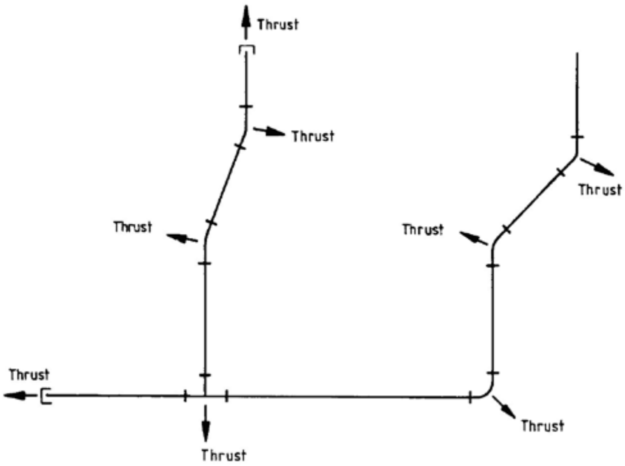
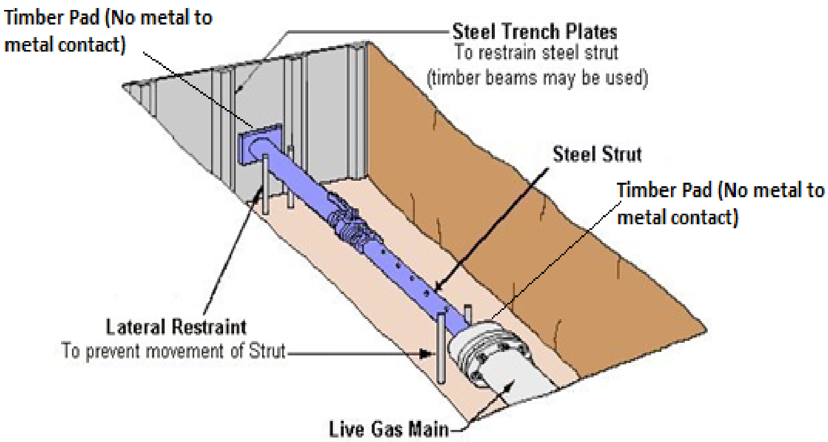
SGN/PM/ANC/4.2

Safety Management Framework

Management Procedure for Anchorage on Systems Operating up to and Including 7bar (≤160 kN)





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Context

Who is this Management Procedure for?

The Management Procedure is for Managers trained in anchorage systems and been assessed as competent involved in the design, selection and construction of temporary and permanent anchorage systems.

What does this Management procedure do?

This Management procedure provides managers with instructions and support material to enable them to design, select and construct anchorage systems.

Scope

This Management procedure covers the provision of both temporary and permanent anchorage of pipes and fittings on mains and services up to 48” nominal diameter and operating pressure up to an including 7 bar pressure.

Why do we need this Management procedure?

To support the safe and adequate installation of anchorage.

CONTENTS

1. OBJECTIVE

1.1 This Management Procedure describes the requirements for anchorage of pipes and fittings on the network operating at pressures up to and including 7 bar.

2. TRAINING AND COMPETENCE

2.1 Managers and operatives involved in the construction of anchorage system must have received training in the use of temporary and permanent anchorage systems and in the calculations of anchorage and temperature expansion forces.

2.2 Where individuals do not have the knowledge to construct and or design a suitable anchorage system advice should be sought from either another manager who is suitably trained. For expert advice contact should be made with a SGNs design team or a qualified company listed in the Technical Services Contract which is managed by Asset Management.

3. BASIC REQUIREMENTS FOR ANCHORAGE

3.1 General

Anchorage is required to restrain movement of pipework and fittings in order to prevent joints being disturbed or fitting becoming dislodged, leading to a release of gas. In a worst case, a fitting such as an end cap could become detached from the main and strike anything in its path, potentially resulting in severe or fatal injury to any individual that may be nearby.

Temporary anchorage is required to restrain the thrust on a pipe or fitting prior to the commencement of additional work, for example an end cap is fitted whilst mains insertion operations progress and at a later date the re connection made using a connection fitting.

Permanent anchorage is provided to restrain the thrust on a pipe or fitting in a manner which will remain unaltered.

Construction of new continuously welded steel and fusion jointed PE pipework should not require anchorage, as all newly jointed mains must be end-load resistant. End-load bearing fittings have higher strength characteristics than the pipe to which they are attached. Such joints include flange joints, electrofusion joints.

When systems are connected to new or existing pipework by flexible compression joints, for example Johnson couplings, Maxi-adaptors etc that do not provide end-load bearing resistance, then these fittings must be provided with anchorage. Temporary anchorage and or permanent anchor blocks must be provided according to the appropriate stage in construction. Vertically driven spikes or stakes are not permitted for use as either temporary or permanent anchorage.

3.2 Ground Movement and Pipe Floatation

Where it is suspected that significant ground movement or flotation of pipework could occur; work must not be progressed until the site conditions have been assessed and any additional anchors have been installed. Specialist advice should be sought, if applicable, either from other Managers who have a detailed knowledge of the subject, SGNs design team or through SGN's technical services contract.

It is important to ensure that a proper assessment of ground conditions is carried out as this affects the ability of anchor blocks or temporary anchorage/ restraints to resist thrust forces within the pipework. The design guidance given in this procedure assumes that ground conditions have been subject to a proper assessment. If there is any doubt as to the validity of the assessment carried out, expert advice should be sought.

Where anchorage is provided by reacting thrust loads against adjacent ground, it must be recognized that ground movement could occur whilst the system is being pressurised. Precautions must be taken to prevent leakage, displacement of fittings or detachment of end caps; if necessary, existing restraining arrangements should be adjusted and/or additional anchorage should be installed.

All concrete anchor blocks must be completely backfilled before the main is pressurised.

4. UNDERSTANDING THE FORCES ON PIPES AND FITTINGS

4.1 Thrust Forces

It is important before considering the type of anchorage required to understand the thrust forces involved and how these thrust forces are calculated. Thrust forces are dependent on the following:-

a) Internal pressure in the pipe

b) The pipe diameter

c) Changes in temperature and the effect on thermal expansion

d) The type of fittings to be restrained (shape factor)

e) Pressurisation effect on PE pipes.

Depending on the thrust forces exerted anchorage will normally be required in the following circumstances:

- The fitting of a flexible non-end loaded compression joint.
- Flow stopping activities dependant on thrust forces involved.
- Full bore connections to existing swaged or inserted PE pipe that are in tension.

4.1.2 Internal Pressure in the Pipe

The gas or air pressure within the pipe will exert a pressure on the pipe and as this pressure increases the thrust force will also increase.

4.1.3 The Pipe Diameter

The thrust forces within the pipe also increase as the diameter increases. When making calculations the diameter for PE and steel pipes the nominal internal diameter should be used, for cast iron, ductile iron and other socket jointed pipe, the internal diameter of the socket should be used. However for simplified calculations the diameter of the equivalent socketed iron pipe can be used for PE and steel pipes. These pressure thrust forces have been calculated and are shown in Table 1.

To calculate the thrust forces arising from the pressure and diameter, the following equation is used: Thrust Force Fp (kN) = 100 X Pressure (bar) X Cross Sectional Area (m^2).

The area is calculated as $\pi D^2 /4$, where π is a constant approximately equal to 3.142.

The pressure is measured in bar.

D = the internal diameter of the pipe, pipe socket or fitting see note 1.

For examples of these calculations see Appendix C and conversion factors Table C.1.

