PARTICULAR SPECIFICATION PB : HDPE PIPING AND FITTINGS

PB 1 SCOPE

This specification covers the materials and components used, the fusion jointing procedure and equipment and the quality assessment of the completed joints for HDPE piping.

PB 2 INTERPRETATIONS

PB 2.1 SUPPORTING SPECIFICATIONS

- SANS/ISO 4427-1:2008: Plastics piping systems -- Polyethylene (PE) pipes and fittings for water supply -- Part 1: General
- SANS/ISO 4427-2:2008: Plastics piping systems -- Polyethylene (PE) pipes and fittings for water supply -- Part 2: Pipes
- SANS/ISO 4427-3:2008: Plastics piping systems -- Polyethylene (PE) pipes and fittings for water supply -- Part 3: Fittings
- SANS/ISO 4427-5:2008: Plastics piping systems -- Polyethylene (PE) pipes and fittings for water supply -- Part 5: Fitness for purpose of the system
- ISO 21307: Edition 2 (2011) : Butt fusion jointing procedures for PE pipes and fittings used in the construction of gas and water distribution systems
- SANS 10268-10:2009: Welding of thermoplastics - Welding processes Part 10: Weld defects
- SANS 2001 – DP2:2008: Construction works part 2: Medium pressure pipelines

PB 2.2 DEFINITIONS

Refer supporting definitions.

PB 3 SUBMITTALS

PB 3.1 PRIOR TO CONSTRUCTION

The following documentation shall be submitted by the Contractor to the Engineer for approval prior to construction.

a) Certificates of Compliance (COC) in terms of ISO 4427 part 1, 2 and 3 on raw materials used and extruded pipe to be supplied by the Manufacturer.
b) All piping and fabricated fittings shall be manufactured from a PE 100 granule compound complying with table 1 as specified in ISO 4427 part 1
c) No recycled material, even internal, is allowed to be used in the pipes manufacture. Manufacturers are to certify this as part of the COC.
d) The Manufacturer's brochures containing complete information and instructions pertaining to the storage, handling, installation, and inspection of pipe and appurtenances shall be furnished.
e) The pipe and fittings manufacturer shall have an established quality assurance program responsible for inspecting incoming and outgoing materials. The pipe manufacturer should preferably be a member of the South African Plastic Pipe Manufacturers Association (SAPPMA) or a similar international accreditation body.
f) As a minimum, incoming polyethylene raw materials shall have a Certificate of Analysis (COA) and be tested for density, melt flow index, oxidative induction time, carbon black content and carbon black dispersion as per the relevant test methods and values stated in **PB 4.1.** All incoming polyethylene materials shall be certified

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by the supplier who must run internal testing to verify the raw material properties. Certification shall be verified by a Manufacturing Quality Assurance programme. Incoming materials shall be approved before processing into finished goods.

g) The pipe and fittings manufacturer shall have an established quality assurance program responsible for assuring the long term performance of materials and products. Representative samples of polyethylene materials shall be tested against the physical property requirements of this specification.

h) Each extrusion line and moulding machine shall be qualified to produce pressure rated products by taking representative production samples and performing sustained pressure tests in accordance with ISO 4427-2, Table 3.

i) Quality assurance test for representative pipe and fitting samples shall include:

Test	Standard	Pipe	Fittings
Slow crack growth	**ISO 13479**	**Yes**	**Not Applicable**
Hydrostatic strength at 80 °C	**ISO 1167-1&2**	**Yes**	**Yes**
Hydrostatic strength at 20 °C	ISO 1167-1&2	Yes	Yes

j) All outgoing materials shall be inspected for diameter, wall thickness, length, straightness, out-of-roundness, concentricity, toe-in, inside and outside surface finish, markings, and end cut. Manufacturing Quality Control shall perform tests of melt flow index, oxidative induction time, carbon black content and carbon black dispersion as per the relevant test methods and values stated in **PB 4.1** on the manufactured pipe. Moulded fittings shall be subject to x-ray inspection for voids, and tests for knit line strength. All fabricated fittings shall be inspected for fusion quality and alignment. The pipe and fitting manufacturer shall maintain permanent QC and QA records.

k) The pipe and fitting manufacturer shall package products for shipment in a manner suitable for safe loading, transport and off-loading by a commercial carrier. When delivered, a receiving inspection shall be performed, and any shipping damage reported to the pipe and fittings manufacturer. Pipe and fittings shall be handled, installed, and tested in accordance with manufacturer's recommendation, and the requirements of this specification.

l) Once delivered to site the *Supervisor* will take a sample of the pipe and perform tests of melt flow index, oxidative induction time, carbon black content and carbon black dispersion as per the relevant test methods and values stated in PB 4.1 on the delivered pipe. The cost of this conformance testing is to form part of the supply rates.

