SECTION 1 - GENERAL

1.1.1 Work covered by contract documents

A. Project Identification: The "**SAOUFAR WATER NETWORK**" project comprises the construction, completion and maintenance during the defects liability period of a Water Supply networks located In **SAOUFAR**, MOUNT LEBANON.

SECTION 2 – EARTHWORKS

2.1 Scope of Work

This section covers trenching and backfilling work and shall include the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent property; backfilling; pipe embedment; surfacing and grading; and other related work.

2.2 Site Preparation

A. Prior to commencing any excavation work, the Contractor shall establish a horizontal and vertical survey, record existing ground elevations and stake the location of trenches to be excavated.

B. The Contractor shall prepare the site for construction by clearing, removing and disposing of all items not indicated on the Drawings to remain or so defined by the Engineer.

C. The Contractor shall obtain relevant excavation and road cutting permits as required to commencing work.

i) Existing Subsurface Structures and Utilities

For all works required to deal with existing subsurfaces and utilities refer to General Section of these Specifications.

ii) Clearing, Grubbing and Grading

A. The Contractor shall perform the clearing and grubbing (if any), of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300 mm from the natural ground level. All materials resulting from the above operations shall be removed from the site, loaded and transported and off loaded, spread and leveled to approved dumps as directed by the Engineer.

B. The Contractor shall include for grading the route to provide access for his equipment and personnel, executing all cuttings to remove the high point of rises in terrain and in all respects prepare the route for pipe laying operations, all in accordance with the requirements of good pipeline construction practice.

2.3 Setting-Out

The Contractor shall stake-out the work as shown on the Drawings and secure the Engineer's

approval of his stake-out before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out, the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-out for further approval in accordance with the relevant Clause of the Conditions of Contract.

2.4 Excavation

A. The Contractor shall perform all excavation true to lines, widths and depths shown on the Drawings or to such further lines, depths or dimensions as may be directed by the Engineer.

B. Excavation work will be done in all kinds of soils.

i) Road along the line.

A. Wherever necessary the Contractor shall prepare a road along the line at such distance from the line that the traffic on the road will in no way interfere with pipe laying work. The Contractor shall also prepare access roads from the highway or other public roads to the said access road.
B. The road along the line and the access roads shall permit the normal movement of trucks and other vehicles and all equipment and plant required for the execution of the works.
C. The employer's employees shall at times have the use of the roads prepared by the Contractor, free of charge.
D. The Contractor shall maintain the road along the line and the access roads in a good and serviceable condition and shall make all repairs that may be necessary during the whole period of construction.

ii) Excavation to reduce levels.

A. Wherever shown on the drawings, the Contractor shall reduce the ground level on the trench site, prior to commencement of trench excavation. Before starting excavation for reducing of levels the Contractor shall move the marking of the alignment to such a distance that the marks will not be destroyed and will not interfere with the execution of the work.
B. Excavation for reducing levels shall be done to the lines and levels shown on the drawings. Where the depth of excavation is not so shown it shall be done to a line parallel to the trench bottom in the section concerned.

iii) Storing of Suitable Excavated Material

During excavation, materials suitable for backfill and fill will be stockpiled on site at sufficient distance from the sides of the excavation to avoid over-loading and prevent cave-ins.

iv) Disposal of Unsuitable and Surplus Excavated Material

Upon the order of the Engineer, all unsuitable and surplus materials shall be immediately removed, loaded and transported off Site area by the Contractor to approved dumps at the Contractors expenxe, and he shall abide by the relevant local regulations.

v) Unauthorized Excavation

If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled by well graded material at the Contractor's expense with thoroughly compacted to an acceptable proctor as directed by the Engineer, if the excavations are for a structure or a manhole, then the void should be filled by class C15 concrete.

2.5 Removal, Restoration and Maintenance of Surface

i) Removal of Pavement

The Contractor shall remove pavement and road surfaces as a part of the trench excavation, and the volume removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures. The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the top width of the trench specified by more than 200 mm on each side of the trench. The widths and lengths of the area of pavement removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 300 mm on each side. Wherever, in the opinion of the Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the Engineer but shall receive no extra compensation therefore. The Contractor shall use such methods, either drilling or chipping, as will assure the breaking of the pavement along straight lines. The cut must be sharp and approximately vertical. The Engineer's representative may require that the pavement be cut with asphalt cut machine without extra compensation to the Contractor.

ii) Restoration of Damaged Surfaces and Property

If any pavement, trees, shrubbery, fences, poles, or other property and surface structures have been damaged, removed, or disturbed by the Contractor, whether deliberately or through failure to carry out the requirements of the contract documents, state laws, municipal ordinances, or the specific direction of the Engineer or through failure to employ usual and reasonable safeguards, such property and surface structures shall be replaced or repaired at the expense of the Contractor. If the Employer specifies that the replacements or repairs shall be made by the Contractor, he shall replace or repair and restore the structures to a condition equal to that before the work began and to the approval of the Engineer and shall furnish all incidental labour and materials.