Nominal Mains Diameter	LP and LP Test Pressure						MP and Test Pressure				IP and Test Pressure		
	30 mbar	40 mbar	75 mbar	140 mbar	200 mbar	350 mbar	1 bar	1.4 bar	2 bar	3 bar	4 bar	7 bar	10 bar
3 inch/75 mm	0.04	0.05	0.08	0.15	0.21	0.37	1.1	1.5	2.1	3.2	4.2	7.3	11
4 inch/100 mm	0.05	0.07	0.12	0.22	0.32	0.6	1.6	2.2	3.2	4.7	6.3	11	16
5 inch/125 mm	0.07	0.09	0.17	0.32	0.45	0.8	2.3	3.2	4.5	6.8	9.0	16	23
6 inch/150 mm	0.10	0.13	0.23	0.43	0.7	1.1	3.1	4.3	6.1	9.2	13	22	31
7 inch/175 mm	0.12	0.16	0.30	0.6	0.8	1.4	4.0	5.6	7.9	12	16	28	40
8 inch/200 mm	0.15	0.20	0.38	0.7	1.0	1.8	5.0	7.0	10.0	15	20	35	50
9 inch/225 mm	0.19	0.25	0.46	0.9	1.3	2.2	6.1	8.6	13	19	25	43	61
10 inch/250 mm	0.22	0.30	0.6	1.1	1.5	2.6	7.4	11	15	22	30	52	74
12 inch/300 mm	0.32	0.42	0.8	1.5	2.1	3.7	11	15	21	32	42	74	105
14 inch/350 mm	0.42	0.6	1.1	2.0	2.8	4.9	14	20	28	42	56	97	138
15 inch/375 mm	0.47	0.7	1.2	2.2	3.2	5.5	16	22	32	47	63	110	156
16 inch/400 mm	0.6	0.8	1.4	2.5	3.6	6.2	18	25	36	53	71	123	176
18 inch/450 mm	0.7	0.9	1.7	3.1	4.5	7.8	23	31	45	67	89	155	221
20 inch/500 mm	0.8	1.1	2.0	3.8	5.4	9.4	27	38	54	80	107	187	267
21 inch/525 mm	0.9	1.2	2.2	4.1	5.9	11	30	41	59	88	117	205	292
22 inch/550 mm	1.0	1.3	2.4	4.5	6.4	12	32	45	64	96	128	223	318
24 inch/600 mm	1.2	1.5	2.8	5.3	7.5	14	38	53	75	112	150	262	374
26 inch/650 mm	1.3	1.8	3.3	6.1	8.7	16	44	61	87	130	174	304	434
27 inch/675 mm	1.4	1.9	3.5	6.6	9.3	17	47	66	93	140	186	326	465
28 inch/700 mm	1.5	2.0	3.8	7.0	10.0	18	50	70	100	150	199	348	498
30 inch/750 mm	1.7	2.3	4.3	8.0	12	20	57	80	114	170	227	396	566
32 inch/800 mm	2.0	2.6	4.8	9.0	13	23	64	90	128	192	256	448	639
33 inch/825 mm	2.1	2.8	5.1	9.5	14	24	68	95	136	203	271	474	677
36 inch/900 mm	2.4	3.2	6.0	12	16	28	80	112	160	239	319	558	797
38 inch/950 mm	2.7	3.6	6.7	13	18	31	89	124	177	265	353	618	882
40 inch/1000 mm	3.0	3.9	7.3	14	20	35	98	137	195	292	389	681	973
42 inch/1050 mm	3.2	4.3	8.0	15	22	38	107	150	214	320	427	747	1067
44 inch/1100 mm	3.5	4.7	8.8	17	24	41	117	164	233	350	466	816	1165
46 inch/1150 mm	3.9	5.1	9.6	18	26	45	127	178	254	381	508	888	1268
48 inch/1200 mm	4.2	5.5	11	20	28	49	138	193	275	413	550	963	1375

Key:		
	All Systems up to 0.1 kN Thrust:	No Anchor Block is Required but see also Section 7.4.1
	All Systems 0.1 to 10.0 kN Thrust:	System Type 1) - see SGN/PM/DIS 4.2 Section 8.2
	All Systems 10.1 kN to 30 kN Thrust:	System Type 2) - see SGN/PM/DIS 4.2 Section 8.3
	All Systems 31 kN to 60 kN Thrust:	System Type 3) - see SGN/PM/DIS 4.2 Section 8.4
	All Systems over 60 kN Thrust:	System Type 4) - see SGN/PM/DIS 4.2 Section 8.5
	All Systems over 160 kN Thrust:	Refer for Special Design

Table 1 - Pressure Thrust Force (kN) for Typical Pipe Sizes at Relevant Pressures

Note 1: The diameter to be used will vary according to the situation.

For cast and ductile iron socketed pipes the internal diameter of the socket must be used, NOT the internal or external pipe diameter. For plain pipes e.g. welded steel and PE pipes without fittings then the plain internal diameter of the pipe is used.

Note 2: The figures in this table are calculated based on socket diameters and not pipe bore as being the most appropriate maximum figures for cast iron. The calculated thrust forces will be higher than those for steel pipes but unless specifically calculated the table can be used for steel, cast iron and imperial plastic pipes (PVC and PE).

Note 3: Table 1 provides details of the basic thrust force developed on an end cap for given mains diameter and pressure. The pressure selected should be the maximum pressure which the pipe may see, e.g. Maximum Operating Pressure, fault pressure, test pressure etc. This should be used in conjunction with the other factors described in this section to determine the thrust force to be restrained.

4.1.4 Changes in Temperature and the Effect on Thermal Expansion

Pipe materials will expand as a result of temperature rise, typically a PE pipe left in the sun during the day will become longer and likewise PE pipe will contract as temperature falls.

Typically a main connected during the middle of the day in summer can see a temperature change during the night of 10 to 20^{O} C. This will cause a contraction of 15 mm per 100 m section per 1^{O} C causing a contraction of 150mm to 300mm.

PE pipe expands and contracts at a greater rate than metallic pipework. When making connections between PE and metallic systems via non-end load fittings the effect of temperature needs to be taken into account as the contraction of PE has the potential to cause pipe fitting separation. This is especially likely when long lengths of PE pipe remain exposed above ground or in open trenches during the day, which cause them to heat up, and then cooled at night. In addition the daily/seasonal changes in temperature below ground between winter and summer will also alter the thrust force being exerted onto the system, albeit this is minimised by the frictional resistance created on the pipe by the surrounding ground conditions holding the pipe in position.

To calculate the Thrust force Fth resulting from thermal expansion of PE pipe, it is calculated by

$Fth = A \times E \times \Delta T \times \alpha$

Where Fth = Thermal expansion thrust force in Newton’s

A= cross sectional area of the pipe (m^2)

E = Young’s modulus for PE (N/m^2) (assumed to be 700 Mpa for PE 80 – 1100 for PE100 pipes)

α = coefficient of thermal expansion for PE (1.5×10^{-4})

ΔT = change in ground or exposed pipe temperature (^{o}C) e.g. 5^{o}C to 20^{o}C =15^{o}C)

These forces have already been calculated and are shown in tables 2.1 to 2.2.

To calculate the force resulting from a specific temperature change, multiple the actual temperature difference by the Figure in the column for 1^{O} Centigrade for the appropriate pipe to get the resulting force. For example Where the Temperature difference of 13^{O}C on a 250mm SDR 21= 1.6kN X 13= 20.8 kN.

Anchorage of PE pipe should normally follow the requirements stated in Section 14 of this procedure.

