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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

RIVER AND RAVINE CROSSINGS

QUALITY ASSURANCE PAGE

CHANGES LOG

REVISIONS LOG

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REFERENCE DOCUMENTS

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[Gas supply systems - Pipelines for maximum operating pressure over 16 bar - Functional requirements]

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[Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel; comparator procedure]

1.0 SCOPE

This specification covers the minimum requirements for construction of crossings of natural gas pipelines with small or shallow rivers and ravines.

For construction of these crossings the requirements of the following, listed in order of precedence, shall be fulfilled:

- Relevant Drawings for river crossings.
- Standard Drawings and Typical Details as shown in Reference Document.
- Relevant River Crossings Studies.
- This Specification and in particular the following sections:
  a. Concrete Weight Coating.
  b. Field Joint Coating.
  c. Pipeline Installation, Bottom Pulling.
  d. Pipeline Installation, Spool Piece Installation.
  e. Pipe String Pressure Test.
- Other Specifications listed in Reference Documents.
- **ELOT EN 1594**

1.1 METHODOLOGY OF RIVER CROSSINGS

1.1.1 OPEN CUT METHOD

The open cut method is mainly applied for small or shallow rivers without significant flow. This method is based on full or partial diversion of water flow by means of retaining dams, in order to install the pipeline in a dry and open trench or in a dry and shored up trench.

Buoyancy control of the pre-assembled part of the pipeline is achieved by concrete saddles put over the pipe or by concrete coating of the pipe prior to its installation.

At pulling and open cut method the pipeline cover should be minimum 2m.

Backfilling material must be granular and must not be eroded by river currents allowing exposure of the pipeline. Usually D50 grain sizes are required for river crossings.

For river crossings design, river studies should be prepared. The design shall cover the following:

- Pipe wall thickness selection
- Pipeline stability
- Installation methodology
- Installation stresses and lift forces
- Trench backfill material sizing
- Operational stress analyses
- Seismic analyses

The crossing types shall be identified and shown on geological maps.

1.1.1.1 PIPE LAYING METHOD

The total part of the pipe to be installed is assembled and coated by concrete and then transferred (floating or in some other way) in its place over the trench. The trench has already been excavated, and the pipe is installed by use of pontoons or floating cranes.

1.1.2 BOTTOM PULLING METHOD

Bottom pulling method can be used for rivers that have soft muddy bottom with no rocks, even if they have great flow velocity.

The total part of the pipe to be installed is assembled and coated by concrete on one side of the river. The trench is prepared by excavation and in case that it collapses, a concrete pulling head can be coupled on the pulling wire to open the trench again during installation (pulling) of pipe in the soft river bed.

1.1.3 HORIZONTAL DIRECTIONAL DRILLING METHOD (HDD)

This is an alternative solution instead of the above mentioned conventional methods. By use of this method parts of pipeline 2,000 m long can be installed with pipe diameter up to DN 1050.

For developing the design of an HDD part, extensive geotechnical research is required. Boreholes along the axis of the pipeline routing must be executed to determine the formation that will be crossed. Moreover the following design data are required:

- Determination of entrance and exit points
- Determination of the smallest depth
- Design of directional drilling
- Determination of installation method
- Load analysis during installation and operation
- Buoyancy control

The drill opens a directional hole of DN 250. The hole is then broadened to the desired diameter and the pre-assembled part of the pipeline is pulled in the hole by a pulling wire.

The drilling fluid (a mixture of bentonite and water) is permanently recycled to reduce the quantities of required bentonite (mineral of clay).

Major advantage of this method is the fact that it allows quick, effective, and safe installation without any negative environmental affect in the area of crossing.

Installation of pipelines with the horizontal directional drilling method will not be described further in this specification because it is covered in detail in **Job Specification No. 499/22.**

2.0 EXTENT

Contractor shall carry out all excavation and blasting, concrete and earthworks in connection with the river crossings.

This includes excavation of trenches, dewatering of trenches and excavations, supply of materials, necessary backfilling, removal of excess material, and backfill and reinstatement of surfaces unless otherwise stated (construction of rip-rap or gabions).

Furthermore, Contractor shall carry out all construction works including transportation, welding, concrete weight coating, field joint coating, installation of gas pipelines, installation of two conduit pipes for an RCC fibre optic cable together with the gas pipeline, and performing pressure testing of pipe strings and installed pipeline. The HDPE installation will be according to **Job Spec. No. 499/19.**

Contractor shall take all necessary precautionary measures in connection with construction of the crossings. All work shall be carried out in accordance with safety regulations of the relevant authorities.

Warning signs shall be erected as agreed with the Owner Representative or when requested by authorities whenever inconveniences are imposed on the public.

In case that additional space, further to the space specified in the contract drawings, will be required for the construction of river crossings, Contractor is responsible to proceed with all the necessary actions (contacts with Landowners/Authorities, payment of compensations etc), to secure the additional space at no extra cost to the Owner.

Contractor shall be responsible for obtaining all authority approvals for his work.

3.0 SPECIAL SPECIFICATIONS

31 CONCRETE WEIGHT COATING

3.1.1 GENERAL

Contractor shall supply all materials for the application of reinforced concrete weight coating, i.e. cement, fine and coarse aggregates, water and reinforcement.

Contractor shall provide suitable mechanical equipment for the application of the concrete coating to the specified degree of uniformity with respect to the thickness, density and strength.

The concrete coating shall comply with the Standards, Specifications and practices referred in Job Specification No. 499/7 and the additional requirements given in this section.

3.1.2 COATING MATERIAL SPECIFICATIONS

The cement shall be low-alkali, sulphate resistant cement in accordance with the Hellenic cement regulations for concrete structures **(Presidential Decree 244/29.02.1980 - ΦΕΚ 69 Α/ 28.03.1980).** Slag cement may also be used. Cement that has hardened, partially hardened or become lumpy shall not be used. Test certificates from the cement manufacturers shall be supplied to Owner for every cement delivery to the coating yard site.

The sand shall be silica type sand and well graded from fine to coarse.