PB 4 MATERIALS

PB 4.1 CHARACTERISTICS/ PHYSICAL PROPERTIES

The Materials used for the manufacturer of polyethylene pipe and fittings shall meet the following minimum characteristics for polyethylene compound in granule and pipe form, and shall comply to the physical property requirements for **PE100**:

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Physical Properties - Granule	Test Method	Values	Unit
Density	ISO 1183-2	≥ 930	Kg/m^3
Carbon Black Content	ISO 6964	2.0 – 2.5	% by mass
Carbon Black Dispersion	ISO 18553	≤ Grade 3	
Volatile Content	EN 12099	≤ 350	mg/Kg
Water Content	ISO 15512	≤ 300	mg/Kg
Oxidative Induction Time	ISO 11357-6	≥ 50	minutes
Melt flow index (190°C/5Kg)	ISO 1133:2005	0.2 – 1.4	g/10 min
Note: Water content is only applicable if the measured volatile content is not in conformity with its specified measurement.			

Physical Properties Pipe	Test Method	Mode
Tensile strength for butt fusion	ISO 13953	Ductile-pass, brittle - fail
Slow crack growth	ISO 13479	No failure during test
Hydrostatic strength	According to ISO 4427-2 Table 3	
Elongation at break	According to ISO 4427-2 Table 5	

PB 4.2 PIPE AND FITTINGS

a) Dimensions (PE100):

1. Pipe diameter and Class to be used shown in table below

Type	Diameter	Class	SDR
Under drainage herringbone pipes (ADF)	110 OD	25	7.4
Under drainage collector pipes and LC herringbone pipes (ADF)	160 OD	25	7.4
Under drainage outlet and LC collector pipes (ADF)	200 OD	25	7.4
LC herringbone pipes (ADF)	160 OD	25	7.4
LC collector pipes (ADF)	200 OD	25	7.4
LC outlet pipes (ADF)	315 OD	25	7.4

2. Pipe Dimensions: The nominal inside diameter of the pipe shall be true to the specified pipe size in accordance with ISO 4427-2 Part 2 Table 1 & 2. Standard laying lengths shall be 6 m or 12 m, as may be specified by the Engineer.
3. All piping shall be black with or without a blue identification stripe. No other colour identification stripe shall be accepted.

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4. Fitting Dimensions: Fittings such as coupling, wyes, tees, adaptors, etc. for use in laying pipe shall have standard dimensions that conform to ISO 4427-3 Part 3.

b) Where possible, pipe and fittings should be produced by the same manufacturer from identical materials meeting the requirements the ISO 4427 Part 3 specification.

c) Pipe and fittings shall be pressure rated to meet the service pressure requirements specified by the Engineer. Whether moulded or fabricated, fittings shall be fully pressure rated to at least the same service pressure rating as the pipe to which joining is intended.

d) Moulded fittings shall meet the requirements this specification. At the point of fusion, the outside diameter and minimum wall thickness of fitting butt fusion outlets shall meet the diameter and wall thickness specifications of the mating system pipe. Fitting markings shall include a production code from which the location and date of manufacture can be determined. Upon request, the manufacturer shall provide an explanation of this production code.

e) Markings:

1. All piping and fabricated fittings shall be clearly marked as per ISO 4427 Part 2 and 3 section 11, thus enabling full traceability at all times.
2. Typically this must display as a minimum the: Standard to which this is produced, The Manufacturer ID, pipe dimensions, SDR, material spec, Pressure rating and unique identification mark.
3. The info as per item 2 must be displayed once/ meter pipe and at least once on the fitting.