PE80 YELLOW PIPE - Contraction/ Expansion Force per 1°C				
Nominal Pipe Dia mm	SDR11 kN	SDR17.6 kN	SDR21 kN	SDR26 kN
75	0.17	0.11	0.10	-
90	0.24	0.16	0.14	-
110	0.35	0.23	0.20	-
125	0.46	0.30	0.25	-
140	0.6	0.37	0.32	0.26
160	-	-	0.41	0.34
180	1.0	0.7	0.6	0.43
200	1.2	0.8	0.7	0.6
213	-	-	-	0.6
225	-	1.0	0.8	0.7
250	1.8	1.2	1.0	0.9
268	-	-	-	1.0
280	2.3	1.5	1.3	1.1
315	2.9	1.9	1.6	1.3
355	3.7	2.4	2.0	1.7
400	4.6	3.0	2.6	2.1
450	5.8	3.8	3.2	2.7
500	7.2	4.7	4.0	3.3
560	9.0	5.9	5.0	4.1
630	12	7.4	6.3	5.2
Note: For 75mm dia PE80 SDR 13.6 use value for 75mm SDR 11				

Table 2.1 - Expansion Forces for PE80 Pipes per 1 ^{O} Centigrade

	Contraction/Expansion Force per 1°C		
Nom Pipe Dia	PE100 PEELABLE		PE100 ORANGE PIPE
	SDR21	SDR26	SDR11
mm	kN	kN	kN
75	0.15	-	0.26
90	0.21	-	0.37
110	0.31	-	0.6
125	0.40	-	0.8
140	0.50	0.41	0.9
160	0.7	0.6	-
180	1.0	0.7	1.5
200	1.0	0.9	1.9
225	1.3	1.1	-
250	1.6	1.3	2.9
280	2.0	1.6	3.6
296	-	1.8	-
315	2.5	2.1	4.5
355	3.2	2.6	5.7
400	4.0	3.3	7.3
440	-	4.0	-
450	5.1	4.1	9.2
500	6.2	5.1	12
560	7.8	6.4	-
630	9.9	8.1	-

Table 2.2 - Expansion Forces for PE100 Pipes per 1^{O} Centigrade

4.1.5 Shape Factors

The direction of thrust forces acting on a typical pipework system due to internal gas pressures can be seen in Figure 1. To determine the imposed thrust force on a fitting to be restrained, reference should be made to the shape factor shown in Table 3. The thrust force on a 90° bend is 1.5 times as great as that acting on an end cap and acting in the direction shown in Figure 1. It is crucial that the correct positioning of an anchor/system reacts against the direction of the generated thrust force.

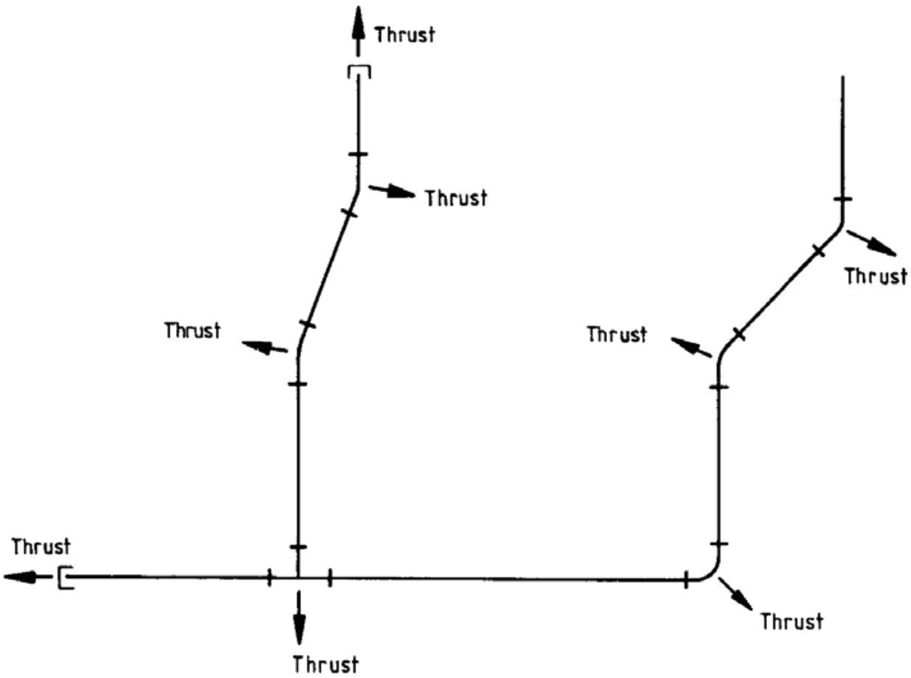


Figure 1 – Thrust Force Diagram

Type of Fitting	Shape Factor
End Cap	1
Equal Tee	1
11 ¼ ^{O} Bend	0.2
22 ½ ^{O} Bend	0.4
45 ^{O} Bend	0.8
90 ^{O} Bend	1.5

Table 3 – Shape Factors

Example:

To obtain the thrust force acting on an equivalent diameter bend multiple the thrust force from Table 1 for the relevant diameter and pressure by the shape factor from Table 3. For example a 12” 90^{o} bend at 2 bar pressure has a thrust force of 21kN. Therefore 21 x 1.5 (90° Bend shape factor) = 31.5 kN.

Note: As the direction of the resulting thrust force depends on the fitting type at the point where the thrust is to be reacted, it is crucial that all anchors or thrust restraints are positioned correctly, so as to react against the direction of the resulting thrust force, as shown in Figure 1.

4.1.6 Pressurisation Effect on PE Pipe

All pipes expand in diameter to some degree as the internal pressure increases, although, for metallic pipe, the expansion is negligible. For PE pipe, the diameter expansion is much greater and leads to a corresponding contraction in pipe length, which in turn results in a contraction force along the pipe; this force is essentially similar to a thrust being applied in the opposite direction.

Typically, a 100 m length of 250 mm PE pipe pressurised to 2 bar may contract in length by around 84 mm unless restrained by joints/fittings. When restrained, the contraction will generate a linear force at adjacent joints/fittings, similar to the force generated by thermal expansion of PE pipe. Sections of PE pipe containing non-end-load bearing joints, i.e. compression joints such as “Johnson” couplings are at risk of being separated or displaced - see precautions in Section 14.

4.1.7 Combined Pressure and Thermal Expansion Forces

Where PE pipe is not to be restrained using Tapping Tees/ Saddles cast into concrete blocks as shown in Section 14.2, then calculations must take into account both pressure force and PE thermal expansions force. These forces are then added together in order to determine the total thrust force, as follows:

For 180 mm PE pipe connected to 6 inch LP cast iron pipe, the combined thrust force is as follows:

Pressure: Maximum pressure thrust for 6 inch pipe at 75 mbar, from Table 1 = 0.23 kN

Expansion: Maximum expansion force for 180 mm PE80 SDR17.6 pipe for 20°C temp change, from Table 2: = 13 kN (or 0.7 kN per each 1°C change in temperature)

Total Thrust Force = Pressure Thrust + Expansion Force

= 0.23 kN + 13 kN

= 13.23 kN total thrust to be restrained

Note: For metallic pipe, there is no requirement no calculate a thermal expansion force

4.2 Calculations

When making the calculations to determine the total thrust forces you must follow the steps shown in Figure 2, this will ensure that all of the appropriate stages are included.

4.2.1 Results

Having followed the steps in Figure 2 the total thrust force for the situation will have been determined. The type of anchorage required must now be identified either temporary or permanent, where it has to be installed and in what ground conditions. If the temporary anchorage is required and the Thrust Force does not exceed 60kN then refer to Table 1 to determine the colour code and the system type 1 to 3 to be used. If the Thrust Force exceeds 60 kN or permanent anchorage is required then the soil type at the location of the proposed anchorage (see Section 5 and Appendix D) must be identified.