The types and grading of aggregates are subject to approval by Owner prior to the start of concreting. The aggregates shall be crushed (not natural), shall conform to Hellenic Concrete Technology Regulation and shall be free of injurious amounts of salt, clay, alkali-reactive material, deleterious substances and organic impurities that may affect the quality of concrete.

Owner reserves the right to sample the aggregates used either at the job site or at supply sources, and to reject any aggregates that are not deemed to be acceptable.

The cleanliness and grading of aggregates supplied shall be checked at least once every 3 days during production.

Aggregates from different sources shall be stored in separate containers or prepared areas. Prepared areas shall be cobbled, paved or well compacted to allow for adequate drainage of materials.

The water shall be clean and free from injurious amounts of oil, acid, sulphates, alkali, organic matter or any other deleterious substances. Salt water shall not be used.

The reinforcement shall consist of high ductility deformed bars (S500s as per the Hellenic Reinforcement Technology Code **KTX-2000**) with minimum diameter 8mm in the circumferential direction.

Alternatively, heavy gauge (minimum 3mm in the circumferential direction) galvanized welded wire mesh may be used. Galvanized wire shall not be used together with black reinforcement.

3.1.3 CONCRETE DESIGN AND MIXING

Contractor shall design concrete mixes using approved type of aggregates, and shall determine the proportions which will give the specified strength and density.

The concrete coating shall have a minimum equivalent characteristic cube strength of 25 MPa at 28 days and not less than 17.5 MPa at 7 days. Density of the concrete shall be 2300 kg/m^3.

All mix designs shall be approved by Owner before commencement of the works. The water/cement ratio shall not exceed 0.58, and the minimum cement content shall be 350 kg/m^3. A suitable filler material may be substituted for some of the cement, if Contractor can show that the quality of the concrete will not be reduced.

Contractor shall provide full details of the mix with regard to:

- The proportions and weights of the respective materials used in the mix.
- The water/cement ratio.
- The grading of various aggregates with combined grading curves as necessary.
- Preliminary strength and density results obtained by tests on trial lengths of coated pipe, cf. **Section 3.1.4.**

Constituent parts of the concrete shall be weight-batched using a batching plant of approved design. Accuracy of the batcher shall be within ± 3% of the indicated values.

A water gauge accurate to within ±3% of the indicated value shall be used for adding water to the mix.

Batching scales shall be maintained in good condition and will occasionally be checked at Contractor's expense, as directed by the Owner. The calibration of batcher and the water gauge shall be checked at least once per week.

Moisture content of the aggregates used shall be checked at least once per shift or more frequently if it is shown to be necessary, in order to maintain a satisfactory control of water/cement ratio of the concrete mix.

Contractor shall demonstrate to the complete satisfaction of the Owner that the concrete batching and mixing plant produces a consistent quality of concrete. No concrete in the batcher shall be used until the batch is thoroughly mixed.

Moisture content, aggregate/cement ratio and water/cement ratio of the fresh concrete shall be determined on samples taken from the batch discharge at regular intervals throughout production.

3.1.4 TESTING OF CONCRETE

The strength of each batch of concrete shall be determined by tests on cast cubes in accordance with Hellenic Concrete Technology Regulation.

in case that the specified compressive strength of concrete cubes is not achieved, then the compressive strength of the concrete coating shall be determined by tests on drilled-out cores in accordance with Hellenic Concrete Technology Regulation. Three cores shall be drilled-out on one pipe, selected by Owner, in every ten pipes coated.

Prior to drilling, the concrete surface shall be milled plane. The position of the test hole shall be such that the main reinforcement is not damaged. Should the main reinforcement be damaged, then the coating of the section in question shall be removed and re-coated or repaired, as agreed with the Owner, at the Contractor's expense.

The drill shall have a stop fitted to ensure that drilling does not penetrate to a depth closer than 8 mm from the corrosion coating. In the event of any damage to the corrosion coating or the steel pipe, the section of the concrete in question shall be removed and the pipe inspected. It may be accepted or rejected thereafter at the discretion of the Owner. If accepted, the corrosion coating shall be made good and the concrete coating replaced. Under no circumstances shall a drill hole be refilled without prior inspection and permission from Owner's Resident Engineer.

The strength requirements shall be considered to be satisfied if none of the strengths measured is below specification.

If the above requirement is not met, the Owner shall require more tests to be carried out on joints of coated pipe in the affected batch, and should these not meet the specification Owner may reject the pipe joints whose strengths are not as specified.

Density shall be determined on hardened and cured concrete of minimum 4 days of age taken from coatings as applied in normal coating procedures. A sample of area not less than 250 cm^2 shall be oven dried at 100°C to constant weight, then the sample shall be allowed to cool to ambient temperature and the weight W_{dry} shall be determined. The sample shall be then submerged in water at room temperature for a minimum of 24 hours, withdrawn from the water, the excess moisture removed, and the weight W_{sat} determined.

Finally, the sample shall be weighed submerged in water to determine the weight W_{sub}.

All weights shall be determined to within the nearest gram, and the dry density ρ_c in kg/m will be calculated as $\rho_c = 1000\ W_{dry} / (W_{sat} - W_{sub})$.

It will be necessary to establish the equivalent wet density of the concrete coating, so that acceptance or rejection can be made immediately after application of the coating. A test procedure for the determination of this relationship shall be proposed by the Contractor and approved by the Owner prior to the start of coating operations. Contractor shall have available at least one coated pipe of sufficient length, and suitable for use in the making of test specimens from the hardened coating.

3.1.5 REINFORCEMENT PLACING

Contractor shall immediately before the concrete coating operations perform holiday detector tests of the factory corrosion coating. Any damage or pin-holes shall be repaired and re-tested as described in **Job Specification No. 834/1.**

Reinforcement type and size shall be as shown in the relevant drawings. The circumferential reinforcement may be placed as a spiral or as a welded reinforcement cage.

If discontinuous cages are used, the minimum overlap of longitudinal reinforcement shall be 200mm.

The reinforcement shall be completely free from oil, grease or dirt, as well as excessive rust.