2.6 Trench Excavation

i) General

A. The minimum trench width at the bottom shall be equal to the external pipe diameter plus 500 mm provided that the minimum clearance between the installed pipe and the trench side shall not be less than 250 mm. The rest of the trench, unless otherwise shown on the drawings or instructed by the Engineer, shall be excavated with approximately vertical sides as much as possible.
B. The trench width at the ground surface shall be excavated as narrow as practicable but may vary with, and depend upon its depth and the nature of the ground encountered.
C. Trenches shall be of such extra width, when required, as will permit the convenient placing of timber support, sheeting and bracing and handling of specials.
D. The graded material bedding under the pipe shall be not less than 200 mm thick in any point and as shown on the drawings and as directed by the Engineer.
E. The trench depth shall give the required minimum cover over the pipe as specified.
F. The trench bottom shall be straight and even so as to provide a good support for the pipe on its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating. The excavated material shall be placed alongside the trench in such a manner as not to interfere with the work and to prevent its falling down into the trench.
G. Where welds or joints of pipes and accessories are required to be done in the trench, it shall be widened or deepened to the usual enlarged dimensions or as directed by the Engineer so as to easily permit the proper execution of all welding and fixing works at all their stages, coating repairs, and thorough inspection of all these operations.
H. Separate excavations are to be made for manholes, pipe junctions, etc.
I. No more trench shall be opened in advance of pipe laying than is necessary to expedite the Work.

100m shall be the maximum length of open trench within urban areas and 500m in rural areas.

A. Hand excavation must be applied where existing cables, water mains, sewers, etc., cross or are in the main roads where traffic is likely to be unreasonably dislocated by use of machine or where instructed by the Engineer. In other places hand or machine excavating may be employed at the discretion of Contractor.

ii) Types of Trench Excavation

1. Common and Sand Excavation.

When excavating in ordinary soil or sand the Contractor shall take all precautions to prevent slides caused by material placed alongside the trench or for any other reason.

Wherever the danger of slides exists, the Contractor shall slope the trench walls, install supports, bracing, etc., and shall make all other arrangements which may be necessary to prevent slides.

2. Trench Excavation in Rock.

Trench walls excavated in rock shall be as nearly vertical as possible, and the Contractor shall consolidate the walls wherever they have been loosened by blasting or for other reasons, or shall remove the loosened material.

The Contractor shall take all necessary measures to maintain the trench in its proper shape and to prevent it from being filled with eroded earth or mud until the pipe has been laid.

iii) Mechanical Excavation

A. The use of mechanical equipment must be jointed with the approval of the Engineer. The use of mechanical equipment will not be permitted in locations where its operation would cause damage to trees, buildings, culverts or other existing property, utilities or structures above or below ground. In all such locations hand excavation shall be used. The Contractor will be held responsible for making good at his own cost all additional damage to road surfaces and private lands caused by the use of mechanical excavators.

B. Mechanical equipment if used for trench excavation shall be of type approved by the Engineer. Equipment shall be so operated that the rough trench excavation bottom can be controlled; that uniform trench widths and vertical sides are obtained at least from an elevation 200mm above the top of the installed pipe when accurately laid to specified alignment will be centered in the trench with adequate clearance between the pipe and sides of the trench.

iv) Alignment and Minimum Cover

A. The alignment of each pipeline shall be fixed and determined from offset stakes. Horizontal alignment of pipes and the maximum joint deflection used in connection therewith shall be in conformity with requirements of the section covering installation of pipe.

B. Pipe grades or elevations are not definitely fixed by the Contract Drawings, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe of 700mm for diameters less than 150mm or as mentioned in the bill of quantities. Greater pipe cover depths may be necessary at certain locations, the locations and depths will be determined by the Engineer, and will be followed by the Contractor. Measurement of pipe cover depth shall be made vertically from the outside top of pipe to finish ground or pavement surface elevation except where future surface elevations are indicated on the Drawings. Where there is no adequate minimum cover, concrete encasement will be used as hereinafter and as shown on the Drawings and as directed by the Engineer.

v) Excavation in Confined Areas.

In confined areas, where the passage of excavating equipment is impossible, or where the Engineer deems to use of such equipment impracticable or undesirable for any reason whatsoever, trench excavation shall be done by hand. All requirements specified above for common or sand excavation shall also apply to trench excavation by hand.

vi) Padding of Trench Bottom.

A. Wherever the trench bottom is in rock or where the Engineer will decide that the trench bottom is unsuited for laying of pipe on it, the trench will be excavated to an additional depth, and the Contractor shall pad the trench bottom with a layer 100 mm thick of selected excavated material not containing stones larger than 30 mm measured in any direction provided that the quantity of stones smaller than 30 mm is not more than 20% by volume.
B. The surface of the padding shall be finished to grade as specified above so as to provide an even and solid support for the pipes to be laid.

2.7 Excavation for Concrete Valve Chambers

A. Excavation for the concrete valve chambers shall be carried out to the dimensions, lines and grades shown on the Drawings or required by the Engineer.

B. Wherever the depth of the excavation or the nature of the soil makes it necessary to avoid caving in, the Contractor shall excavate the walls to a slope or brace and support the excavation.

C. Should nevertheless earth slides occur, the Contractor shall remove the material resulting there from, clean the excavation of all stones, clods and other loose material and shall provide a clean excavation surface in which concrete can be cast according to required dimensions and grades.

D. Should it appear that the bottom of the excavation does not provide a solid base for the casting of the concrete floor, the Contractor will be required to consolidate the bottom using hand tampers and increasing the moisture content, if required, until the required density is obtained, a/o placing concrete class (C15) as blinding, all as directed by the Engineer.