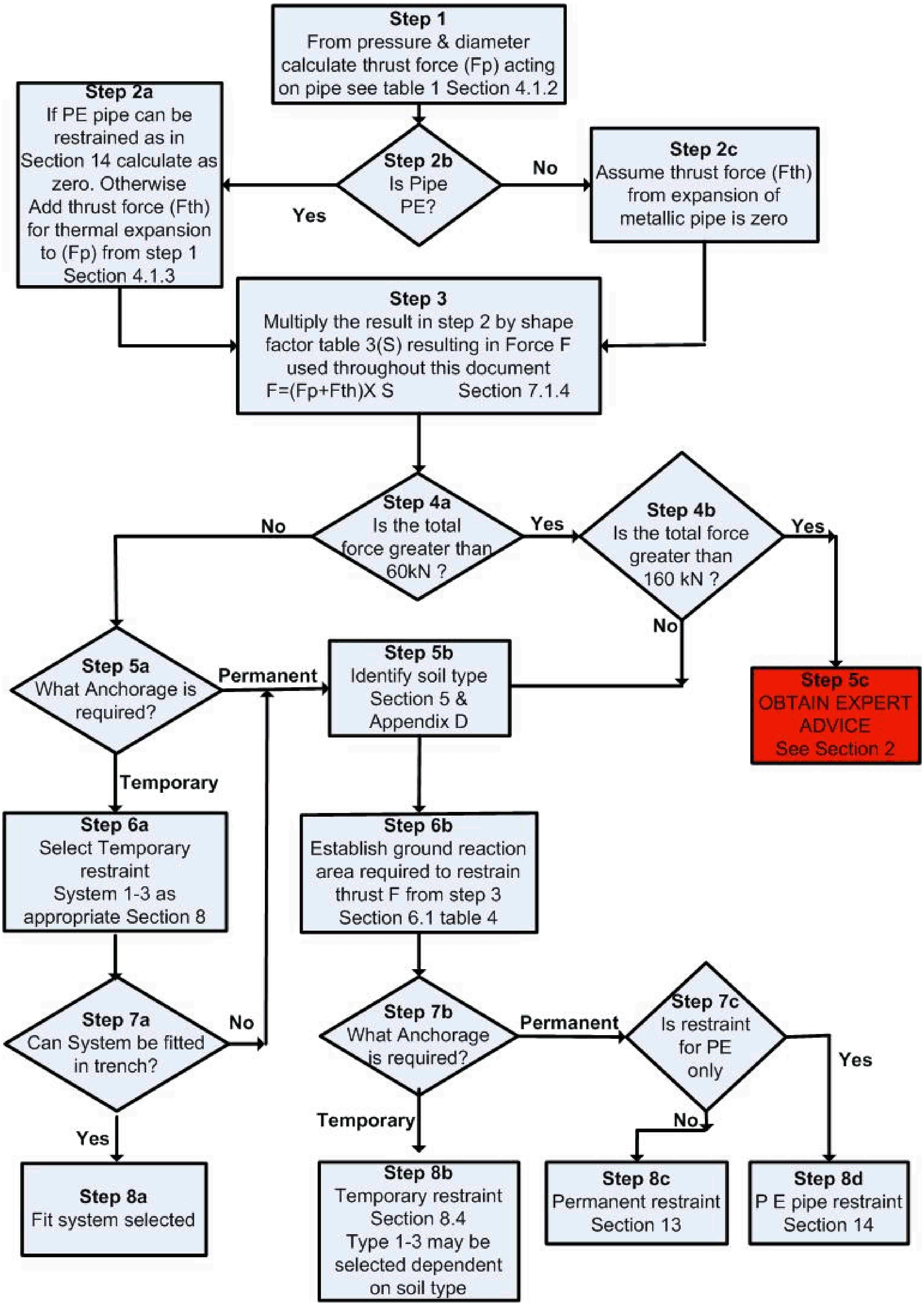


Figure 2 – Process for Calculating Thrust Forces in Pipes

5. SOIL TYPES

The design of suitable anchorage should be provided to teams from SGN work instruction SGN/WI/ANC/4.2.2. If using transverse beams installed into the adjacent ground or when creating permanent anchor blocks the type of ground conditions will dictate the ground reaction area required to restrain imposed thrust force and take into account the soil type present. These range from the following:

i) Very stiff, hard clay, rock

ii) Stiff clay

iii) Dense granular material (dry or wet)

iv) Firm clay

v) Non-dense Granular Material or Dense Coarse Grained soil

vi) Non-dense Coarse Grained Soil

vii) Soft clay made up ground or re-used excavated spoil

Guidance on identification of soil types is given in Appendix D.

6. DETERMINING THE ANCHOR BLOCK SIZE

When the resulting thrust force and direction of thrust have been determined in accordance with Section 4, the location at which any anchorage or thrust restraint must be provided will also be clear.

If anchorage is to be provided by any arrangement of transverse beams, with or without struts, props or trench shoring, then no anchor block is likely to be required - see Section 8 for the design of temporary anchorage or Section 13 for the design of permanent anchorage.

Where thrust forces are to be held by use of anchor blocks, whether temporary or permanent, the anchor block design will depend on the load bearing capacity of the ground that will support the block(s) - see Appendix D for identification of the type of ground adjacent to required anchor block locations.

6.1 Calculation of Thrust Reaction Area

To ensure adequate anchorage, soil types likely to be encountered in UK have been classified within a range of assumed characteristic strengths and appropriate safety factors, as shown in Table D.1. When the type of ground has been identified, the size of the required anchorage i.e. the face area of the anchor block can be determined. For each soil type, the anchor block face area required to restrain the resulting thrust force is as shown in Table 4.

Required Face Area of Anchor Block - m^2 {will depend on ground type identified in accordance with Appendix D}							
Resulting Thrust Force F kN	Soil 1) Rock or Very Stiff, Hard Clay	Soil 2) Stiff Clay	Soil 3) Dense Granular Material	Soil 4) Firm Clay	Soil 5) Non-dense Granular or Dense Coarse Grained Soil	Soil 6) Non-dense Coarse Grained Soil	Soil 7) Soft Clay or Made Ground or Reused Excavated Spoil
Up to 0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.01
0.11 to 0.2	0.00	0.00	0.00	0.00	0.01	0.01	0.01
0.21 to 0.5	0.00	0.00	0.01	0.01	0.01	0.02	0.03
0.51 to 1	0.01	0.01	0.02	0.02	0.03	0.04	0.05
1.1 to 2	0.01	0.01	0.04	0.04	0.06	0.07	0.12
2.1 to 4	0.02	0.03	0.07	0.07	0.11	0.15	0.24
4.1 to 7	0.04	0.05	0.10	0.13	0.19	0.26	0.35
7.1 to 10	0.05	0.07	0.15	0.19	0.28	0.37	0.50
10.1 to 15	0.08	0.10	0.22	0.28	0.42	0.55	0.75
15.1 to 20	0.10	0.13	0.30	0.37	0.56	0.74	1.01
20.1 to 25	0.13	0.17	0.35	0.47	0.70	0.92	1.25
25.1 to 30	0.15	0.20	0.40	0.56	0.83	1.11	1.53
30.1 to 35	0.18	0.23	0.45	0.65	0.97	1.29	1.75
35.1 to 40	0.20	0.27	0.50	0.75	1.11	1.48	2.00
40.1 to 45	0.23	0.30	0.60	0.84	1.25	1.66	2.25
45.1 to 50	0.25	0.33	0.70	0.93	1.39	1.85	2.50
50.1 to 60	0.30	0.40	0.82	1.12	1.67	2.22	3.00
60.1 to 70	0.35	0.47	0.94	1.31	1.95	2.59	3.50
70.1 to 80	0.40	0.53	1.06	1.49	2.23	2.96	4.00
80.1 to 100	0.50	0.67	1.30	1.87	2.78	3.70	5.00
100.1 to 120	0.60	0.80	1.46	2.24	3.34	4.44	6.00
120.1 to 140	0.70	0.93	1.62	2.61	3.90	5.18	7.00
140.1 to 160	0.80	1.07	1.80	2.99	4.45	5.92	8.00
Over 160	**Requires Specialist Assessment and Anchor Block Design**						

Key:	
Anchor Block Face Area Less Than 0.01 m^2	**No Anchor Block is Required see also section 7.4.1**
All Systems 0.1 to 10.0 kN Thrust:	**System Type 1) - See SGN/PM/DIS 4.2 Section 8.2**
All Systems 10.1 KN to 30 kN Thrust:	**System Type 2) - See SGN/PM/DIS 4.2 Section 8.3**
All Systems 31 KN to 60 kN Thrust:	**System Type 3) - See SGN/PM/DIS 4.2 Section 8.4**
All Systems over 60 kN Thrust:	**System Type 4) - See SGN/PM/DIS 4.2 Section 8.5**
All Systems over 160 kN Thrust:	**Refer for Special Design by SGN Design Team**

Table 4- Anchor block face area required to restrain thrust for a defined soil type

Note 1: Very soft clays, silts and very loose granular fills require special consideration and are outside the scope of this procedure. Expert advice should be obtained in these circumstances.
Note 2: The smallest anchor block to be constructed should have a face area of $0.1m^2$. If the required face area of the anchor block from Table 4 is less than $0.1m^2$, then no concrete anchor block is required.