The main reinforcement shall be placed in the middle third of the concrete coating, and minimum concrete cover shall be 30 mm. The method of positioning the reinforcement shall be approved by the Owner prior to the start of operations. If spacers are used, their size shall be chosen so as to keep the reinforcement rigidly in place without damage to the corrosion coating.

Minimum distance between the reinforcement and the ends of concrete cover shall

be 25 mm with a tolerance of +5 mm.

The concrete cover will be at least 20mm in any case.

From time to time, Contractor shall remove local areas of concrete on the pipe to demonstrate correct location of reinforcement after coating. Contractor shall repair these areas to the satisfaction of the Owner.

3.1.6 APPLICATION AND CURING OF CONCRETE

The procedure of concrete application shall be approved by the Owner prior to start of coating operations. Proper designed metal forms (moulds) fixed in place shall be used for pipe concreting. They will be of split type and a filling aperture (slot) shall be at the top of the mould. No method/equipment that causes segregation of aggregates shall be used.

In all cases, the concrete shall be cast within 45 minutes after water is first added to the mix. Each pipe joint shall be coated in one continuous operation. If more than one application is required to produce coating of the specified thickness, then the time lapse between the first and the last coating shall not exceed 45 minutes. If this requirement is not fulfilled, the previous coating shall be removed and the entire section re-coated at Contractor's expense.

Concrete application shall not be carried out when temperature of the corrosion coated pipe, including reinforcement and anodes, or that of the concrete mix is below 5°C.

A length of no less than 350 mm and no more than 380 mm at both ends of each pipe section shall not be coated. Concrete face at the edge shall be square-shouldered. The uncoated part of the pipe, including corrosion coating, shall be kept completely free of concrete, spatter, oil, grease or any deleterious substances.

Concrete shall be applied in such a way that the coating is free from undulations and irregularities. The concrete coating shall be concentric with the pipe, and variations in concrete thickness on each pipe joint shall be kept to the minimum. Damages to the wet coating inflicted during handling may be repaired, if the area of such patches does not exceed 500 cm^2. More extensive damage will entail the pipe joint to be re-coated at Contractor's expense.

Patching may only be carried out by removing the affected coating down to the reinforcement level, taking care not to damage the reinforcement, and filling the cavity using a mix similar to that used for the coating process, possibly with the addition of just sufficient water to allow for hand application. A bonding agent approved by the Owner may be used in the mix, in strict accordance with the Manufacturer's instructions.

The concrete coating shall be cured in water, steam or high humidity atmosphere. The concrete shall be kept moist for 8 hours or until the coating has achieved a compressive strength of at least 10 MPa.

Contractor shall demonstrate that the curing temperature is not injurious to the corrosion coating.

Storage of concrete coated pipes shall not take place at temperatures below 5°C until the coating has cured sufficiently to achieve a minimum compressive strength of 11 MPa. Contractor shall prove the time required to attain this minimum strength, and shall supply Owner with a cure curve based on actual test results.

All concrete coated pipes must be cured for not less than 4 days after application of concrete and no concrete coated pipe shall be loaded out from the coating yard until so cured. No deviation from this requirement will be permitted.

3.1.7 MEASUREMENTS

Immediately after the pipe is removed from the concrete coating equipment, it will be weighed and measured. Diameter of the concrete coating is determined by means of a girth tape in 6 approximately equi-spaced positions, with the two end measurements being taken approximately 500 mm from the ends of the concrete coating. The tolerance shall be +5% of the nominal concrete thickness. Any joint found to be outside the dimensional tolerances shall be repaired at the discretion of Owner, at Contractor's expense.

The overriding criterion for acceptance shall not be the thickness, but the specific gravity, as defined below.

Specific gravity (SG) and negative buoyancy (NB) of the saturated, cured pipe in water shall be calculated by the formula:

$$SG = \frac{W_{cp} + [\pi/4(D_o^2 - D_i^2)\, l_c\, (P_{sat} - P_{wet})] - [W_p(l_p - l_c)]}{\pi/4\, D_o^2 l_c P_w}$$

$$NB = \pi/4\, [D_o^2 P_w\, (SG-1)]$$

where:

W_{cp} = total weight of freshly coated pipe

W_p = weight per unit length of steel pipe

D_o = outer diameter of concrete (based on average girth measurement)

D_i = outer diameter of corrosion coated pipe

l_c = length of concrete coating l_p= total length of steel pipe joint

P_{sat} = density of cured, saturated concrete (assuming 2% water absorption, subject to verification by tests)

P_{wet} = density of freshly applied concrete
P_w = density of water

Individual pipe joints may be as much as 5% below or above the specified specific gravity, provided that over (or under) weight joints are compensated for by an equal number of under (or over) weight joints.

A water absorption test shall be carried out not less than 24 hours after concreting. Water absorption shall be measured by completely immersing a concreted pipe joint in a tank of water for at least 12 hours, and weighing the pipe upon removal from the tank after surplus water has been drained off. The frequency of testing for water absorption shall be one pipe in 50, or at least two per 24-hour period.

The period of immersion may be reduced by mutual agreement if Contractor can show to the satisfaction of Owner that the 12-hour period is not necessary to obtain full saturation.

The frequency of testing may be reduced if Contractor can show to the satisfaction of Owner a relationship between dry concrete density, concrete strength and water absorption.

3.1.8 INSPECTION, TESTING AND REPAIR

Contractor shall non-destructively test every joint of coated pipe, not less than 3 days after coating by such means as "ringing", to determine whether any defects are present. Where this procedure indicates faulty coating, Contractor shall test the concrete strength of the suspect pipe. If these tests indicate defective concrete, Contractor shall remove all such coating by a method agreed with Owner, and re-coat the pipe to the satisfaction of Owner at no extra cost.

Damage to hardened concrete may be accepted without repair if the area is less than 1.000 cm^2 and the depth is less than 25% of the concrete thickness.

More extensive damage may be repaired by hand patching, provided that the area affected does not exceed 3.000 cm^2. Should the damaged area be more than 3.000 cm^2, the coating shall be removed around the entire periphery of the pipe throughout the entire damage area. Where damage is in excess of 25% of the total coating, then repair shall not be allowed under any circumstances. The entire coating shall be removed and the pipe joint re-coated at Contractor's expense.

