Κώδικας Πρακτικής για την αντικατάσταση κύριων αγωγών με τη μέθοδο της ένθεσης σωλήνα PE σε ανενεργό μεταλλικό αγωγό (dead mains insertion)

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CODE OF PRACTICE FOR MAINS REPLACEMENT- DEAD MAINS INSERTION (PE. PIPE)

1. SCOPE

This Code of Practice is intended for guidance by Engineers or their representatives responsible for the replacement of existing mains by the insertion of PE pipe and should be used in conjunction with the corresponding Procedure for operational personnel.

2. REFERENCES

Unless otherwise specified this document shall be used with reference to the latest editions of related procedures, standards and specifications dealing with safety, construction planning, PE pipe welding (EN 13067), traffic management, excavations, reinstatements and materials, plant and equipment.

3. DESIGN

3.1 General

Mains insertion/slip-lining using polyethylene (PE) pipe is highly suitable for existing gas mains replacements, that are predominantly straight, have few connections and can operate satisfactorily at reduced pipe diameter or considered for up-rating to a higher working pressure. However, this technique is also suitable where the existing main does have bends, branch and service connections but with additional enhancements to the insertion process including pulling as well as pushing techniques. Due attention must be made to details of existing mains records, careful planning, mains tracing, location and size of launch/reception pits, use of pipe coils and pipe trailers to maximise production and avoid delays.

3.2 Selection of insertion pipe by diameter

The size of insertion pipe should be selected to give an annular clearance which is sufficient to enable the pipe to be inserted without causing damage to it. The existing pipe material, service and other fittings protruding into the main and pipe corrosion products may affect this clearance. The internal condition of the main should be examined and immediately before insertion work commences, a final check made to ensure that the selected pipe can be inserted successfully using closed circuit television (CCTV) camera inspection and survey equipment and/or a gauge proving length. Where the existing main is heavily congested with corrosion products, drag scraping using scraper pigs, rubber plungers or pull throughs. is recommended to clean the main, usually by means of inserting fibreglass flex-probe rodding from a reel and used for attaching a winch cable. The winch cable can also be used for the CCTV survey and to pull the gauge prover through the main to check if obstructions will prevent free passage or cause scoring to the insertion pipe. Polyethylene pipe scores to a depth greater than 10% of the pipe wall thickness are unacceptable and the location of any obstructions

causing such scoring or preventing free passage should be identified for removal.
A guide to the selection of the preferred maximum size of pipe is given in Table 1.

TABLE 1- Selection of insertion pipe size. Preferred maximum sizes.

Existing main Nominal bore		Insertion Pipe Outside diameter	Diametrical clearance
inches	mm	mm	mm
4	100	75	25
5	127	90	37
6	153	125	28
7	178	140	38
8	206	160	46
9	232	180	52
10	258	200	58
12	303	250	53
14	354	280	74
15	379	315	64
16	404	315	89
18	455	355	100
20	506	400	106
21	531	450	81
24	608	500	108

3.3 Selection of insertion pipe SDR (Standard Dimension Ratio)

The pipe SDR is defined as follows:

$$SDR = \frac{\text{Specified outside diameter}}{\text{Minimum specified wall thickness}}$$

The SDR should be selected giving due consideration to the maximum operating and test pressure limits for the main and should not be amended in any way as a result of insertion.

Table 2 is indicative of the maximum SDR/pressure values for normal operation in the temperature range 0°C to 20°C for medium density (MD) PE pipe. Constructional and special operational requirements may dictate the use of pipe of a lower or higher SDR class or the use of higher density/performance (HD/HP) PE pipe. In this case reference should be made to the operational procedure dealing with pipe system construction for polyethylene systems and the pipe manufacturer's PE pipe ratings.

3.4 Location of excavations

A thorough examination should be made of all records of the existing main, together with details of other Utilities plant along the route. Additionally, a survey of the existing main should be made using a pipe location instrument and the position of the existing main and of any changes in direction should be both recorded and marked on the highway surface. Attempts should also be made to locate any suspected changes in depth, which may have required the use of bends, by trial hole excavation.

