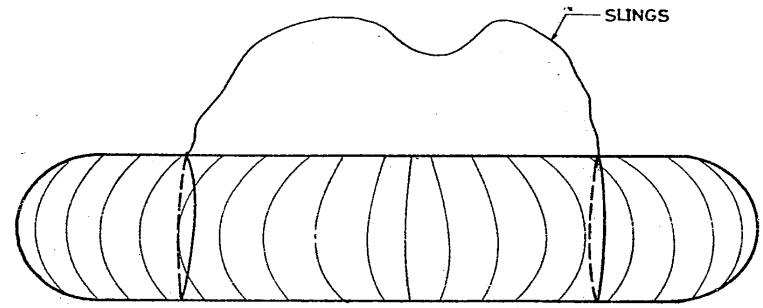
[e] Longest length of brittle failure in any of the test samples.

[f] Test sample can be mechanically reduced in wall thickness for testing purpose of large diameter fittings by keeping a minimum of 15 mm wall thickness of each component.

[g] Alternatively, for fittings type (B) $d_n > 450$mm, this characteristic can be checked by the strip-bend test according to ISO 21751. (See Reference [7] in the Bibliography).

[h] Applicable to d_n 90 mm and above.

Note : Loop of sling should be adequately long and strong for lifting the coil



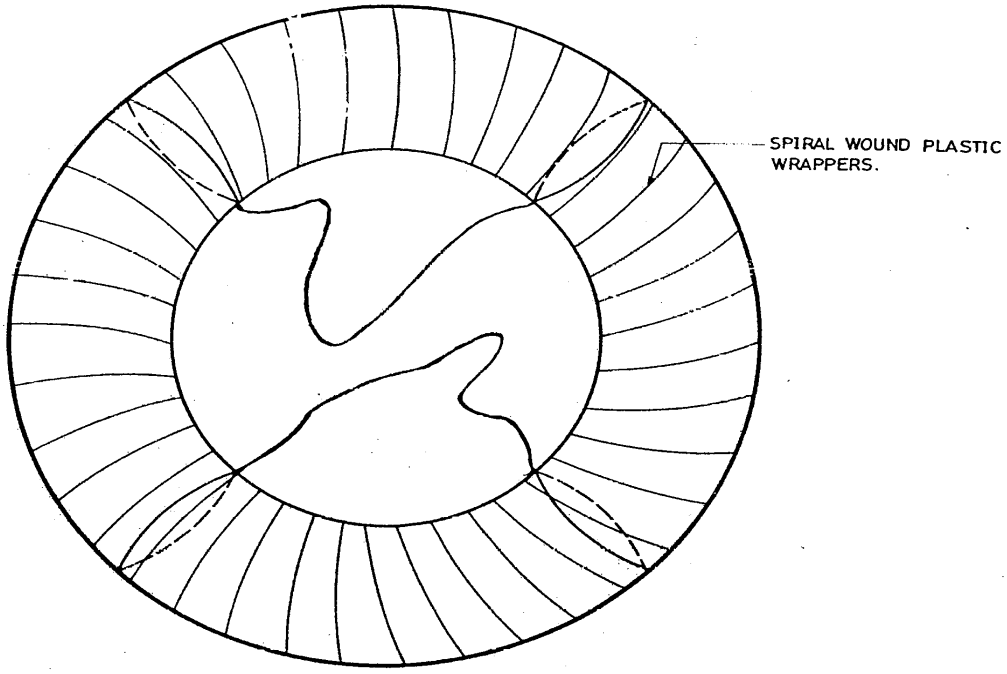


Fig. 1 - SLING ARRANGEMENT FOR LIFTING 63 mm ϕ COILS