Repairs shall be made by satisfactorily restoring the reinforcement if necessary, removing all cracked or broken concrete, undercutting the concrete remaining in place so as to provide a key lock, wetting the surface of the concrete, and trowelling in a stiff mixture until the surface is level with the coating around the repair. The pipe shall then be carefully laid in a position where it shall be allowed to moist cure for a minimum of four days.

The resulting coating shall be equal in weight, density, uniformity, strength and other characteristics of the originally applied coating.

Cracks that are more than 1.5 mm wide and extend over 180° circumferentially around the pipe, or longitudinal cracks that are more than 300 mm long, irrespective of width (excluding hairline cracks), shall be repaired. Repair shall be made by chiseling out the crack to a minimum width of 25 mm throughout the length of the crack, and filling up as indicated above. The repairs shall be allowed to remain undisturbed for at least 36 hours.

3.1.9 REJECTION OF CONCRETE COATING

Causes for rejection of concrete coating shall include the following:

- Failure to comply with the specified specific gravity or negative buoyancy;

- Improper placement of reinforcement steel; (concrete cover over the reinforcement less than the limits specified herein).

- Damage to coating during handling or storage which is considered by Owner to be excessive and beyond repair.

- Any failure to meet these specifications, or any defective condition that in the opinion of Owner renders the coated pipe unsuitable for the use and purpose for which the pipe has been coated.

All rejected joints of pipe subsequently to be recoated, shall have the concrete carefully removed. After removal of the defective concrete coating, the corrosion coating shall be examined for damage and tested by a holiday detector. All damaged corrosion coating shall be repaired in accordance with the specifications and re-tested before subsequent re-coating with concrete.

All removal and replacement of concrete not meeting specification shall be at Contractor's expense.

3.2 FIELD JOINT COATING

3.2.1 SCOPE

This chapter states the requirements for corrosion prevention coating and concrete coating of the field joints during string manufacture, as well as for the tie-in of pipe strings.

Contractor shall supply all supervision, labour, materials, services and equipment necessary for and incidental to the application of pipe protection materials to all field joints.

All Contractor furnished equipment, tools and supplies shall be of good quality and adequate design, must be maintained in good order during use, and be subject to approval by Owner.

3.2.2 GENERAL

The pipe field joint in between the factory applied coating (corrosion prevention coating), shall be cleaned and wrapped with a corrosion protective wrap.

The prepared field joint shall be completely filled with concrete, in line with the concrete coating of the pipeline.

Unless otherwise stated below, the field joint concrete shall comply with:

- Hellenic Reinforced Concrete Code (ΕΚΩΣ-2000)

- Hellenic Concrete Technology Regulation (ΚΤΣ-1997)

- Hellenic Standard Technical Specification T110 (ΦΕΚ 203/1967)

Field joints made at the tie-ins of pipe strings during installation (tie-in joints), shall be concreted with quick hardening concrete, and the steel sheet shutters shall be left permanently around the joints.

Field joints made during manufacture of the pipe strings (pipe string joints), may be made with the same concrete as used for coating the pipeline (see Chapter 3.1), using reusable shutters.

Contractor shall furnish and install tape wrap material, sheet metal forms, bands and concrete.

Contractor shall obtain Owner's written approval of materials for field joints coating

prior to use.

Contractor shall transport and store all field joint materials in a manner preventing any damage or deterioration of the materials. Any coating materials which are damaged, or deemed to be unsuitable by Owner because of Contractor's negligence, shall be replaced by Contractor at his own expense.

All materials shall be certified by means of the Manufacturer's certificate, with analysis/mechanical properties of each batch of material supplied. Representative samples of material may be tested by Owner, and if the material is rejected the cost of testing shall be born by Contractor.

All field joints shall be approved by Owner before the placing of shutters and after concreting.

If tests or inspection of any field joint in the opinion of Owner indicate defects, Contractor shall repair or replace the field joint as directed by Owner.

3.2.3 JOINT PREPARATION

The pipe steel at the field joint shall be thoroughly cleaned by grit blasting to remove all weld spatter, rust, dirt and dust. The surface quality shall be SA 2 1/2 according to **ELOT EN ISO 8503-2** or uniform grey-white metallic finish. Any oil or grease shall be completely removed by solvent swabbing.

Surface of the field joint area shall be free of dust, dirt or any other extraneous matter, and shall be dry in preparation for field joint coating.

Field joint coating shall be performed immediately after the joint preparation.

3.2.4 FIELD JOINT CORROSION COATING

Corrosion coating of the field joints shall consist of sintered polyethylene powder or primer heat shrinkable polyethylene sleeves, with thickness equal to that of the factory applied coating. Other coating systems or materials may be considered provided that Contractor can document, to the satisfaction of the Owner that such systems have performed satisfactorily under similar conditions.

The existing PE-coating shall be abraded with a rotating wire brush.

The joint shall be pre-heated to the temperature specified by manufacturer of the powder. The applied flame torch shall be able to secure a uniform heating of the entire coating area and shall be approved by Owner or his representative. The heating shall be carried out carefully to avoid damage to the existing coating.

When the required temperature has been attained, the pipe surface shall immediately be sprinkled with polyethylene powder to improve the coating bond.

The polyethylene powder is applied to the hot field joint area by means of a sleeve form, which is held tight against the factory coating. This form shall be kept in place until the required coating thickness has been obtained. Excess powder shall be removed, and the transition to the factory coating shall be smoothened by a steel roll or similar.

3.2.5 TEST OF FIELD JOINTS (CORROSION COATING)

Contractor shall immediately before concreting perform holiday detector tests of the field joint corrosion coating.

The Holiday Detector shall be adjusted to 5KV plus 5 KV/mm coating thickness, maximum 15KV.

Any defects shall be repaired to the satisfaction of Owner and the repaired section shall be re-tested.

3.2.6 REINFORCEMENT

Reinforcement of the field joint concrete coating shall be welded wire mesh of 6 mm deformed bars with spacing of 50 mm in the longitudinal direction of the pipe. In the circumferential direction spacing may be greater, but not more than 200 mm.