PB 4.3 SOURCE QUALITY CONTROL

a) Inspection requirements:

1. Notification - If inspection is specified by the purchaser, the manufacturer shall notify the purchaser in advance of the date, time and place of testing of the pipe in order that the purchaser may be represented at the test.
2. Access - The *Employer*'s representative shall have free access to the inspection area of the manufacturer's plant. The manufacturer shall make available to the *Employer*'s representative, without charge, all reasonable facilities for determining whether the pipe meets the requirements of this specification.
3. Certification - As the basis of the acceptance of the material, the manufacturer will furnish a certificate of conformance of these specifications upon request. When prior agreement is being made in writing between the purchaser and the manufacturer, the manufacturer will furnish other conformance certification in the form of affidavit of conformance, test results, or copies of test reports

b) Physical Test Requirements

1. Sampling - The selection of the sample of pipe shall be as agreed upon by the purchaser and the manufacturer. In case of no prior agreement, any sample selected by the manufacturer shall be deemed adequate
2. Conditioning - Conditioning of samples prior to and during test shall be as per the specified national or international standard. In case of no applicable standard, conditioning shall be for a minimum time of 24 hrs at a temperature of 23 °C ± 2 °C.

PB 5 EXECUTION

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PB 5.1 FIELD QUALITY CONTROL

a) Pipe may be rejected for failure to conform to specifications or following:

1. Fractures or cracks passing through the pipe wall.
2. Scratches, mechanical damage sufficient to impair strength, durability or serviceability of pipe.
3. Defects indicating improper proportioning, mixing, and moulding.
4. Damaged ends, where such damage prevents making satisfactory joint.
5. Pipe ends shall be cut cleanly and square to the axis of the pipe.
6. Pipe internal and external surface appearance shall be smooth, clean and free from scoring, cavities and other surface defects such as pinholes.

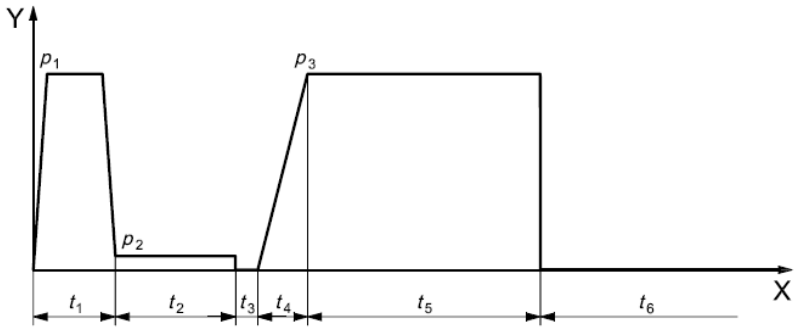
b) Acceptance of fittings, stubs or other specifically fabricated pipe sections shall be based on visual inspection at job site and documentation of conformance to these Specifications and ISO 4427 Part 3.

c) Notify Engineer prior to backfilling trench. Contractor is to obtain as-built top of pipe coordinates and elevations at 20m intervals along the pipe prior to backfilling. **Also see PC 6 Testing.**

PB 5.2 INSTALLATION

a) Heat fusion of pipe to be single pressure with high fusion jointing pressure in accordance with ISO 21307 and SANS 10268 as specified in the table below:

Parameter	Unit	Value
Heater plate temperature	ºC	200 – 230
Initial bead-up fusion jointing pressure	MPa	0.52 +/- 0.1
Min heat soak time	sec	(11 +/- 1) x e_n
Min bead size after heating	mm	0.15 e_n + 1
Heat soak pressure	MPa	0 to drag pressure
Max heater plate removal time	s	0.1 e_n + 8
Fusion jointing pressure	MPa	0.52 +/- 0.1
Min cooling time in the machine under pressure	min	0.43 e_n
Min cooling time out the machine	min	[a]
[a] = A cooling time out of the machine and before rough handling may be recommended but in most cases is not necessary with these cooling times		



Key

X time
Y pressure
t_1 initial bead-up time
t_2 heat soak time
t_3 heater plate removal time
t_4 time to achieve fusion jointing pressure
t_5 cooling time in the machine under pressure
t_6 cooling time out of the machine
p_1 initial bead-up pressure
p_2 heat soak pressure
p_3 fusion jointing pressure