7. ANCHORAGE REQUIREMENTS

7.1 Responsibility

Operational Managers must approve the temporary and or permanent anchorage system to be used prior to pipe isolation, pressure testing or commissioning.

All calculations and designs for anchorage at or above 2 bar must be checked by another Operational Manager and for designs at or above 7 bar the design must be checked by a Senior Manager or a specialist designer.

7.2 General

- Anchorage is required to prevent movement of pipe work and/or fittings that could cause a joint to be disturbed or a fitting to be displaced.
- Joints used to connect an end cap to an existing cast iron, ductile iron or steel systems need special consideration as the movement of the cap could cause a flexible compression joint to be disturbed.
- Mechanical self-anchoring joints must not be relied upon to provide anchorage; i.e. external thrust anchorage must be provided.
- During live gas working on medium and intermediate pressure mains, the pressure in the main should be reduced as far as possible.
- Where it is suspected that flotation of the pipe work or significant ground movement could occur: work must not be progressed until the site conditions have been assessed and any additional anchorage requirements installed. Specialist advice should be sought if applicable. This advice is available either from other Managers who have a detailed knowledge of the subject or through SGN's technical services contract.
- Where the anchorage is provided by reacting thrust forces against adjacent ground, it must be recognized that movement of the ground might occur whilst the system is being pressurised. Precautions must be taken to prevent leakage or displacement of fittings by adjusting the restraining arrangement if necessary.
- Anchorage must not be installed on to PE fittings unless the fittings have been installed for the purpose of anchorage only. Such fittings must not subsequently be used as part of the gas carrying system (i.e. they must not be used for any gas carrying purpose purging, bypass connections, etc. see Figure 25, 26 and 27).
- Vertically driven anchors i.e. spikes, are not permitted.
- All concrete anchor blocks must be completely backfilled before the main is pressurised.
- When anchorage is required for compression joints on steel systems, this should be by the use of tie bars or anchor blocks.
- It is important to ensure that a proper assessment of the ground condition is carried out as this affects the ability of an anchor block, or temporary anchorage system, to provide the necessary anchorage. The design guidance given in this procedure assumes that a proper assessment is carried out. If there is any doubt as to the validity of the assessment carried out, expert advice should be sought.
- Where external anchorage system is required on end caps fitted to MP and IP systems, the preference is to provide anchorage by using a steel screw strut. (see Figure 11). Alternatively, for insertion operations use of transverse beam into the sides of the excavation or a combination of transverse beams and steel strut anchored from the front face of the excavation (limitations on these systems are shown in section 8).

7.3 Temporary Anchorage Systems

- Temporary anchorage systems must be provided to prevent pipework movement, or fittings being dislodged, during pressure testing, cut out operations or flow stopping where mechanically jointed systems are involved.

- When temporary anchorage is required during pressure testing, the anchorage must be designed so as to retain the main under full pressure test.
- Where an excavation contains mains under pressure, and a temporary anchorage has been constructed, the excavation should either be temporarily backfilled or securely fenced off to prevent unauthorized interference with the anchorage system.
- Temporary anchorage systems must be inspected on a regular basis by the Operative to ensure that the integrity of the anchorage is maintained.
- The Operational Manager should determine the frequency of inspection following a suitable and sufficient risk assessment that should include factors such as gas / air pressure, pipe diameter, ground conditions, location of the works, traffic and other types of vibration (piling), inclement weather conditions, etc.
- An inspection should verify that adequate anchorage is provided and should take into account the potential for ground movement.
- The inspection must be recorded see appendix E.
- The thrust force to be anchored must be minimized by reducing the working pressure where possible.
- On the LP system, the use of a steel screw strut is preferred, but suitable wooden strut(s) may be used. Where wooden strut(s) are used, care must be taken to ensure that they are of sufficient cross-sectional area refer to Table 10, and that they are installed such as to minimize any off centre loading.
- Where external anchorage is required on end caps fitted to IP and MP systems, it should be provided using a steel strut/prop in accordance with Section 12.2. Where there is insufficient space to use a steel strut/prop, a timber beam can used in accordance with Section 8.4.
- Where two end caps are located opposite one another, the preference is to provide restraint by using a steel strut between end caps (see Figure 12). Alternatively, for insertion operations use of transverse beam into the sides of the excavation or a combination of transverse beams and steel strut anchored from the front face of the excavation (limitations on these systems are shown in Section 8.

7.4 Requirements for Anchorage of end caps

7.4.1 Installing iron caps without external anchorage

Iron End caps may be installed without external anchorage only if the:-

- end cap is to be fitted on a system operating at a pressure no greater than 75mbar, and
- the diameter is 12” /300 mm or less, and
- the end cap has been approved by SGN for use without anchorage, and
- the end cap is to be fitted in a below ground situation, and
- there are no other exposed joints in the same excavation on the pipe to which the end cap is to be fitted, and
- the mechanical end cap fitting, sealing gland, backing ring and bolts have not been damaged, and
- the pipe end is prepared and cleaned to accept the end cap, and
- the end cap is torqued to the maximum torque setting of 30 Nm as stipulated by the manufacturer.

7.4.2 Ductile Iron Self Anchored Joints.

Ductile iron mains may be encountered which when originally installed had mechanical self-locking end caps, for example Stanlock jointing. The use of a self-locking end cap alone is unacceptable and all end caps other than those meeting the requirements stated in 7.4.1. must be provided with an external anchorage system.

8. ANCHORAGE SYSTEMS – TEMPORARY ANCHORAGE

8.1 Requirements for Transverse Beam anchorage

In most circumstances, an end cap can be anchored by transverse timber or steel beams, to provide a central working space within an excavation. Transverse beams may be installed in front of the cap, within lateral cut-outs excavated into each side of the trench - see Figures 5, 6 and 7. For all transverse beam anchorage:

a) The thrust force that can safely be anchored is determined by the lateral cut-out face area and how it is shored.
b) A lateral cut-out must be excavated into each side of the trench, with the downstream face area of each cut-out, close shored over the required minimum width and minimum depth, depending on the thrust to be anchored - see Section 11.2 and Figure 3.
c) Any spaces behind the shoring must be completely filled with compacted granular material, compacted lean concrete or structural concrete.
d) One or more transverse beams inserted between the cut-outs must enter each cut-out by at least the required minimum width.
e) Where necessary, additional stability can be provided to the transverse beams by temporarily backfilling the lateral cut-outs and any trench not required for the planned operations. Backfilling must not be carried out whilst the end cap is pressurised, and the anchorage system must be checked for damage.
f) At higher thrust forces, the trench sides, downstream of the transverse beams, must be close shored to prevent collapse of ground around the cut-outs. Each trench side must be shored over the required minimum area (width and depth) - see Section 8.3 and Figure 4.
g) If the thrust force is too great to be anchored by transverse beams alone, excess thrust must be restrained via two or more longitudinal struts/props bearing against the end face of the trench and the transverse beams. At the end of the trench, an area at each side of the trench must be close shored over the required minimum area (width and depth) - see Section 8.4 and Figure 5.
h) Where 2 or more beams are required they must be placed alongside (not on top of) each other to increase the transverse stiffness or strength.
i) For guidance on transverse beam selection, including timber beams, see Section 12.1.
j) Where only limited trench access is needed, and a central working space is not required, end caps can be restrained by struts/props reacting against the shored end of the trench, as shown in Figure 11, or by double strut/prop arrangements reacting against the other end of the cut-off main, as shown in Figure 12. Requirements for the use of single and double strut/prop arrangements are provided in Section 12.5.
k) In all cases requirements of Section 7.1 of this procedure must be followed for the selection, approval and checking of appropriate designs. This includes the sizing of cut-outs, side and end shoring, and selection of the steel struts/props.