Reinforcing wire mesh shall be wrapped around the joint with minimum overlap of 200 mm, and positioned by means of suitable insulating spacers, subject to approval by Owner. Minimum number of spacers will be 16, placed in pairs approximately evenly spaced around the pipe circumference. The nominal distance from the pipe shall be 40 mm, and no part of the reinforcement shall be closer than 20 mm to the pipe coating or to the steel shutter.

Contractor shall perform checking of conductivity between reinforcement bars and pipeline before pulling or lowering of the coated pipeline.

Any damage to the corrosion coating of the pipe or the field joint shall be repaired by Contractor at his own expense.

3.2.7 CONCRETE SHUTTERS

Sheet steel to be used for the field joint concrete form shall be 22 gauge (1.22 mm) and minimum 1,200 mm wide.

After corrosion protection has been applied and reinforcement placed, the sheet steel shall be completely wrapped around the field joint, overlapping the concrete coating on each side by an equal amount. The ends of the steel form shall overlap by a minimum of 200 mm at the 12 o'clock position.

The pre-cut sheet steel wrap shall be firmly fixed in place by a minimum of four steel straps - two on each overlap.

The steel straps shall be nominally 18 mm wide, 0.75 mm thick.

A filling aperture, approximately 200 X 200 mm, shall be prepared at the top and forward end of the sheet steel wrap by pre-slotting the steel and folding back the flap so formed.

Pipe string joints may be concreted using reusable shutters. The design of formwork, and the timing of stripping, shall be approved by Owner prior to the start of operations.

3.2.8 CONCRETING OF PIPE STRING JOINTS

The cement for concrete structures shall be low-alkali, sulphate resistant cement in accordance with the Hellenic Cement Regulation (Presidential Decree **244/29.2.80 - ΦΕΚ 69Α/ 28.3.80).**

The sand shall be silica type sand and well graded from fine to coarse.

The aggregates shall be crushed and shall conform to Hellenic Concrete Technology Regulation **(ΚΤΣ-1997)** and shall be free of injurious amounts of salt, clay, alkali reactive material, deleterious substances and organic impurities that may affect the quality of concrete. Types and grades of the aggregates are subject to approval by Owner prior to the start of operations.

Aggregates from different sources shall be stored in separate containers or

prepared areas. Owner reserves the right to sample the aggregates used, either at the job site or at supply sources, and to reject any aggregates that are not deemed to be acceptable.

The water shall be clean and free from injurious amounts of oil, acid, sulphates, alkali, organic matter or any other deleterious substances. Salt

water shall not be used.

All mix designs shall be approved by Owner before commencement of the works. The water/ cement ratio shall not exceed 0.58 and the minimum cement content shall be 350 kg/m^3. A suitable filler material may be substituted for some of the cement, if Contractor can show to the satisfaction of Owner that the quality of concrete will not be reduced.

Contractor shall demonstrate to the complete satisfaction of Owner that the batching and mixing equipment produces a consistent quality of concrete. No concrete in the batcher shall be used until the batch is thoroughly mixed.

The strength of each batch of concrete shall be determined by tests on sets of cast cubes, in accordance with Hellenic Concrete Technology Regulation (**ΚΤΣ-1997**). The minimum numbers of sets (3 cubes) is:

1 per batch of concrete

4 per day's production

Minimum characteristic cube strength of the concrete shall be 25 MPa at 28 days. The concrete shall be moist cured for 8 hours, or until it has achieved strength of at least 10 MPa. The pipe string shall not be moved for at least 4 days after application of the concrete.

In agreement with Owner, the concreting may also be carried out as specified for the tie-in joints in section 3.2.9 below,

3.2.9 CONCRETING OF TIE-IN JOINTS

The concrete shall be a quick hardening concrete made from pre-batched components, which shall be mixed according to the manufacturer's instructions. The material is subject to approval by Owner.

When the first hand mix is completed it is poured into the cavity, and the concrete is vibrated internally by a vibratory poker and externally by vibrating the bottom of shutter. The second batch is mixed while the first is being placed, thus ensuring a continuous pour.

This procedure is repeated until the joint is filled to the top of the shutter gap. The concrete shall be thoroughly vibrated, but care shall be taken to avoid segregation of aggregates by over-vibration.

The additives for rapid curing shall be activated by heating the joint with flame torches. The heat treatment is carried out for a period of 10 - 15 minutes, and the metal shutter is tapped with a hammer to ensure that all regions of the concrete are setting.

Upon completion of the heating, the hardness of concrete at the shutter gap is checked.

In case the spool pieces are longer than 10m and the tie-in joints are less than 20cm, the tie-in joints alternatively can be rapped by two layers of rockshield 15mm thick and tied with plastic ties.

3.3 PIPELINE INSTALLATION, BOTTOM PULLING

3.3.1 SCOPE

This chapter covers all work associated with the assembly of pipe strings, wire laying, pipe pulling, rectifying of free spans and repair of damaged pipe and coating.

3.3.2 COMPLIANCE WITH SPECIFICATION

All works performed, related to the installation of the present crossing shall conform to this specification and codes and standards referenced herein.

3.3.3 EQUIPMENT

Contractor shall use equipment which will not damage the pipeline, coating or field joints.

Contractor shall demonstrate to the satisfaction of Owner that all equipment required for carrying out the works, including associated instrumentation and control of the winches, are in full working order and good condition for successful completion of the works.

Contractor shall document to the satisfaction of Owner the accuracy of pull winch and hold back winch load cells.

Furthermore Contractor shall document that the control systems in general are accurate, efficient and reliable.

Should Owner require a demonstration of equipment accuracy, Contractor shall be prepared to perform demonstration tests.

Prior to start of pulling, Owner shall have the option of checking the height of each roller to ensure adherence to Contractor furnished drawings. Rollers shall be soft faced with mounded polypropylene or similar. Worn rollers shall be replaced at the discretion of Owner.

If Contractor decides to use pontoons/buoyancy tanks during the pipeline pulling, Contractor shall document, to the satisfaction of Owner, that the pontoons/buoyancy tanks can be installed and removed in a safe way without causing any damage to the pipeline.