1. Provide fusion operators certified by the pipe manufacturer.
2. Butt fusion equipment for joining procedures shall be capable of meeting conditions recommended by ISO 21307 including, but not limited to, temperature requirements, alignment, and fusion pressures.
3. For cleaning pipe ends, planning unit and heater surfaces, a dry, clean, lint-free, non-synthetic cloth such as cotton is to be used every time. In extreme cases water can be used for cleaning followed by drying with a cloth as above. In the case of oil contamination Acetone or greater than 90% Isopropyl alcohol can be used.
4. Do not bend pipe to greater degree than minimum radius recommended by manufacturer for type and grade.
5. Do not subject pipe to strains that will overstress or buckle piping or impose excessive stress on joints.
6. Branch saddle fusions shall be joined in accordance with manufacturer's recommendations and procedures. Branch saddle fusion equipment shall be of size to facilitate saddle fusion within trench.
7. Trial welds to be undertaken and externally tested prior to production welds being initiated.
8. Clamp the components in the butt fusion jointing machine and adjust as necessary to achieve proper alignment.
9. Plane the pipe or fitting ends to establish clean, parallel mating surfaces.
10. Remove any shavings from the pipe or fittings. Inspect the pipe for incomplete planning, voids or other imperfections and then bring them together to check for proper alignment.
11. Measure the gauge pressure required to overcome the frictional drag force of the machine and pipe. This pressure shall be added to the calculated bead-up and fusion jointing pressure.
12. Heater plate to be checked with hand held thermometer for even temperature distribution. The temperatures are to be taken at a minimum of four positions on the plate, and should not vary by more than 5 degrees. Readings to be recorded in the CQA data.
13. Install the heater plate in the machine and bring both pipe ends simultaneously into full contact with the heater plate to produce molten surfaces for fusion jointing. Pipe ends are not to be over pressurised during the soak time to prevent formation of pockets on the joint, maximum allowed pressure is to be 10% of the fusion pressure, soak pressure to be recorded in the CQA data.
14. At the completion of the heat soak time, pull the pipe from the heater plate then remove the heater plate and bring the pipes together in a controlled manner. The joint shall be held at the jointing pressure for the prescribed jointing time.
15. The molten joint shall be held immobile under pressure in the machine for the prescribed time.

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16. An even double roll back bead all around the circumference of the pipe should be visible, both in width and height, with a smooth appearance. The pipes must be properly aligned, no mitered joints allowed, and there must be no visual evidence of any contamination in the bead.
17. Cover at end of each working day open ends of fused pipe. Cap to prevent entry by animals or debris.
18. Use compatible fusion techniques when polyethylenes of different melt indexes are fused together. Refer to manufacturer's specifications for compatible fusion.
19. Remove shavings inside pipe caused by perforation drilling prior to jointing.
20. Remove internal beads on leachate collection pump riser to allow for smooth entry and exit of the pump.
21. The details of the fusion joint procedure and conditions under which the fusion joint was executed must be fully logged. Electronic equipment, such as data loggers, is the preferred method. Data captured must comply with ASTM F3124 – Data capture requirements.

b) Flange Jointing:

a) Used on flanged pipe connection sections.
b) Connect slip-on carbon steel backup flanges with stainless steel nuts and bolts.
c) Butt fuse fabricated/ moulded flange adapters to the pipe.
d) Observe the following precautions in connection of flange joints:
    a. Align flanges or flange/valve connections to provide a tight seal. Gaskets are not required for HDPE/ HDPE and HDPE/ Carbon connections as specified by the Engineer. Flange faces are undamaged and clean – rectify any surface damage prior to starting the bolt up process.
    b. Place round washers as may be required on some flanges in accordance with manufacturer's recommendations. Bolts shall be lubricated with grease in accordance with manufacturer's recommendations.
    c. Tighten flange bolts in a criss-cross sequence and accordance with manufacturer's recommendations. Hand tighten/ normal spanner tighten the bolts and nuts in the required sequence and recheck that there is no gap between the flange faces. The faces must be parallel.

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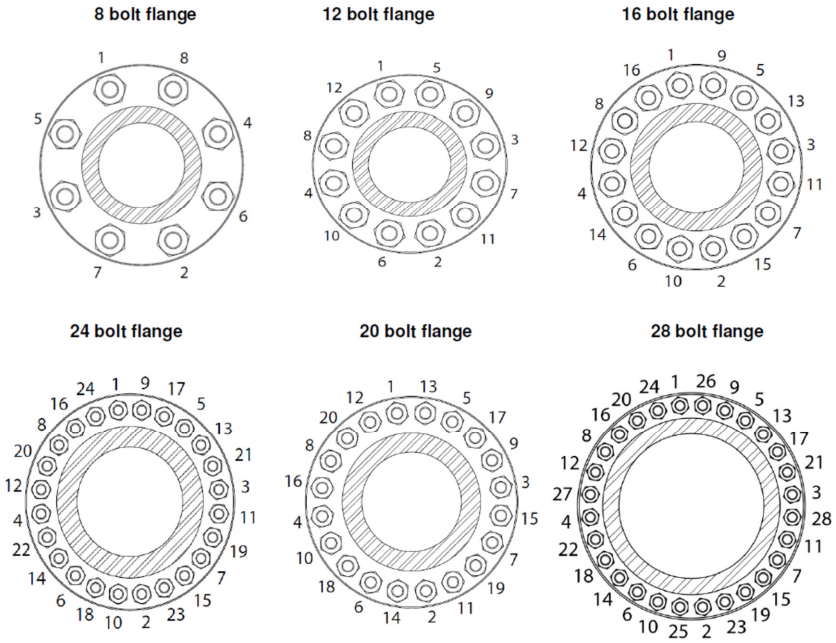