E. Any over-excavation at the bottom of the structure shall be restored to the proper grade by filling the over excavation class (C15) concrete or shall be filled with the concrete of which the structure is cast. In the case of over-excavation in the walls, whether caused by careless work or by the necessity to prevent slides by excavating to a slope or for any other reason, the Contractor shall remove all loose material from the excavation, cast the walls of the structure to the dimensions shown on the Drawings and fill the spaces between the structures and the sides of the excavation with compacted backfill in layers of 100mm thickness. The material of the backfill shall be moistened if necessary and compacted to the level of the adjacent natural soil.

2.8 Backfilling of Trenches

i) General

A. Every section of the pipeline shall be covered as soon as possible after being lowered into trench, but no section of the line shall be covered without express approval of the Engineer. Each section shall be backfilled after the pipe has been placed in its final position on the trench bottom and after all weld joints and bends have been coated and all defects in the pipe coating repaired.
B. Backfilling shall be done carefully to prevent displacement of the pipe or injury to the pipes. The backfill material shall completely fill the entire space between the pipe and the trench surfaces, without leaving any voids.
C. Care shall be taken that the backfill material does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tyres, ashes, refuse, oil or soil soaked with oil.
Stones removed during trench excavation may be used in the second stage of backfilling as specified below.
D. On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to

direct the flow of rainwater into the natural drain courses and away from the pipeline trench.

E. Where the pipeline crosses natural drainage channels, an opening in the backfill shall be made to avoid interference with normal drainage of the surrounding land.
F. Backfilling shall be done so as not to spoil the road or disrupt its continuity.

ii) Backfilling of Trenches in Cross-Country Areas

Where the pipes are laid cross-country, the backfilling of trenches shall be done as follows:

A. **Soft Backfill** (surrounding the pipe) shall consist of fine aggregates from an approved source. This material shall be placed 200 mm below the invert level up to 200 mm over the crown of the pipe and for the full width of the trench, or to the depths specified in the Bill of Quantities.
B. **Final Backfill** for the remainder of the trench shall be by using well graded approved backfill material. (as specified herein after in paragraphs 2.9(i , ii))
C. The trench shall be filled to the level of the natural adjacent ground level in layers not exceeding 200 mm, wetted and compacted by rolling, tamping to 90 percent of maximum dry density. If rolling is employed, it shall be by use of a suitable roller or tractor, being careful to compact the fill throughout the full width of the trench.

iii) Backfilling of Trenches in or Adjacent to Streets

Where the pipes are laid in or adjacent to streets, the backfilling of trenches shall be done as follows:

A. **Soft Backfill** shall be done as specified above in paragraph 2.8(ii-A)
B. **Final Backfill** for the remainder of the trench shall be by using well graded approved backfill material. (as specified herein after in paragraphs 2.9(i , ii))
C. The selected backfill shall be up evenly on all sides, in layers not exceeding 200 mm measured before compaction, thoroughly wetted and compacted by rolling, tamping, or vibrating with mechanical compacting suitable equipment or hand tamping, to 95 percent of maximum dry density. Where these methods are not practicable, compaction shall be done by using of pneumatic ramming with tools weighing at least 10 Kg. The materials in this case being spread and compacted in layers not more than 150 mm in thickness. If necessary, sprinkling shall be employed in conjunction with ramming.
D. The top 200mm sub-base for pavement replacement, shall consist of one layer of approved base course material, wetted and compacted to 95 percent of maximum dry density.
E. Should the contractor wish to use the material excavated from the trench as sub-base for pavement replacement, the contractor shall at his own expense have samples of the material tested by an independent and certified laboratory at intervals not to exceed 150 m, in order to establish its compliance with the specifications. Only material which has been tested by the contractor and approved by the engineer shall be allowed to be incorporated into the work.

iv) Backfilling of Trenches with Excessive Slopes

A. On trenches with slopes exceeding 15 percent, a 300 mm wide, stone partitions shall be built across the trench every 10 meters length.
B. These partitions shall be done constructed over the first stage of the backfill up to the natural ground level, and shall exceed the trench width with 200 mm from each side inside the ground.

v) Restoring Trench Surface

A. Where the trench occurs adjacent to paved streets, in shoulders, sidewalks, or in cross-country areas, the contractor shall thoroughly consolidate the backfill and shall maintain the surface as the work progress. If settlement takes place, he shall immediately deposit additional fill to restore the level of the ground. In some areas it may be necessary to remove excess materials during the clean-up process, so that the ground may be restored to its original level and condition.
B. The surface of any driveway or any other area which is disturbed by the trench excavation and which is not a part of the paved road shall be restored by the contractor to a condition at least

equal to that existing before work began.

C. All road surfaces shall be broomed and hose-cleaned immediately after backfilling. Dust control measures shall be employed at all times.

2.9 Material Used in Backfill

i) General

A. Backfill and fill material shall be suitable excavated material, natural or processed mineral soils obtained from off-site sources, or graded crushed stones or gravel.

B. Backfill and fill material shall be free from all organic material, trash, snow, ice, frozen soil, or other objectionable material which can't be properly compacted. Soft, wet, plastic soils which may be expensive, clay soils having a natural in-place water content in excess of 30 percent, soil containing more than 5 percent(by weight) fibrous organic material, and soil having a plasticity index greater than 30 shall be considered unsuitable for use as backfill and fill material.