3.3.4 PROCEDURES

Contractor shall submit detailed procedures for approval to Owner before commencing work for the following operations:

a) Laying of pull wires.

b) Pulling of the pipeline.

c) Procedures to protect the pipeline in case of extreme currents.

d) Procedures for rectifying free spans longer than specified.

e) Procedures for repairing of any damage to the pipeline or coating, onshore and offshore.

f) Procedures for carrying out diving operations required during the works, including details of the diving equipment and personnel.

e) Emergency procedures.

3.3.5 ENGINEERING

Contractor shall submit for approval to Owner, detailed engineering design and calculations including the following:

a) Drawings showing layout of construction sites and pull sites. The drawings shall include but not be limited to pipe supports, spacing between string supports, position and height of rollers, length of pipe strings, location, foundation and anchoring of pull and hold back winches, launch ramps, wet ditches, tie-in point for string tie-ins. These drawings must be fully dimensioned and shall include those dimensions necessary to physically check the roller heights and launch ramp configuration.

b) Drawings showing pulling wire arrangement, including travelling sheaves and blocks, if any. The drawings shall include all wires, pipe-strings and anchoring wires from hold-back winch anchor to pull winch anchor and shall clearly demonstrate major intermediate stages of the pulling operations.

The drawings shall be fully dimensioned, including dimensions of wires, sheaves and blocks.

c) Detailed drawings of the pull head.

d) Pipeline installation engineering results for:

Pipe stress analysis including calculation of pull loads and pull stresses, bending stress due to trench bottom curvature and launch ramp curvature.

Pipe stress analysis documentation specifying the safe maximum spacing of pipe supports (plinths, rollers) during installation.

Calculation of handwinches to be mounted around the pontoons/buoyancy tanks (if used). The handwinches shall have sufficient strength to permit lowering of the pipeline onto the seabed.

All calculations shall state the methods of calculation and any assumption or interpretation of the information given in the specification and Owner furnished information.

All dimensions and calculations shall be given in the SI Unit System.

336 ALLOWABLE STRESS LEVELS

Engineering calculations shall demonstrate that during installation operations, combined stresses in the pipe will not exceed 72% of SMYS.

3.3.7 STRING SUPPORTS

The pipe strings shall be as long as possible within the limitations of construction site areas.

The pipe strings shall be supported by concrete supports giving a distance from the ground to bottom of the pipe, sufficient enough not to damage the pipe coating.

Contractor shall pay special attention to avoid damage of pipe concrete coating while the pipe strings are rolled to the centre line pulling position.

3.3.8 REPAIR TO CONCRETE COATING

The concrete coating of each pipe joint shall be checked for damage made during welding and pulling operations and it shall be free from visible defects such as cracks or spalls as described in paragraph 3.1.8 of this specification.

At the discretion of Owner, minor damage may be repaired on site by cleaning and removing loose concrete and undercutting into sound concrete to provide a lock for the repair material. Concrete specified for field joints shall be applied within a metal form which shall wrap around the pipe completely and be strapped to it as per the Field Joint Coating Specification.

Should the damage to the concrete be so severe as to preclude carrying out repair as described, the damaged pipe shall be removed and replaced as described in paragraph 3.1.8 of this specification.

3.3.9 WIRE LAYING

Contractor shall demonstrate to the satisfaction of Owner that prior to the performance of the pull, the pulling wires are in centre line of the bottom of the trench and are not overriding or twisted.

3.3.10 PULL HEAD

Contractor shall be responsible for the design and supply of pull heads required for installation of the pipeline.

The method of attachment of pull wires to the pulling head shall ensure that no bending stresses of any magnitude are induced in the pipe by the pulling wires.

Pulling heads shall be designed so as to minimize the possibility of pulling the pipe into the bottom of the trench.

3.3.11 PIPELINE PULLING

Contractor shall provide all instrumentation necessary for direct read-out and recording of pull loads and hold- back loads, and shall record the entire pulling operation in terms of time, including start-up pulling loads and end loads to the satisfaction of Owner.

Contractor shall be totally responsible for the design, stability and safe working loads of all temporary facilities and pipe pull equipment.

Owner reserves the right, without incurring additional cost, to instruct Contractor to modify, alter or reconstruct any part or parts of the temporary works where there is risk of instability or violation of safety standards.

3.3.12 PIPE PULLING RECORDS

Contractor shall, at all times during the pulling operations, keep an accurate record of the pipe sequential number as-laid and pipe description data including pipe length, weight, negative buoyancy and identification number, together with any other information that Owner may require.

The records shall be kept in a neat and orderly manner and at the end of each day, they shall be agreed upon and signed by Owner and Contractor and two copies shall be supplied to Owner.

Sequential pipe number referring to the pipe and adjacent field joint shall be painted clearly on the top of the concrete coating of pipe near the field joint. The paint shall be suitable for a long term immersion in sea water and shall be approved by Owner prior to use.

3.3.13 DIVING

Contractor shall provide at no extra cost to Owner, an experienced diving team with all required facilities to properly conduct the work.

Contractor shall perform diver inspections during the installation for: -

- Inspection of trench configuration prior to pulling;

- Inspection of pulling wires prior to pulling;
- Inspection of trench and pipeline during pulling;
- Inspection of the as-installed pipeline;
- Any inspection required for proper installation of the pipeline.

3.3.14 FREE SPANS

A survey for free spans shall be made prior to flooding the pipeline and at other times as required by the specifications. Details of all free spans found shall immediately be reported to Owner in writing.

Owner will decide on whether remedial action such as sand bagging, rock dumping or other methods will be required. Contractor shall perform all such remedial work upon direction by Owner.

Contractor shall be required to provide all materials and equipment for the alleviation of free spans. Sand bags used to support free spans shall be filled with a suitable cement/sand/gravel mix unless otherwise required by Owner.

3315 UNDERWATER REPAIR OF DAMAGED CONCRETE AND CORROSION COATINGS

Underwater repairs of excessively damaged concrete coating shall be performed by Contractor. Methods such as sand bagging, saddle weights or anchoring may be utilized. The method and procedure used for such repair work shall, in all cases, be approved by Owner prior to use.