8.2 System Type 1 - Transverse Beam and Thrust Anchorage up to 10 kN

Where the resulting thrust (T), calculated in accordance with Section 4, does not exceed 10 kN, the thrust may be restrained via transverse beams reacting against lateral cut-outs in the trench sides. There is no requirement to assess the ground adjacent to the cut-outs as worst case ground conditions have been assumed. The width and depth of cut-out sections in each trench side are defined as follows:

Cut-out Width W: Is the minimum horizontal distance to excavate into each side of the trench.

Cut-out Depth D: Is the minimum vertical depth of the cut-out = nominal pipe dia or D whichever is greater.

Use Table 5 to identify the dimensions for the width (W) mm and depth (D) mm, these dimensions increase as the Thrust to be restrained (T) increases. The minimum shored area of A m² represents the total ground area restraining the thrust (T) up to 10 kN. The downstream vertical face of each cut-out must be close shored, as shown in Figure 3.

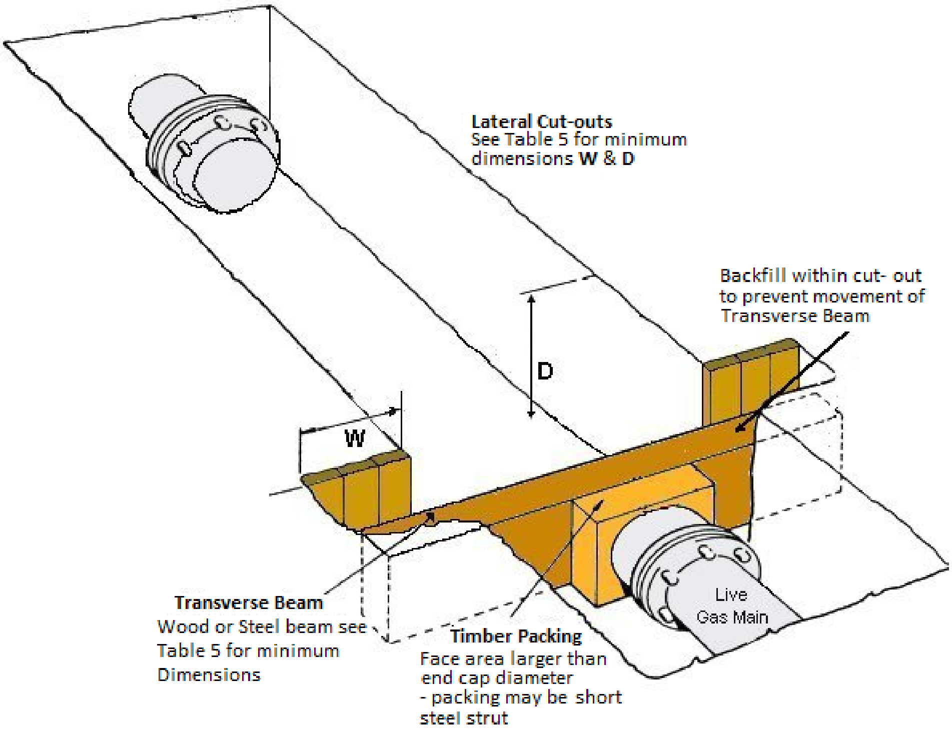


Figure 3 - System 1 for Thrust Anchorage up to 10kN Allowing Access to Trench

Resulting Thrust T (maximum) kN	Dimensions of Trench Cut-Out - Per Side		Cut-Out Area A Restraining Beams (both cut-outs) m²
	Width W (minimum) mm	Depth D = Nominal Pipe Dia (minimum) mm	
2	200	300	0.12
4	300	400	0.24
6	400	400	0.32
8	450	450	0.40
10	500	500	0.50
Anchorage of Thrust forces from beams/cut-outs, without ground assessment = 10 kN Max			

Table 5 - Minimum Cut-out Dimensions for System 1 - Anchorage up to 10 kN

One or more transverse timber or steel beams, selected in accordance with Section 12.1, must be inserted into each cut-out to a distance of at least the required Width W, as shown in Figure 3. If this anchorage is to become permanent then Steel beams must be used.

8.3 System Type 2 - Transverse Beam for Thrust Anchorage up to 30 kN

Where the resulting thrust (T) calculated in accordance with Section 4, does not exceed 30 kN, the thrust may be anchored via transverse beams reacting against lateral cut-outs in the trench sides with the addition of trench side shoring (see Figure 4).

There is no requirement to assess the ground adjacent to the cut-outs as worst case ground conditions have been assumed.

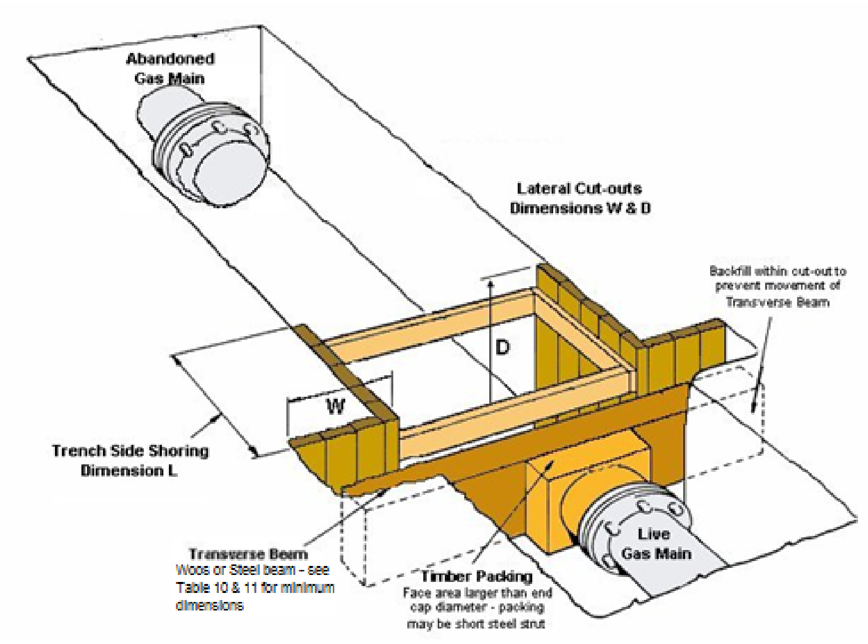


Figure 4: System 2: Anchorage up to 30 kN - Allowing Trench Access

The trench side shoring width: minimum horizontal distance to shore, forward of cut-outs = 800 mm each side. The trench side shoring depth: minimum vertical depth of shoring at each side of trench, forward of cut-outs = Cut-out Depth as above i.e. nominal pipe dia or D whichever is greater.

Use Table 6 to identify the dimensions for the width (W) mm and depth (D) mm, as in system type 1, these dimensions increase as the thrust to be restrained (T) increases. The minimum shored area A m² represents the total ground area restraining the thrust (T) up to 30 kN.

The downstream vertical face of each cut-out and the area downstream of the cut outs and transverse beams each side of the trench must be close shored over the minimum shoring width and shoring depth as shown in Figure 4.