Table 2 – Maximum operating pressure limits for medium density PE pipes

Pipe Outside Diameter	MDPE Pipe SDR (class)			
	11	17.6	21	26
	Maximum operating pressure (at 0°C to 20°C ground temperature)			
mm	bar	bar	bar	bar
16	5.5	-	-	-
20	5.5	-	-	-
25	5.5	-	-	-
32	5.5	-	-	-
63	5.5	-	-	-
50	-	-	-	-
75	5.5	-	-	-
90	5.5	3.0	-	-
106/110	-	3.0	-	-
125	5.5	3.0	-	-
140	5.5	3.0	-	2.0
162/160	-	3.0	-	2.0
180	4.7	3.0	-	2.0
200	4.4	3.0	-	2.0
213	-	-	-	2.0
225	-	-	-	2.0
250	4.0	3.0	-	2.0
268	-	-	-	2.0
280	3.8	2.9	-	2.0
315	3.4	2.7	-	2.0
355	3.1	2.5	2.0	-
400	2.9	2.3	2.0	-
450	2.7	2.2	2.0	-
469	-	2.1	2.0	-
500	2.5	2.0	2.0	-

Note: Pipe sizes indicated by a dash (-) for the various SDR ratings in the above table are not normally available with the full range of complementary fittings required for use in the gas industry, but may possibly be in development.

Details should also be recorded of traffic conditions, vehicle and pedestrian crossings and access points, and any other features along the route which may affect the selection of excavations for launch, reception and intermediate pits.

Wherever possible, the dual use of excavations should be made for the removal of obstructions, bends, tees, syphons, etc; or the installation of new connections as well as for use during the insertion process. However, particularly when the insertion pipe is considerably smaller than the carrier pipe, it may be possible for some minor degree bends to be retained, provided that the buckling/crimping pipe bending radius of curvature stress limits of the inserted pipe are not exceeded. Typically, a safe bending radius for SDR 11 and SDR 17.6 pipes should not be less than 25 times, increasing to 35 times the pipe OD in very cold weather. For thinner-walled SDR 21, SDR 26 and SDR 33 pipes, these values should be increased by as much as 50 per cent.

The length of main which can be inserted will be affected by the insertion pipe size and material selected, gradient, changes in direction, annular clearance, the number of services connected etc; and it is not possible to specify maximum lengths. As a general guide, in average conditions, welded pipe strings of up to 700m in length for MDPE and up to 1000m long for HDPE can be pulled into place, irrespective of diameter or SDR without excessive axial strain. However, the maximum recommended pulling loads as indicated in Table 3 must not be exceeded. Where long lengths of main are to be inserted, additional intermediate excavations may be required to obviate abortive insertion attempts.

The location of all excavations should be indicated clearly on project drawings and also where possible on the highway surface.

3.5 Selection of pipe storage sites (pipe dumps)

Where straight pipe lengths are to be used for insertion, a storage site or sites should be selected to provide, so far as possible, nearest available proximity to the working area, security and protection from impact damage, vandalism and with minimal obstruction to pedestrians and other road users. They should be planned in advance to ensure that the amount of PE pipe stored coincides with that required for each section of main to be inserted with sufficient space to allow pre-assembly of lengths of pipe to form pipe strings as required. During pressurisation prior to testing, pipe sticks are liable to movement and hence a site which is not accessible to the public is preferable but where this is not possible, barriers, fencing and warning signs must be erected.

Where radiography of joints is required and whether or not lead screening is used, access by the public shall be prohibited to a safe distance as specified by the Engineer.

To minimise on site storage and jointing requirements, transportable pipe coils and trailers should be used in preference to straight length pipe sticks.

Where it is expected that pipes will be stored on site for an extended period, attention should be given particularly for larger diameter pipes, to the protection using plastic end caps/bags and support of pipe ends, to avoid ingress of debris, pipe deformation and consequent difficulties with jointing.

Pipe storage, stacking and handling must be in accordance with the pipe and associated plant and equipment manufacture’s safety precautions and instructions with particular attention drawn to the safe handling of pipe coils.

3.6 Relaxation, temperature effects and anchorage

Polyethylene pipes exposed to high ambient temperatures or strong sunlight will expand in length and when stored in stacks or coils may even become oval in circumference. Also during insertion the length of installed PE pipe may be increased further by tensile pull-in forces but will conversely contract and reduce in length when the existing carrier main is cold. Consequently, to address these effects, it is important to consider the following measures.