C. Backfill and fill material shall have a maximum of one percent expansion when testing is performed on a sample remolded to 95 percent of maximum dry density at a two percent below optimum moisture content under a 490 kg/m2 surcharge.

ii) Common Backfill Material

A. Common Backfill or fill material shall not contain Granite blocks, broken concrete, masonary rubble, asphalt pavement, or any material larger than 150 mm in any dimension provided that this material is not more than 25 percent of the backfill or fill material.

B. Common Fill shall have physical properties, as approved by the engineer, such that it can be readily spread and compacted.

iii) Selected Backfill Material

Selected Backfill and Fill material shall conform to the requirements of common Backfill except that the material shall not contain any materials larger than 50 mm in its largest dimension provided that this material is not more than 20 percent of the Backfill or fill material.

iv) Structural Fill

Structural Fill shall be gravel, sandy gravel, or gravelly sand. Material shall have a plasticity index of less than 15 and shall conform to the gradation limits shown in table 2.1 below :

Table 2.1

Sieve Size	**Percent Finer By Weight**
150 mm	100
No. 4	20 - 70
No. 40	5 - 35
No. 200	0 – 7

v) Crushed Stones

Crushed stones shall be sound durable stone, angular in shape, and free of foreign material, structural defects and chemical decay. Crushed stones shall be of a maximum dimension of 50 mm and a minimum of 12 mm measured in any direction.

2.10 Quality Assurance

Laboratory Testing

A. At least seven days prior to the placement of any Backfill or Fill material, the contractor shall deliver a representative sample of the proposed material weighing at least 22 Kg to an approved soils testing laboratory to perform:

i- Grain size analyses of the samples to determine their suitability for use as Backfill or Fill material in accordance to the material requirements specified in section 2.11

ii- The appropriate Proctor analysis to determine the maximum dry densities required for compaction testing as specified in the contract documents.

B. The test results and determinations of suitability shall be delivered to the engineer no later than three days prior to the placement of Backfill or Fill materials.

2.11 Replacement of Pavements and Structures by the Contractor

A. Unless otherwise shown on the Drawings or mentioned in the bill of quantities, the Contractor shall restore all pavements, sidewalls, sidewalks, curbs, gutters, shrubbery, fences, poles, sod, or other property and surface structures removed or disturbed as a part of the work to a condition equal to that before the work began, and shall furnish all incidental Labour and materials. No permanent pavement shall be restored unless and until, in the opinion of the Engineer, the condition of the backfill is such as to properly support the pavement and not before written approval from the Engineer to commence such works.

B. Where pipelines pass underneath asphalted roads and parallel to the axis of the road, the final 250 mm of the trench backfill shall be furnished as follows:
   1. 200 mm (after compaction) shall be done by using approved base course material, placed, wetted and compacted to not less than 95 % of the modified Proctor density.
   2. Spraying 2 kg of prime coat (MCO) per each square meter over the compacted base course, and applying a layer of asphalt mix in a thickness not less than 50 mm after compaction.

2.12 Measurement and Payment

A. All Excavated material of whatever type shall be measured as “unclassified” which shall be deemed to include all materials encountered of any nature, including silts, clays, sand, gravel and granular materials and fractured, jointed and solid rock, and unsuitable material.

B. Trench Excavation shall be measured, as classified in the Bill of Quantities, and trimmed to required line, grade and cross section, including depositing excavated material along the side of trench if directed or hauling away and wasting, stockpiling or depositing on or in the vicinity of the works completed and accepted.

C. Measurement of Backfilling of trenches included in Excavation and Backfilling price.

D. Soft Backfilling from the bottom of the trench to at least 200 mm above the crown of the pipe, with fine aggregate fill as specified.

E. Final Backfilling for the remainder of the trench above the zone around the pipe with selected fill material as specified.

Reinstatement of roads and paved surface shall be measured in linear meter. The work will include removal, restoration and maintenance of surfaces and property, preparation of road foundation and replacement of hard core, asphalted layer as indicated in the specification and the Bill of Quantities.

SECTION 3 – WATER SUPPLY PIPEWORKS – POLYETHYLENE PIPES

3-1 General Terms And Conditions

3-1-1 Scope

This specification covers requirements for polyethylene piping system (pipe and fittings) for the supply of water under pressure intended for human consumption both above ground and in buried pipe applications.

3-1-2 Engineered And Approved Plans

Construction shall be performed in accordance with engineered construction plans for the work prepared under the direction of a Professional Engineer.

3-1-3 Referenced Standards

Most recent ISO standards or European Norms EN12201/EN12202 or DIN 8074/8075 shall apply.

3-1-4 Inspections

All work shall be inspected by an Authorized Representative of the Owner who shall have the authority to halt construction if, in his opinion, these specifications or standard construction practices are not being followed. Whenever any portion of these specifications is violated, the Engineer or his Authorized Representative shall, by written notice, order further construction to cease until all deficiencies are corrected. A copy of the order shall be filed with the Contractor's license application for future review. If the deficiencies are not corrected, performance shall be required of the Contractor's surety.