Contractor shall be required to effect underwater repairs of damaged concrete or corrosion coatings by means of Napko No. 5682 Splash Zone Barrier or equivalent epoxy.

Application shall be in accordance with the manufacturer's instructions and subject to Owner's approval.

3316 UNDERWATER REPAIR OF DAMAGED PIPE

Damaged pipe discovered after pulling shall be repaired by Contractor. Contractor shall present the method of repair to Owner for approval.

All repairs shall utilize welded pipe connections. In all cases, the repair methods and procedures shall be approved by Owner prior to use.

3.3.17 BACKFILLING OF TRENCH

See **Job Specifications No. 499/2 and 499/4.**

3.3.18 PIPE ENDS

Upon completion of pipeline installation, the onshore part of the pipeline shall be backfilled. At the pipe ends Contractor shall construct suitable hellholes. These shall be large enough to provide adequate access for welding, weld inspection and coating and shall be of construction which is acceptable to the relevant safety authorities.

There shall be clearance of at least 0.60 m around the pipe and the length of the bellhole shall be at least 1.50 m. These dimensions refer to the length actually available for the welder. The bell holes shall be kept free of water shall be secured against collapse and shall be properly fenced to the satisfaction of Owner.

3.3.19 FABRICATION OF INSTALLATION OF TEMPORARY PIPEWORK

Contractor shall design, supply and fabricate all temporary pipework associated with construction of the river crossing pipelines. This shall include, but not be limited to test heads, temporary scraper traps, test manifolding, etc.

All temporary pipework which may be pressurized, shall be designed in accordance with **ELOT EN 1594.**

The design shall be approved by Owner prior to fabrication.

Temporary scraper traps, test heads and manifolding shall be pressure tested to pipeline strength test pressure prior to connection to the pipeline.

Hosing or pipe shall be provided by Contractor to drain water according to **Job Specification No. 181/2,** from the pipeline end during filling or pressure testing operations.

If required by Owner, Contractor shall fence off at no extra cost to the owner, sufficient area around the installed temporary pipework adequate for site offices, compressors, pumps and other equipment required for ongoing pipeline construction activities. After reinstatement of the rest of the site, Contractor shall be required to restrict all related construction work within that area.

3.4 SPOOL PIECE INSTALLATION

3.4.1 SCOPE

This chapter covers all work associated with the assembly of spool piece, spool piece lifting and lowering, rectifying of free spans and repair of damaged pipe and coating.

3.4.2 COMPLIANCE WITH SPECIFICATIONS

All works performed, related to the installation of crossings shall conform to this specification and codes and standards referenced herein.

3.4.3 EQUIPMENT

Contractor shall use equipment which will not damage the spool piece, coating or field joints.

Contractor shall demonstrate to the satisfaction of Owner that all equipment required for carrying out the works, including associated instrumentation, are in full working order and in good condition for successful completion of the works.

Contractor shall document that the control systems in general are accurate, efficient and reliable. Should Owner require a demonstration of equipment accuracy, Contractor shall be prepared to perform demonstration tests.

Contractor shall document, to the satisfaction of Owner, that the spool piece can be lifted and maneuvered into position without causing any damage to the spool piece.

3.4.4 PROCEDURES

Contractor shall submit detailed procedures for approval to Owner before commencing work for the following operations:

a) Lifting of the spool piece and manoeuvring it into position.

b) Lowering of the spool piece.

c) Procedures to protect the spool piece in case of extreme currents.

d) Procedures for rectifying free spans longer than specified.

e) Procedures for repair of any damage to the spool piece or coating, onshore and offshore.

f) Procedures for carrying out required diving operations during the works, including details of the diving equipment and personnel.

g) Emergency procedures.

3.4.5 ENGINEERING

Contractor shall submit for approval to Owner detailed engineering studies and calculations including the following:

a) Drawings showing layout of construction site. The drawings shall include but not be limited to pipe supports and spacing between string supports.

b) Spool piece installation engineering results for:

- Pipe stress analysis documentation specifying the safe maximum spacing of pipe supports (plinths), during installation.

- Pipe stress analysis during lifting and lowering of the spool piece, taking into account the current and wave induced water particle velocity.

All calculations shall state the methods of calculation and any assumption or interpretation of the information given in the specification and Owner furnished information.

All dimensions and calculations shall be given in the metric Unit System.

3.4.6 ALLOWABLE STRESS LEVEL

Engineering calculations shall demonstrate that during installation operations, combined stresses in the pipe will not exceed 72% of SMYS.

3.4.7 STRING SUPPORTS

The pipe strings shall be supported by concrete supports giving a distance from the ground to bottom of the pipe sufficient enough not to damage the pipe coating.

3.4.8 REPAIR OF CONCRETE COATING

The concrete coating of each pipe joint shall be checked for damage made during welding and lowering operations and it shall be free from visible defects such as cracks or spalls as described in paragraph 3.1.8 of this specification.

At the discretion of Owner, minor damage may be repaired on site by cleaning and removing loose concrete and undercutting into sound concrete to provide a lock for the repair material. Concrete specified for field joints shall be applied within a metal form which shall wrap around the pipe completely and be strapped to it as per the Field Joint Coating Specification.

Should the damage to the concrete be so severe as to preclude carrying out repair as described, the damaged pipe shall be removed and replaced as described in paragraph 3.1.8 of this specification.

3.4.9 SPOOL PIECE INSTALLATION

Contractor shall be totally responsible for the design, stability and safe working loads of all temporary facilities and equipment for spool piece installation.

Owner reserves the right, without incurring additional cost, to instruct the Contractor to modify, alter or reconstruct any part or parts of the temporary works where there is a risk of instability or violation of safety standards.

3.4.10 INSPECTION

Contractor shall perform a procedure for inspection of installation of the spool piece.

Contractor shall perform the following at no extra cost to Owner:

- Inspection of river bottom prior to installation.
- Inspection of trench before installation of the spool piece.
- Inspection of the as-installed spool piece.
- Any inspection required for proper installation of the spool piece.