Prior to installation, the PE insertion pipe, especially that supplied in coils should be checked for ovality using pipe callipers. Whilst the carrier main may have been proved using a straight gauging length, significant scoring and difficulty could arise on insertion due to reduced clearances if the inserted pipe supplied from a pipe coil is oval. To overcome this potential problem, it may be necessary to use a coiled PE pipe straightener/re-rounder or to cold-draw/pull the pipe through a re-rounding die. In this event, tensile winching forces will be increased and tend to further stretch the pipe.

When the pull-in forces are released, the PE insertion pipe relaxes at an exponential decay rate. The relaxation times indicated in Part B, clause 7.1 ensure that unsafe stresses do not arise in the main if at least one end of the main is free. No relaxation period is necessary if the PE pipe is inserted by pushing. However, if the pulling operation requires high forces for long periods (i.e. over 30 min) consideration should be given by the Engineer to increasing the times for the inserted pipe to relax.

Pipe volume changes occurring during relaxation should be completed before taking the first reading of the pressure test. No relaxation period is necessary prior to making the final connection after the pressure test.

The coefficient of expansion for PE is about 15 times that for steel or ductile iron. Therefore, expansion or contraction of the inserted length may occur as the surface ambient temperature of the pipe equilibrates with the ground temperature. For example, the change in length of 100 m PE pipe will be 15mm per 1°C change in temperature. Depending upon local conditions, and latitude, ground temperatures at gas mains depth vary seasonally and can be from say, 20°C or more in summer down to 0°C or less in mid-winter. Where ground temperatures, are likely to be higher than 20°C, especially in summer, then it is recommended that an overnight temperature stabilisation period should be allowed, and in extreme cases as much as 24 hours. In normal circumstances, temperature stabilisation and relaxation periods are given in clauses 3.5 and 7.1 of part B of this procedure.

Local anchorage of PE mains will negate temperature effects. Anchorage should be provided at tie-in and valve connections and at service and branch connections to prevent movement caused by thermal expansion. At tie in and valve connections and at intermediate excavations, fused fittings having a positive end loading capacity should be used, whilst at service and branch connections anchorage should be provided using un-drilled service saddles fused to the main and encased in concrete anchor blocks.

Where PE mains are exposed to the seasonal extremes of atmospheric temperature (e.g. bridge crossings) the effects of seasonal expansion and contraction should be considered on an individual basis, possibly with additional restraint using pipe hoop clamps or with consideration towards using expansion joints.

3.7 Sealing of annular openings

At every location where a section of existing main is to be removed or broken for service transfers, the annular space between the inserted PE pipe and the existing main should be sealed against gas ingress using cement grout or expanding foam.

Where the insertion pipe is small in relation to the existing main size or where thin-walled PE is used and additional structural support and reinforcement of the new pipe is required, consideration shall be made to pressure grouting the annular space along the whole length of the main.

For long pipe strings and especially those operating at a higher working pressure above 4 bar, it is generally recommended that a pipe relaxation period of at least 24 hours has elapsed before grouting or making permanent tie-in joints and lateral connections.

3.8 Provision of alternative facilities and temporary gas supplies

Where a PE pipe is to be inserted into a main to which services are connected, consideration should be given to the alternative means available to maintain gas supplies to customers.

Where an alternative main is available, the temporary or permanent transfer of services may be preferred.

Where there are a large number of services or where the duration of insertion work is expected to be long, a by-pass pipeline to which services are transferred may be required. A by-pass will also be required where the existing main to be replaced is a single source supply to downstream customers.

The by-pass should, where exposed, be metallic and of sufficient size to adequately supply transferred services and downstream customers, as appropriate.

The by-pass may be installed on the surface, but provision shall be made to preclude so far, as is reasonable, damage from vehicles. Vehicular access shall also be maintained and where necessary for this purpose, ramps over the by-pass should be provided or sections of it sleeved or notched into the surface, particularly at road junctions. Details should be recorded on the project working drawings.

Where services are also considered for replacement, it is recommended that this work is undertaken in advance of mains insertion operations, to minimise on disruption that later service renewal work would potentially cause.

3.9 Customer relations

To maintain good customer relations and co-operation, customer liaison, notification and advice concerning the work programme is essential prior to work commencement.