3-1-5 Warranty And Acceptances

The Contractor shall warrant all work to be free from defects in workmanship and materials for a period of [one year] from the date of completion of all construction. If work meets these specifications, a letter of acceptance, subject to the [one year] warranty period, shall be given at the time of Completion. A final acceptance letter shall be given upon final inspection at the end of the [one year] warranty period, provided the work still complies with these specifications. In the event deficiencies are discovered

during the warranty period, they shall be corrected by the Contractor without additional charge to the owner before final acceptance. During the warranty period, the Engineer shall determine if warranty repairs or replacement work shall be performed by the Contractor. The decision of the Engineer shall be binding upon the Contractor.

3-1-6 Qualification Of Manufacturers

The Manufacturer shall have manufacturing and quality control facilities capable of producing and assuring the quality of the pipe and fittings required by these specifications. The manufacturer's production facilities shall be open for inspection by the Owner or his Authorized representative. Qualified Manufacturers shall be approved by the Engineer.

3-1-7 Approved Manufacturers

Manufacturers must be pre-qualified and pre-approved by the Engineer. Products from unapproved manufacturers are prohibited.

3-2 Polyethylene Pipes / Fittings

3--2-1 Raw Materials

The polyethylene compounds used in the manufacture of products furnished under this specification shall be made from compounded pellets obtained by the addition of the correct type and amount of *carbon black* and necessary antioxidants and other additives to protect the pipe during extrusion and assure the life expectancy of the pipe. ***Pipe produced by the addition of black masterbatch to polyethylene is strictly forbidden***. The compound material shall comply with the requirements as specified in EN 12201-Part 1.

Typical material properties as described by the Raw Material Supplier brochure shall be submitted to the engineer for analysis and verification of compliance. These properties are not to be misconstrued as specification minimums.

All Raw Material used shall be approved and certified ***Pipe Grade Material*** for the transportation of potable water.

3-2-2 Polyethylene Pipe

3-2-2-1 Pipe Coil

Pipes with OD up to 110 mm shall be supplied in coils where the inside diameter of the coil is 30 times OD. Pressure pipes with OD of 140mm and above shall be supplied in straight lengths. When needed special pipe length can be supplied with the approval between purchaser and manufacturer.

3-2-2-2 Marking of Pipe

All pipes shall bear permanent identification markings that will remain legible during normal handling, storage, installation, and service life and that have been applied in a manner that will not reduce the strength nor otherwise damage the products. The marking shall not initiate any defects in the surface and will not provide leakage channels when elastomeric gasket compression fittings are used to make joints. Both hot tape marking and Ink Jet printing are acceptable.

Marking on pipe shall include the following and shall be applied at intervals of not more than 1.5 meters:

1) Normal size (i.e. 90mm)
2) Standard PE designation (i.e. PE-HD PE 100)
3) The Standard Dimension Ratio (i.e. SDR 11)
4) Marking the product with the applicable standards designation (EN 12201).
5) Production date
6) Nominal pressure rating of pipe (i.e. PN10)
7) Manufacturer's Name
8) Country of production

3-2-2-3 Service Identification Stripes

PE Pipes shall be permanently color-coded with stripes for instant identification as potable water service pipes. Stripes shall be provided by co-extruding four (or more) equally spaced blue color stripes into the pipe outside surface. The striping material shall be the same material as the pipe material except for color. ***Stripes printed on the pipe outside surface shall not be acceptable***.

3-3 Manufacturer's Quality Control

The pipe manufacturer shall have an established quality control program responsible for inspecting incoming and outgoing materials. Incoming PE materials shall be inspected for density, melt flow rate, and contamination. The cell classification properties of the material shall be certified by the supplier, and verified by Manufacturer's Quality Control. Incoming materials shall be approved by Quality Control before processing into finished goods. Outgoing materials shall be checked for:

a) Outside diameter and wall thickness as per EN 12201-Part 2 at a frequency of at last once/hour or once/coil, whichever is less frequent.
b) Out of Roundness at a frequency of at least once/hour or once/coil whichever is less frequent.
c) Quality Control shall verify production checks and test for:
d) Melting Index as per ISO 1133 at a frequency of at least once per extrusion lot.
e) Hydrostatic Strength testing (up to Ø110mm) as per EN 921 at a frequency of at least once per day per line.
f) All fabricated fittings shall be inspected for joint quality and alignment.

3-3-1 Permanent Records

The Manufacturer shall maintain permanent QC and QA records.

3-3-2 Compliance Tests

Manufacturer's inspection and testing of the materials. In case of conflict with Manufacturer's certifications, the Contractor, Engineer, or Owner may request retesting be the Manufacturer or have retests performed by an outside testing service. All retesting shall be at the Contractor's expense, and shall be performed in accordance with the Specifications.

3-4 Characteristics

3-4-1 External Aspect Of Pipes

Pipe surface shall be smooth, free from scoring, pinholes, and other surface defects. Pipe ends must be cut clean and perpendicular to the axis of the pipe. End caps at pipe extremities are required in order to prevent unwanted matter entering the pipe during storage.

3-4-2 Engineering Characteristics

The pipes thickness shall depends to the properties used in manufacturing and shall conform to PR-EN 12202-2 and nominal pressures PN10, PN12.5, PN16 bars and PN20 for PE100 material.