Resulting Thrust T (Maximum) KN	Dimensions of Trench Cut-Out - Per Side		Cut-Out Area A Restraining Beams (Both Cut-outs) m²	Trench Side Shoring Dimension L mm
	Width W (Minimum) mm	Depth D = Nominal Pipe Dia (Minimum) mm		
12	550	550	0.60	800
14	600	600	0.72	800
16	625	650	0.81	800
18	650	700	0.91	800
20	700	725	1.01	800
22	750	750	1.12	800
24	775	800	1.24	800
26	800	825	1.32	800
28	825	850	1.40	800
30	850	900	1.53	800
Anchorage of Thrust Forces from Beams/Cut-outs, Without Ground Assessment = 30 kN Max				

Table 6 - Minimum Cut-out Dimensions for System 2 - Anchorage up to 30 kN

One or more transverse timber or steel beams, selected in accordance with Section 12.1, must be inserted into each cut-out to a distance of at least the required Width W, as shown in Figure 4.

8.4 System Type 3 - Transverse Beam for Thrust Anchorage up to 60 kN

Where the resulting thrust (T), calculated in accordance with Section 4, does not exceed 60 kN, this may be anchored by a combination of two systems as follows:-

a) Up to 30 kN Thrust Force may be anchored, by transverse beams, cut-outs and trench shoring; the requirements are, in all respects, unchanged from System 2 and Table 6. Only the required trench shoring width differs, increased to 1000 mm (from 800 mm in System 2).

b) A further 30 kN Thrust Force may be anchored by two steel struts/props reacting against the trench end, as shown in Figure 5.

Where thrust is anchored by two separate systems, both means of anchorage should share the force to be anchored approximately equally (50%) in order to ensure overall stability. There is no requirement to assess the ground as worst case ground conditions have been assumed.

8.4.1 Anchorage of 50% Thrust Force using Transverse beams and cut outs sections.

Shoring Width: minimum horizontal distance to shore, forward of cut-outs for system type 3 is increased to 1000 mm each side (from 800mm in system type 2).

Shoring Depth: minimum vertical depth of shoring at each side of trench, forward of cut-outs = Cut-out Depth as above i.e. nominal pipe dia or D whichever is greater.

As in System 2, use Table 6 (note Table 7 is not used for this purpose) with 50% of the thrust to be restrained (T) up to 30kN, to identify the dimensions for the width (W) mm and depth (D) mm of each cut-out. The minimum shored area of A m^2 represents the total ground area anchoring the thrust (T). The downstream vertical face of each cut-out and the area downstream of the cut outs and transverse beams each side of the trench must be close shored over the minimum shoring width and shoring depth as shown in Figure 5.

One or more transverse timber or steel beams, selected in accordance with Section 12.1, must be inserted into each cut-out to a distance of at least the required Width W, as shown in Figure 5.

8.4.2 Anchorage of 50% Thrust Force by Two Steel Strut/Props

The remaining 50% of the Total Thrust T of up to 60kN, is referenced as T2 (up to 30kN) which must be anchored by two steel struts/props, each reacting against a shored area on either side of the main at the trench end. The width and depth of shored areas are shown in Table 7 and calculated based on the thrust T2 (50% of T).

The width and depth of end shoring required at each side of the main are defined as follows:

End-shore Width W2 - minimum horizontal width to shore at each side of main

End-shore Depth D2 - minimum vertical depth of shoring is the nominal pipe dia or D in table 7, whichever is greater.

From Table 7, the thrust T2 is to be anchored by steel struts/props, the downstream vertical face of the trench end must be close shored over the minimum width W2 mm and minimum depth D mm at each side of the main, providing a minimum shored area of A2 m^2, representing the total ground area anchored the two steel struts/props.

Two steel struts/props selected in accordance with Section 12.2 and 12.3, must be inserted between the transverse beams and the shored areas at the end of the main as shown in Figure 5.

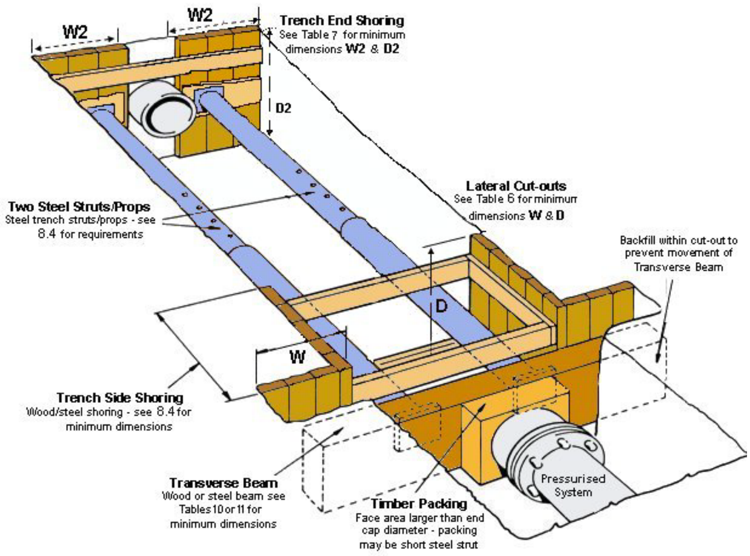


Figure 5 - System 3 - Anchorage up to 60 kN - Allowing Trench Access

Resulting Thrust T2 Restrained by Struts (maximum)	Dimensions of Trench End Shoring - Per Side		End-Shore Area A2 Restraining Struts (both sides at trench end)	Trench Side Shoring Dimension L
	Width W2 (minimum)	Depth D2 = Nominal Pipe Dia (minimum)		
KN	mm	mm	m²	mm
12 (2 struts at 6)	550	550	0.60	1000
14 (2 struts at 7)	600	600	0.72	1000
16 (2 struts at 8)	625	650	0.81	1000
18 (2 struts at 9)	650	700	0.91	1000
20 (2 struts at 10)	700	725	1.01	1000
22 (2 struts at 11)	750	750	1.12	1000
24 (2 struts at 12)	775	800	1.24	1000
26 (2 struts at 13)	800	825	1.32	1000
28 (2 struts at 14)	825	850	1.40	1000
30 (2 struts at 15)	850	900	1.53	1000
Anchorage of Thrust Forces from beams/cut-outs + struts/props, without ground assessment = 60 kN Max **i) Thrust contribution from transverse beam(s) and cut-outs, as per System 2) = 30 kN Max** **ii) Thrust contribution from twin steel struts/props, as tabulated above = 30 kN Max**				

Table 7 - Minimum End-shore dimensions for System 3 – Anchorage up to 60kN.

8.5 System Type 4 – Transverse Beam – Anchoring Thrust Greater than 60kN

Where the resulting thrust exceeds 60 kN, the end cap should, wherever possible, be anchored in a trench separate to that used for other works.

Systems 1, 2 and 3 each provide requirements for anchorage a specific level of thrust, without any ground assessment at the site, they assume that the trench is located in weak ground i.e. Soil Type 7, soft clay or made ground or reused excavated spoil. When anchoring a thrust in excess of 60 KN within a trench separate to that used for other works is not possible or practical, then Systems 1, 2 and 3 may be able to be utilised. This will require a ground assessment in order to determine the maximum thrust that the particular soil type is capable of restraining, or the maximum permitted thrust of the System type, whichever is least.

The soil type should be identified by following the guidance in Appendix D, the maximum resulting thrust that System 1, 2 or 3 is capable of restraining can be determined as follows:

8.5.1 System 1: For any row in Table 5, two cut-outs of width W and depth D provide a minimum area of A m^2 to restrain the resultant thrust T. e.g. the row for 10kN, 500mm(W) X 500mm(D) X 2 = 0.50m^2. By using Table 4 the column with the identified soil type will contain a row with a face area that is equal to, or close to but not more than, the minimum area A m^2 obtained from Table 5 (e.g. above example 0.5m^2). A corresponding Thrust value can now read off in the Thrust Force column. This value now represents the new maximum resultant thrust T that transverse beams for System 1 are capable of restraining in the soil type identified, e.g. Soil type 4 - 0.47m^2 is suitable for 25kN and Soil Type 3 – 0.5m^2 is suitable for 40kN. However, for the purposes of safety, the maximum thrust permitted to be restrained by System 1 is limited to 40 kN.