4. PREPARATION

4.1 Plant, tools and equipment

In addition to the tools and equipment regularly used for pipefitting and laying, arrangements should be made for all or some of the following specialist plant and equipment to be available, as required, in accordance with the project construction plan:

a) Winch (see 4.2)

b) Pulling cables and flat woven webbing slings. (See 4.2)

c) Reel mounted flexible fibreglass rod. – Housed in a metal frame and available in lengths up to 300m long – used for the installation of winch cables and draw ropes.

d) Cleaning equipment. - To include scraper, wire brush and rubber pig pull throughs.

e) Inspection equipment. – CCTV camera, video recorder and monitor, and/or PE gauge pigs, pipe wall damage indicator to accurately measure depth of pipe wall scoring and proprietary de-beading tool.

f) PE pipe coil straightener and re-rounding dies. - Suitable for all grades of PE (MD, HD and HP) in the size range 63mm to 180mm and for any wall thickness. Used for straightening/re-rounding of coiled pipe as it is dispensed and laid from a pipe coil trailer and also for reclaiming/recycling part coils.

g) Pipe towing head assemblies, nose cones, pipe rollers, mechanical fuses, snap-action pipe restraining clamps and insertion trumpets.

h) Heavy-duty swivel, snap-action toggle clamp. – Used to attach the winch cable to the towing head assembly

i) Test ends. – To facilitate testing of pipe sticks and strings, test ends should preferably be used.

j) Combined Wheel Excavator/Loader (>5 tonne) with hydraulic jack-up support legs and the backhoe certified and approved for lifting use applications.

k) PE pipe pushing machine.

4.2 Winching, pulling and pushing operations

4.2.1 General

For small diameter (150mm dia. and below), short length (less than 100m long) mains renewals that are usually prevalent in urban areas, the weight of the insertion pipe and the axial strains involved are substantially less than the forces required for larger diameter and longer length mains insertion renewals. Consequently, pushing from the launch pit should be considered preferable to pulling from the reception pit in these circumstances, with reduced hazard risks and precautionary safety measures required.

Pushing could be considered slower than pulling, but to some extent the time element is not too significant as this would be offset by the set-up time involved if pulling with powered winches were used instead. For relatively light duty applications, pipe pushing is an effective, simple technique that offers a finer degree of control and places less strain on the insertion pipe.

The most common method of pipe pushing, is to employ the use of a mechanical excavator's articulated backhoe with lifting shackle attached to a 4m to 6m long, 100mm wide flat woven polypropylene webbing sling. This can be attached at intervals to the insertion pipe string in the launch pit with a pipe-restraining clamp and back-hauled gradually into the carrier main using the dipper arm. Providing the inserted pipe has free passage, as pre-proved using a gauge length pull through prior to installation, apart from frictional effects, the only constraint to this method is the weight of the pipe being installed. It is therefore essential that if this method is used, an estimate be made of the weight of the pipe length proposed for insertion to ensure that it does not exceed the safe working loads (SWL) of both the machine employed and webbing sling used. As a further safety measure, to allow for frictional effects, it is recommended that the estimated installed pipe weight should be increased by say a notional 20% to give a factor of safety margin of error in the actual weight being hauled. An approved mechanical fuse should be installed between the lifting shackle and pipe sling that is limited to the safe working load (SWL) of the sling. Under no circumstances should any persons be permitted to enter the excavation during the hauling-in of the inserted pipe and all safety measures, rules and instructions concerning the use of excavators as cranes, shackles, eyebolts, mechanical fuses, pipe clamps and lifting slings must be strictly observed. (See Appendix A, Part B)

Proprietary pipe pushing machines are available, but tend to be heavy and bulky in transportation between launch and reception excavation pits and they can require regular maintenance with the potential problem of availability of spare parts. Close attention to anchorage of the machine and a system of pipe rollers needs to be set up for successful operation involving additional set-up time.

Alternatively, instead of using a mechanical excavator to back-haul the insertion pipe into the parent main, hand operated winching could be used to push the inserted pipe towards the reception pit. However, whilst this method is still preferable to powered winching, close attention to anchorage of the hand winch is necessary and suitable precautions will also need to be taken to protect the winch operator from injury resulting from failure of the winch cable.