STANDARD: PR - EN 12201 - 2/TC 155												
PE 100 MATERIAL												
	PN 10			**PN 12.5**			**PN 16**			**PN 20**		
	SDR 17, S-8			**SDR 13.5, S-6.3**			**SDR 11, S-5**			**SDR 9, S-4**		
OD	e min.	e max.	ID(*)	e min.	e max.	ID(*)	e min.	e max.	ID(*)	e min.	e max.	ID(*)
mm	Mm	Mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
110	6.6	7.4	96.4	8.1	9.1	72.6	10.0	11.1	88.8	12.3	13.7	84.0
125	7.4	8.3	108.6	9.2	10.3	88.9	11.4	12.7	100.9	14.0	15.6	95.4
140	8.3	9.3	122.8	10.3	11.5	100.9	12.7	14.1	113.2	15.7	17.4	106.9
160	9.5	10.6	140.4	11.8	13.1	113.2	14.6	16.2	129.2	17.9	19.8	122.3
180	10.7	11.9	157.4	13.3	14.8	129.2	16.4	18.2	145.4	20.1	22.3	137.6
200	11.9	13.2	174.9	14.7	16.3	145.4	18.2	20.2	161.6	22.4	24.8	152.8

225	13.4	14.9	196.7	16.6	18.4	161.6	20.5	22.7	181.8	25.2	27.9	171.9
250	14.8	16.4	218.8	18.4	20.4	181.8	22.7	25.1	202.2	27.9	30.8	191.3

OD = Outside Diameter, ID (*) = Average Inside Diameter

e = Wall Thickness, PN = Nominal Pressure Ratings in Bar

3-4-3 Mechanical Characteristics

All manufactured pipes shall pass the stress test conforming to the requirements of PR-EN 12202-2 using test method of EN 921/ISO 1167. Stress test shall be the deciding factor in accepting or refusing the pipe.

Produced pipes shall pass the internal pressure test (acceptance test) using test method per EN 921.

PE class	Reqts	Stress	Temp.
PE 100	>100hrs	12.4MPa	20 ℃

Note: The Contractor must give the Engineer a report specifying that the pipes he will install fits with the specifications described.

3-4-4 Effect of temperature on working pressure of PE Pipe

Nominal pressure of PE pipes is the service pressure at 20°C with a service life of 50 years. For the use of Polyethylene pipes at higher temperature (up to a maximum of 60°C) the maximum working pressure should be reduced as per the Manufacturer pipe characteristics and ratings.

3--5 Pipe Connections

There are seven acceptable methods of joining polyethylene pipe with each other and with other pieces such as valves, flanges, etc.

1. Plastic Compression connection
2. Metal (ductile Iron) Compression connection
3. Electrofusion Fittings
4. Flange connection
5. Fabricated Fittings
6. Butt Fusion Welding
7. Special tapping fittings

3-5-1 Plastic Compression Fittings for PE Pipes

This type uses mechanical anchoring that holds the pipe in place (clamp ring usually made of Acetalic resin or C-PVC)and a sealing gasket (EPDM or Rubber/food approved) to create a tight grip and prevent water from leaking. Pipes must be pushed inside the fitting without the necessity to disassemble the fittings. The following pipe OD to PN must apply:

- Pipes up to OD = 63mm with pressure rating maximum PN16
- Pipes OD = 75mm up to 110mm maximum PN10. For PN16 applications metal compression fittings or electrofusion fittings should be used.

- Pipes OD >110mm plastic compression fittings are not used. Metal compression fittings or electrofusion fittings should be used.

All fittings must pass the testing requirements of ISO 3458/3459/3501/3503. Manufacturers of compression fittings must show evidence of approvals from at least 2 internationally reputed institutes such as:

DVGW Germany

SVGWSwitzerland.

WRC United Kingdom

KIWA The Netherland

3-5-2 Metal (ductile iron) Compression Fittings for PE Pipes

When joining polyethylene pipe or for joining polyethylene pipe to another material with metal couplings, those couplings shall be fully pressure rated and fully thrust restrained such that when installed in accordance with manufacturer's recommendations, a longitudinal load applied to the mechanical coupling will cause the pipe to yield before the mechanical coupling disjoins. External joint restraints shall not be used in lieu of fully restrained mechanical couplings. Nominal pressure rating of fittings shall be 16 bar.

Materials used in the manufacturing of steel compression fittings shall conform to the following:

- Body : GGG 400 - DIN 1693 (epoxy coated, see below for detailed reqts)
- Lip Seal : EPDM
- Grip Ring : Ms 58 (dezincification resistant brass)
- Bolts : A2 (stainless Steel)

All steel compression fittings must be epoxy coated to the following characteristics:

- Minimum coating thickness 250 μm
- Approved for food handling to KTW standard
- Bacteriological approval to DVGW recommendation W270
- Regular quality tests to DIN 30 677 T2

3-5-3 Electrofusion Fittings for PE Pipes

Electrofusion can be used for all polyethylene pipes irrespective of size and pressure rating as long as pipe and fitting are manufactured from polyethylene resin of the same class and series. It is possible to use fittings with higher pressure rating than pipe, but the opposite is strictly forbidden. Nominal pressure rating of fittings shall be 16 bar.

This type of fittings incorporates electrical heating coil that fuses pipe and fitting by sending an electrical current that heats up the polyethylene material of pipe and fitting at a specific voltage for a specified temperature and duration of time after which pipe and fitting fuse together and become integrated on

the molecular level. Manufacturer recommendations for the electrofusion operation must be strictly followed.