3.4.11 FREE SPANS

A survey for free spans shall be made prior to flooding the pipeline and at other times as required by the specifications. Details of all free spans found shall immediately be reported to Owner in writing.

Owner will decide on whether remedial action such as sand bagging, rock dumping or other methods will be required. Contractor shall perform all such remedial work upon direction by Owner.

Contractor shall be required to provide all materials and equipment for the alleviation of free spans. Sand bags used to support free spans shall be filled with a suitable cement/sand/gravel mix unless otherwise required by Owner.

3.4.12 UNDERWATER REPAIR TO DAMAGED CONCRETE AND CORROSION COATINGS

Underwater repairs of excessively damaged concrete coating shall be performed by Contractor. Methods such as sand bagging, saddle weights or anchoring may be utilized. The method and procedure used for such repair work shall, in all cases, be approved by Owner prior to use.

Contractor shall be required to effect underwater repairs of damaged concrete or corrosion coating by means of Napko No. 5682 Splash Zone Barrier or equivalent epoxy.

Application shall be in accordance with the manufacturer's instructions and subject to Owner's approval.

3.4.13 UNDERWATER REPAIR OF DAMAGED PIPE

Damaged pipe discovered after towing and lowering shall be repaired by Contractor. Contractor shall present the method of repair to Owner for approval. All repairs shall utilize welded pipe connections. In all cases, the repair methods and procedures shall be approved by Owner prior to use.

3.4.14 BACKFILLING OF TRENCH

See **Job Specifications No. 499/2 and 499/4.**

3.4.15 PIPE ENDS

Upon completion of pipeline installation, the onshore part of the pipeline shall be backfilled. At the pipe ends Contractor shall construct suitable hellholes. These shall be large enough to provide adequate access for welding, weld inspection and

coating, and shall be of construction which is acceptable to the relevant safety authorities. There shall be a clearance of at least 0.60 m around the pipe and the length of the bellhole shall be at least 1.50 m. These dimensions refer to the length actually available for the welder.

The hellholes shall be kept free of water, shall be secured against collapse and shall be properly fenced to the satisfaction of Owner.

3.4.16 FABRICATION AND INSTALLATION OF TEMPORARY PIPEWORK

Contractor shall design, supply and fabricate all temporary pipework associated with construction of the spool piece. This shall include, but not be limited to test heads, temporary scraper traps, test manifolding, etc.

All temporary pipework which may be pressurized shall be designed in accordance **with ELOT EN 1594.**

The design shall be approved by Owner prior to fabrication.

Temporary scraper traps, test heads and manifolding shall be pressure tested to pipeline strength test pressure prior to connection to the pipeline.

Hosing or pipe shall be provided by Contractor to drain water according to **Job Specification No. 181/2,** from the pipeline end during filling or pressure testing operations.

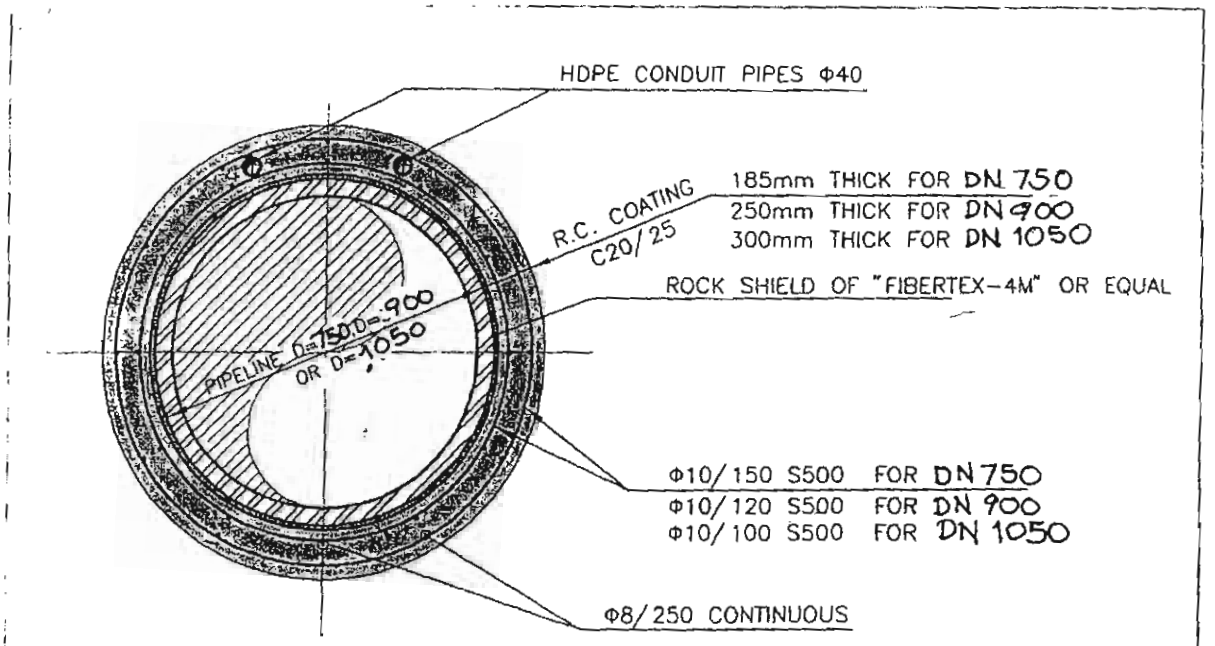
If required by Owner, Contractor shall fence off at no extra cost to the owner, sufficient area around the installation temporary pipework adequate for site offices, compressors, pumps and other equipment required for ongoing pipeline construction activities. After reinstatement of the rest of the site, Contractor shall be required to restrict all related construction work within that area.

3.5 PIPE STRING PRESSURE TEST

The pressure test should be done before the concreting.

Methodology which should be applied is the AZ method according to **Job Specification No. 181/2.**

4. ATTACHMENT



PIPELINE TYPICAL SECTION

REINFORCED CONCRETE COATING DETAIL
FOR PIPELINES DN 750, 900 AND 1050