d. Allow the HDPE to "settle" for a minimum of 4 hrs before the final torque is applied. The correct range size torque wrench must be used and the torque wrench calibration certificate is to be available on site.

e) Pull bolt down by torque in accordance with manufacturer's recommendations, typical torque values shown in the table blow

Pipe OD (mm)	Bolt diameter (mm)	No. of bolts	Max lubed torque (N.m)
90	16	8	70
110	16	8	90
125	16	8	90
140	16	8	100
160	20	8	100
180	20	8	135
200	20	8	165
225	22	12	165
250	22	12	165
280	22	12	220
315	24	12	300
355	24	12	370
400	24	16	370
450	28	16	410
500	28	20	410
560	32	20	490
630	32	24	590
710	32	28	590
800	38	28	870

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900	38	32	950
1000	38	36	950

Refer to Plastics Pipe Institute TN -38/ July 2011

f) Protect below ground bolts and flanges by covering with a 1.5mm thick polyethylene wrap. Denso tape wrap to the HDPE pipe.
g) Electrofusion couplers, where used, shall installed per MAB Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe and Installation Guidelines For Electrofusion Couplings 14" and Larger TN-34/2009 both available on the Plastics Pipe Institute Inc. (PPI) website http://plasticpipe.org

PB 5.3 PIPE PLACEMENT

Pipe placement is to be conducted as follows:

1. Grade control equipment shall be of type to accurately maintain design grades and slopes during installation of pipe.
2. Dewatering: Remove standing water in trench before pipe installation.
3. Unless otherwise specifically stated, install pipe in accordance with manufacturer's recommendations.
4. Maximum lengths of fused pipe to be handled as one section shall be placed according to manufacturer's recommendations as to pipe size, pipe SDR, and topography so as not to cause excessive gouging or surface abrasion; but not to exceed 120m.
5. Cap pipe sections longer than single joining (usually 12m) on both ends during placement except during fusing operations.
6. Notify Engineer prior to installation pipe into trench and allow time for Engineer's inspection, correct irregularities found during inspection.
7. Complete tie-ins within trench whenever possible to prevent overstressed connections.
8. Allow pipe sufficient time to adjust to trench temperature prior to testing, segment tie-ins or backfilling activity.
9. Install reducers adjacent to laterals and tees.
10. To reduce branch saddle stress, install saddles at slope equal to and continuous with lateral piping.
11. Place in trench by allowing minimum 300mm/30m for thermal contraction and expansion.
12. Coordinate construction of pipes near access roads with *Employer* to limit impediment of site operations or operations of other Contractors.

PB 5.4 PERFORATIONS

Perforated seepage collection pipes are to be perforated with 4 x 12 mm diameter holes drilled at 100 mm centre to centre, unless stated as solid or shown differently on the drawings.

PB 5.5 CORRUGATED, SLOTTED AND PERFORATED PIPE

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Specified underdrainge collector pipes shall be slotted and perforated, double wall corrugated pipe.

The pipe shall comply with the following specifications:

Property:	Unit:	Value	Value:
Outside diameter	mm	110	160
Inside diameter	mm	95	137
Infiltration area	mm^2/m	> 7000	
Nominal slot width	mm	1.3	1.8
Nominal hole diameter at 100mm centres	mm	15	
Ring stiffness	kPa	> 450	

PB 6 TESTING FOR PRESSURE PIPELINES

PB 6.1 PREPARATION

a) Commence test procedures when the following conditions have been met.
   1. Pipe section to be tested is clean and free of dirt, sand or other foreign material.
   2. Plug pipe outlets with test plugs. Brace each plug securely to prevent blowouts. Use concrete if necessary.
   3. Add compressed air slowly.
   4. Pressurizing equipment shall include regulator set to avoid over-pressurizing and damaging an otherwise acceptable section of pipe.

a) Provide necessary pipe connections between the section of line being tested and the compressed air supply, together with test pressure equipment, meters, pressure gauge, and other equipment, materials, and facilities necessary to perform the specified tests.