Electrofusion machines used in the electrofusion process must be supplied by the same manufacturer of fittings. It is strictly forbidden to fuse one manufacturer fitting with another manufacturer machine. Installers of Electrofusion fittings must strictly adhere to both fittings and equipment manufacturer's recommended procedures.

3-5-4 Flanged Connections

Flange connections shall be installed in accordance with the Manufacturer's recommended procedure. Flange faces shall be centered and aligned to each other before assembling and tightening bolts. In no case shall the flange bolts be used to draw the flanges into alignment. Bolt threads shall be lubricated, and flat washers shall be fitted under the flange nuts. Bolts shall be evenly tightened according to the tightening pattern and torque step recommendations of the Manufacturer at least 1 hour after initial assemble, flange connections shall be re-tightened following the tightening pattern and torque step recommendations of the Manufacturer. Nominal pressure rating of fittings shall be 16 bar.

Flanged connections shall consist of the following parts/fittings :

- Coupler (Electrofusion)
- Flanged Adaptor

The coupler for jointing plain-end polyethylene (PE) pipe to PE flanged items shall be of the electrofusion type that heats up the PE material of the pipe to the PE material of flanged fitting. Pressure rating of the coupler shall be no less than 16 bar and made of the same PE resin, class and series as the pipe.

The flanged adaptors for jointing plain-end pipe to flanged items shall be of the socket fusion type and made of polyethylene (PE) material of the same class and series as the pipe. Pressure rating of the flanged adaptor shall be no less than 16 bar.

3-5-5 Fabricated Fittings

Fabricated fittings shall be made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock, or molded fittings. Fabricated fittings shall be rated for internal pressure service equivalent to the full service pressure rating of the mating pipe. Directional fittings such as elbows, tees, crosses, etc., shall have a plain end inlet for butt fusion and flanged directional outlets. Part drawings shall be submitted for the approval of the Engineer.

3-5-6 Butt Fusion Welding

For pipes with diameters larger than 75mm, joints between end of the pipes and fittings may be made by butt fusion, and joints between the main and saddle branch fittings shall be made using saddle fusion using only procedures that are recommended by the pipe and fitting Manufacturer. The Contractor shall ensure that persons making heat fusion joints have received training according to the Manufacture's

recommended procedure. The Contractor shall maintain records of trained personnel, and shall certify that training was received not more than 12 months before commencing construction.

Heat Fusion Training Services - Upon request, the Manufacturer must provide training in the Manufacturer's recommended butt fusion and saddle fusion procedures to the Contractor's installation personnel, and to inspectors representing the Owner.

3-5-7 Tapping Fittings

Branch connections to the main pipeline i.e. (branch OD 63mm) can be made using either tees or special tapping fittings (saddle fittings). These fittings can be either mechanical type, electrofusion type or metal type (ductile) and should be designed for the connection to polyethylene (PE) pipes

Tapping fittings according to DIN 3543 are provided for welding to PE-HD pipes. They are welded to the main pipe according to the indications of international standards.

Tapping fitting for polyethylene main lines of PVC or PE-HD must have large contact surfaces and particularly for PE-HD special sealing elements in order to limit to a minimum the surface pressure.

When tapping the main pipeline, it is important to adhere to the respective guidelines for the pipe material. Only appropriate drills for the specific purpose, e.g. crown drills with sufficiently dimensioned flutes may be used. The construction of the drill must prevent the milled-out piece from falling into the pipe.

The material of the main pipeline determines the saddle width of the tapping fitting. The minimum width should be 100 mm for mechanically fastened fittings with rubber seals on PE-HD main lines.

3-6 Installation Of Polyethylene Pipe System

3-6-1 Foundation & Bedding

Pipe shall be laid on grade and on a stable foundation. Unstable or mucky trench bottom soils shall be removed, and a minimum of 100mm foundation or bedding of compacted fine gravel or sand shall be installed to pipe bottom grade. Excess groundwater shall be removed from the trench before laying the foundation or bedding and the pipe. A trench cut in rock or stony soil shall be excavated to 100mm below pipe bottom grade, and brought back to grade with compacted fine gravel or sand bedding. All ledge rock, boulders and large stones shall be removed.

3-6-2 Pipe Laying

A) In case of outdoor temperatures lower than 0°C, it is recommended to lay polyethylene pipes only under application of particular measures. Pipe ends and pipeline elements must be cleared prior to installation, damaged parts must be removed. Cuts are to be executed vertically to the pipe axle with the aid of suitable equipment, e.g. a fine-toothed saw. Cutting of the pipes can be made, too, using a casing cutter for plastic pipes. Burrs and uneven areas are smoothed down using suitable tools, e.g. a shaver or a scraper. The cut ends are then prepared for the jointing method to be used.

B) When lifting pipes with slings, only wide fabric choker slings shall be sued to lift, move, or lower pipe and fittings. Wire rope or chains shall not be used. Slings shall be of sufficient capacity for the load, and shall be inspected before use. Worn or defective equipment shall not be used.

C) Exercise care to keep foreign material and dirt from entering pipe during storage, handling, and placing in trench. Close ends of in-place pipe at the end of any work period to preclude the entry of animals and foreign material.

D) Do not lay pipe when trench bottom is muddy or frozen or has standing water.