Steel wire cable shall be used in preference to natural or synthetic fibre ropes. A current, valid insurance test certificate shall be available for the steel cable, ropes and winch and all must be rated for the purpose for which they are intended.
The hand-operated winch can also be used at the reception pit excavation in order to pull the pipe instead of pushing.

4.2.2 Hand operated winch, cables, ropes and slings

The winch shall be equipped with a dynamometer or an approved mechanical breakaway connector fuse (weak-link) which is limited to either the safe maximum allowable working load (SWL) for the cable selected or for the maximum allowable “pull-in” force (F) on the PE pipe selected, whichever is the smaller. - (See: Table 3)

The safe working load (SWL) is usually designated at 10% of the breaking strain/load of the cable, rope or sling, but the manufacture’s “stamped” or “plated” SWL value should always take precedence.

To avoid over-stretching and exceeding the elasticity limits on the insertion pipe, the maximum allowable pull-in force (F) on the PE pipe, expressed in “Newtons” (N) is given by the following equation:

$$\mathbf{F = 0.5 \pi D t Y}$$

Where:

D is the PE pipe outside diameter, in mm.

t is the pipe wall thickness, in mm.

Y is the specified minimum yield stress (SMYS), in MN/m².

The values for (F) indicated in Table 3 are based on this formula, (but expressed in kN) are valid for medium and high density polyethylene pipes in common use, in the size range and SDR class tabulated. For other pipe size and SDR values not shown, for either MD or HD/HP PE pipes, the value of (F) may be calculated using the above formula.

As 10kN = 1 Tonne force = 1000kg.f, to convert from kN to tonnes force is to multiply those values shown in Table 3 by 10 or by 100 to convert to kg.f.

4.2.3 Power operated winch

For larger diameter (>150mm and above), longer length (in excess of 100 metres) mains renewals, and where pulling forces are likely to exceed 5 tonnes (49kN), powered winching is recommended.

For such heavy duty applications, a tractor or other moveable plant or vehicles fitted with Power take Off (PTO) winches shall not be used for towing-in the inserted pipe through the carrier main, only a purpose designed and static machine is permitted.

The power operated winch shall be fitted with a mechanical fuse or dynamometer as detailed in 4.2.2.

A suitable size winch and cable should be selected for the anticipated pull-in forces for the size and length of insertion pipe considered, to be set up at the reception pit of the pipeline to be slip-lined.

Table 3 – Maximum allowable pull-in force (F) in kN

Pipe outside diameter mm	Pipe material (SDR) and maximum allowable forces (F)			
	Medium Density PE		High Density PE	
	SDR 11	SDR 17.6	SDR 11	SDR 17.6
	(F) kN	(F) kN	(F) kN	(F) kN
20	0.80	0.52	1.03	0.67
25	1.25	0.81	1.61	1.04
32	2.05	1.33	2.64	1.71
63	7.94	5.14	10.21	6.61
75	11.25	7.28	14.46	9.36
90	16.19	10.48	20.81	13.47
125	31.23	20.22	40.15	25.98
140	39.18	25.36	50.37	32.59
180	64.78	41.93	83.28	53.89
200	79.97	51.76	102.81	66.53
250	124.46	80.88	160.65	103.96
280	156.74	101.45	201.31	130.39
315	198.36	128.39	255.02	165.02
355	251.96	163.08	323.93	209.61
400	319.88	207.04	411.25	266.11
450	382.55	243.01	510.04	323.91
500	499.11	323.50	642.57	415.80

5. INSTALLATION PROCEDURE.

The mains insertion/slip-lining installation procedure is detailed in Part B, together with safety requirements (Appendices A and B) for operational personnel.

Safety of winching operations shall be strictly observed as detailed in Appendix B.

6. INSPECTION, TESTING AND COMMISSIONING.

During and following installation, the inserted main shall be inspected, tested and commissioned in accordance with those procedures specifically assigned for this purpose.

However, for larger diameter insertion pipes operating in the higher-pressure range (75mb to 7bar), consideration may further apply to supplement the pneumatic pressure testing procedure with radiographic examination.

Where radiography is employed, the working area shall be fenced off and all safety precautions and inspection criteria in an approved method statement provided by a certified Test Engineer/PE Pipe Welding Inspector shall apply. (Ref: EN 13067)