b) Furnish and install bulkheads, flanges, valves, bracing, blocking or other temporary sectionalising devices that may be required

c) Remove temporary sectionalising devices after tests have been completed

PB 6.2 TESTING EQUIPMENT

- Contractor shall provide all equipment required for this testing procedure.
- Testing Equipment shall include, but may not be limited to:
  1. Polyethylene flange adapter with steel blind flange.
  2. Temperature gauge (0ºC to 100ºC) tapped and threaded into blind flange.
  3. Pressure gauge (0 to 1000 mb) ASME Standard B40.1 Grade 2A (accuracy of ±0.5% of full scale) with minor graduation marks no greater than 10 mb.
  4. Inlet valve to facilitate compressed air hose.
  5. Ball valve to release pipe pressure at test completion.
  6. Polyethylene reducers to be used to adapt test flange to size of pipe being tested.
  7. Air compressor shall provide adequate air supply for testing.
  8. Pressurizing equipment shall include a regulator set to avoid over-pressurizing and damaging otherwise acceptable pipe.
- Provide verification and results of gauge calibration prior to (less than 60 days) and after Project completion.

PB 6.3 TESTING

a) *EMPLOYER* and *ENGINEER* shall be given 24-hr notification prior to test.

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b) Appropriate Safety precautions must be in-place.
c) Pipe Test Segments:
   1. Butt-fusion weld pipe segments.
   2. Less than 610 meter in length.
   3. Blind flange with test apparatus on one end and fused cap or blind flange assembly on opposite end.
d) Environment:
   1. Place test segment in trench or lay test segment on ground surface and allow it to reach ambient temperature before test.
   2. Perform test during period when pipe segment will be out of direct sunlight to minimize pressure changes as a result of temperature fluctuations.
e) Test:
   1. Apply test pressure of 1000 mb to test segment.
   2. Observe test pressure for 1-hour.
   3. Mathematically correct pressure drop for temperature change.
   4. Temperature corrected pressure drop over 1-hour period should not exceed 1%.
   5. If retest is necessary, allow pressure to relax to 0 mb for a minimum of 8 hours prior to retest.
f) Test Failure:
   1. If retest is necessary, allow pressure to relax to 0 psig for at least 8 hours prior to retest.
   2. Perform the following when pipe segment fails test:
      i. Check entire length of pipe and fusion welds for cracks, pinholes, perforations or other possible leakage points.
      ii. Check blocked risers and capped ends for leakage and check gaskets at blind flanges.
      iii. Verify leaks by applying a soapy water solution and observe for bubble formation.
   3. Repair pipe and fused joint leaks by cutting out leak areas and refusing suitable segments.
   4. After the leaks are repaired, retest the pipe after the 8 hour relaxation period.

PB 6.4 TEST REPORT

Each test shall be reported in writing, on the "HDPE PIPE PRESSURE TEST REPORT" included at the end of this section.

If failure occurs, the following information is to be included:
1. *Location of failure segment.*
2. *Nature of leaks.*
3. Details of repairs performed.
4. *Retest*

PB 6.5 HYDRAULIC TESTING

Hydraulic testing in accordance with SANS 1200 L, Section 7.3, and SANS 2001: DP 2 Medium Pressure pipelines is also permissible.

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HDPE PIPE PRESSURE TEST REPORT

Project Name/No.: _____ Date: _____
Contractor: _____ Time: _____
Person Performing Tests: _____
Description/Location of Test Segment: (Pipe Diameter, Length, and SDR's)

_____

_____

Location of Pipe Test Segment _____
Station From: _____ Station To: _____

Ti = Initial Temperature = _____ °C
Pi= Initial test pressure = _____ mb
Pc = Initial Pressure in mb corrected for temperature (Tt) at time "t"
t = Time in minutes from initiation of test
Tt= Temperature in °C at time 't'
Pt= Test pressure in mb at time 't'

$$Pc = \left[\frac{(P_i + 1013)(T_i + 273)}{T_i + 273}\right] - 1013$$

$$\text{Percent Pressure Drop} = \frac{Pc - Pt}{Pc} \times 100$$

Time (min)	Tt Temp Reading (°C)	Pt Gauge Pressure (mb)	Pc Corrected Pressure (mb)	Pressure Drop (%)
0				
20				
40				
60				

Pass/Fail: _____ Retest (yes/no) _____

Description/Nature of leaks repair of retest segment:

_____

_____

_____

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