E) Use only those tools specifically intended for cutting the size and material and type pipe involved. Make cut to prevent damage to pipe and to leave a smooth end at right angles to the axis of the pipe.

F) Unwinding of pipe coils can be carried out by various methods. Pipes with an outside diameter up to 63 mm can be unwound from the coil in a vertical position whilst securing the pipe end. For larger diameters it is recommended to use an unwinding mechanism. The coils can, for instance, be placed flat onto a rotating wooden or steel cross and be unwound manually or with the aid of a slow-moving vehicle.

The pipes must be unwound in a straight manner without any buckling. Spiral unwinding must be avoided.

When unwinding pipes from drums or coils it is essential to pay attention that the pipe end cannot spring outwards when loosing the fastening. As considerable forces are released, particularly from the large diameter pipes, take the necessary measures of precaution (danger of accident !). Drums should unwound from the top.

When unwinding the pipes, note that the flexibility of the polyethylene pipes is subject to the ambient temperature. At temperatures near the freezing point, pipes exceeding 75 mm of outside diameter are to be warmed, if possible. This can be carried out by pumping warm water through the coil or by using non-pressurized steam or hot air (max. 100° C).

Temperature changes cause alterations of length. This must be taken into consideration when cutting and installing the pipeline. 1 m of polyethylene pipe will elongate by 0.2 mm per °C in case of an increase in temperature and will shorten by 0.2 mm per °C in case of a decrease in temperature.

Temperature of Pipe laying	**Smallest Admissible Bending Radius**
20° C	25 x d
10° C	35 x d
0° C	50 x d

Note: Directional changes of the pipeline profile are achieved by installing pipe bends. To a limited degree the elasticity of the pipe material can be used to bend the pipe even without pre-warming. The smallest admissible bending radius must, however, not fall below the values given in the table above.

Pipes passing through a wall must be lead through a protective pipe sleeve which, as far as drinking water pipelines are concerned, must be in accordance with the requirements of DIN 1988.

3-6-3 Backfilling

Refer to Section 2 - EARTHWORK subsection 8 **"Backfilling of Trenches"**.

3-6-4 Final Backfilling

Refer to Section 2 - EARTHWORK subsection 8 **"Backfilling of Trenches".**

Note: Consulting the Manufacturer during installation phases is recommended to obtain detailed information on the methods and techniques used for proper execution.

3-7 Hydrostatic Pressure Testing

3-7-1 General

During pressure tests on polyethylene pipes, the properties of the material cause elongation of the pipes to take place. The test results can be further influenced by changes in the temperature of the pipe wall while the test is in progress. This is due to the relatively high coefficient of thermal expansion of polyethylene pipes. The temperature rise in the pipe wall causes a drop in pressure. When carrying out the pressure test, it is, therefore, desirable to keep the temperature of the pipe wall as constant as possible to ensure that the temperatures at the start and finish of the pressure test are at the same level. For this reason, particular importance attaches to the temperature measurement.

It is also important to ensure that each pipeline is carefully vented, since air trapped in the line can influence the variation of the pressure drop with time. Due to an effect similar to that of a compressed-air chamber, the rate of pressure drop diminishes, which in turn could conceal an increase in the rate possibly caused by a leak. Any air still in the line - at joints and fittings - should be dissolved in water during the preliminary test. A pressure drop also results from temperature fluctuations and expansion of the polyethylene pipes.

In order that the often appreciable temperature influences can be largely eliminated, the tests should where possible be carried out at times of day when temperature fluctuations are small. The temperature level should be approximately the same at the start and finish of the test. Preliminary tests are essential in order that the material related elongation of the line can take place. The increase in the volume of a line at a testing temperature of 20°C and at nominal pressure amounts in the case of polyethylene pipes to 1.5 - 2%. This elongation takes place over a period of time, but is almost completed after 12 hours.

With the air vents open, it is expedient to fill the line slowly from its deep point, so that the air can escape. As regards the filling of the line, the following empirical values can be recommended:

OD (mm)	Inflow in l / s
140	0.5
180	0.7
225	1.5

3-7-2 Execution of Test

The length of the pipeline section to be testing shall be reasonable (less tham 500 m). Ensure all fixed points are surely anchored. Pipes shall be backfilled, joints shall be left exposed for inspection. The test section shall be blanked off with steel blank flanges of adequate thickness supported to resist the end thrust forces and shall be filled from the lowest point with all air valves open.

The correct pre-conditioning of the pipeline is absolutely vital for the acceptance of the main test. This preliminary conditioning serves to bring the pressure time and temperature dependent changes in volume to a steady state, thus ensuring that the results obtained during the main test are reliable.

The preliminary conditioning must be carried out using one and a half times nominal pressure of the pipes, to be checked and corrected if necessary at two hourly intervals. Duration of the preliminary test is 12 hours.

During the main test, it must be taken into consideration that the polyethylene pipeline material may not have completed the expansion process; Therefore, the main test shall be started no sooner than 2 hours after the last pressure increase in the preliminary tests.

Test pressure during the main test is at 1.3 of pipeline section the nominal pressure and the test duration is 3 hours.

For the main test, the results are deemed to be satisfactory when the pressure loss observed from the pressure of the polyethylene pipeline is less than 0.3 bar after the completion of the main test (after 3 hours).