8.5.2 System 2: As for System 1 above, for any Table 6 row, the relevant row in Table 4 equal to, or closest to but not more than, the minimum area A m^2 from Table 6, now indicates the thrust force F representing the new maximum resultant thrust T that transverse beams to System 2) are capable of restraining in the relevant soil type. However, for the purposes of safety, the maximum thrust permitted to be restrained by System 2 is limited to 80 kN.

8.5.3 System 3: As for System 2 above, for any Table 6 row, the relevant row in Table 4 is determined in the same manner to identify the thrust force F representing the new maximum thrust T that transverse beams for the 50% of value of System 3 transverse beams are capable of restraining in the relevant soil type.

For the second 50% value, for any Table 7 row, the relevant row in Table 4 equal to, or closest to but not more than, the minimum area A2 m^2 in Table 7 now indicates the thrust force F representing the new maximum thrust T2 that struts/props to System 3 are capable of restraining, in the relevant soil type.

The sum of T + T2 now represents the maximum resultant thrust that System 3 is capable of restraining in the relevant soil type. However, for the purposes of safety, the maximum thrust permitted to be restrained by System 3 is limited to 160 kN. A worked example for System 4 is shown in Appendix C7. Expert advice can be obtained via SGN’s Design Team or through Technical Service contract.

9. ANCHORAGE - SAFETY REQUIREMENTS DURING OPERATIONS

9.1 Permitry

Reference must be made to GDN/PM/SCO1, 2, 4 and 5, The Safe Control of Operations suite of procedures in order to determine if a Permit to work, Routine or non-routine Operation is required for the activity. A site specific risk assessment should be completed to determine if additional controls are required and if so these are to be included within a routine operation for non-complex low pressure operations and for low pressure complex and where test pressures exceeding 350 mbar these are to be included within a Non routine Operation.

9.2 Testing of Mains and Services

Flexible fittings / joints [compression end caps] must not be used on sections of pipe systems under pressure testing. However where blanked open valves or flanged joints form the end cap of a test section then anchorage of these fittings must be provided.

The Testing requirements for pipe systems are stated in SGN/PM/MSL/1 – Part 1 Management Procedures for Main Laying and Servicelaying and these must be followed. The purpose of testing is to confirm the integrity of the pipe system. Whilst preparing, during and de-pressurising the test pressure it must be assumed that the pipe work, including PE pipe systems could fail suddenly.

9.3 Site Requirements

The following precautions must be taken to protect the general public and all those present on site.

- Operatives and managers must be competent and conversant with procedures.
- Managers must ensure that Personnel are fully aware of the hazards associated with the energy stored within a pressurised pipe and pipes under test with both water and air.
- Personnel must not enter any excavation whilst a pipework remains under test pressure or is being pressurised / de-pressurised.
- Personnel must not attempt to adjust anchorage whilst pipework is pressurised or is being pressurised / de-pressurised.
- Personnel must not attempt to adjust pressurised pipework or fittings which are suspected of movement.
- Designs for anchorage MUST take into account the correct pressure, for example if testing then the full test pressure and not the operating pressure must have been used.
- All anchor blocks must be completely backfilled before any pressure testing commences.
- As much pipe as possible of open cut sections of pressurised pipework should be backfilled.
- Where an excavation contains mains under pressure, and a temporary anchorage system has been constructed, the excavation should be temporarily backfilled to prevent unauthorised interference.
- Pipe ends should be below ground during pressure tests to minimise the risk of injury in the event of a pipe end failure. If this is not practicable, a site specific risk assessment must be undertaken and recorded, and adequate controls must be applied to prevent injury to site personnel and the public.
- Where above ground pipe work is to be pressure tested, the on-site risk assessment must state protection measures that need to put in place, for example the use of Heras type fencing, as a minimum and restraining the pipe ends – (not an exhaustive list and site specific factors need to be taken into account).
- If timber beams are used for anchorage it must either be structural grade or wooden railway sleepers and NOT locally available soft or hardwood.

- On PE systems, end caps used on temporary installations or for testing must be fusion fittings or blank flange adapter [fused] fittings.
- Vertical wooden stakes / spikes driven into the ground are not capable of restraining the thrust forces and MUST NOT be used to anchor end caps. Suitable anchorage MUST be used as described in this procedure.
- Exposed pipe ends, and fittings should be marked either using engineering chalk or paint in a contrasting colour. This will enable a movement of a cap end or fittings to be identified more easily.
- Work areas must be correctly barriered to protect the public and workers onsite and where required by our procedures and the onsite risk assessment.
- "Mains under test" signs must be displayed.
- The full number of appropriate studs or bolts provided for pipe flanges and under pressure-drilling equipment must always be used. Any studs or bolts with worn or damaged threads must be replaced.
- Mains/pipes must not be subjected to any form of shock loading or work of any description whilst a pressure test is ongoing.
- Where temporary anchorage is to be dismantled following a pressure test or mains operation, care must be taken to ensure the system is fully depressurised before dismantling commences.

9.4 Inspections

The anchorage and trench support systems should be visually examined at frequent intervals to confirm that all anchorages, thrust and other restraints are secure and that no hazard exists. As a minimum, inspections should be made at the start and end of operations each day and additionally when any activity has been carried out which may affect the anchorage system. In some cases it may be appropriate to maintain a presence on site at all times in order to minimise the impact of failure of these systems. A site-specific risk assessment should determine whether or not this is necessary, depending on factors such as location, pressure and diameter - see Appendix E.

9.5 Pipe or anchorage movement during pressure testing

Where it is observed that pipework, fittings or anchorage has moved, then the test procedure must be abandoned and the main safely de-pressurised before any action is taken to refit and retighten the fittings or anchorage. **No person can be allowed to enter the excavation until the main has been safely de-pressurised.**

9.6 Trench Support system or trench movement.

If it is observed that the trench or the trench support system is collapsing or has collapsed and that it will potentially affect any of the following:-

- the main
- the anchorage system
- services in the trench
- cause a hazard above ground.

Then the test must be abandoned and the main safely de-pressurised before any action is taken to refit the trench support system. No person can be allowed to enter the excavation until the main has been safely de-pressurised. Where it is identified that the movement will not cause a hazard and that the area surrounding the excavation is secure then the test can remain in place. Consideration must be given to additional inspections to ensure that further deterioration can be identified.

10.ANCHORAGE REQUIREMENTS DURING CONSTRUCTION

At the planning stage of a scheme anchorage must be designed to be eliminated or reduced to a minimum. Similarly during the construction phase where it was not possible to identify anchorage requirements the use of anchorage systems must be minimised whenever possible. Consideration should be given to:-

- Avoidance or minimising the number of bends and tees required
- Selection of materials
- When using PE, ensure that end loaded fittings are used.
- Minimise the number of locations where PE to steel jointing is utilised.
- Routing to avoid areas where soils are poor and unable to support anchorage.

10.1 Requirements

- If timber beams are to be used for anchorage, the beams must either be structural grade or wooden railway sleepers, and all must be in sound condition. Locally sourced soft or hardwood should not be used.
- Vertically driven anchors i.e. spikes must not be used.
- Authorising Engineers must ensure that where NRO's require anchorage, that relevant design details and construction methods are identified in section 3a of the NRO and that a Permit to work are issued as appropriate.

11. ANCHORAGE REQUIREMENTS DURING CUT OUT / FLOW STOPPING OPERATIONS

11.1 General

It is necessary to restrain mains working at medium pressure when the presence of fittings is identified or suspected as it cannot be assured that these are end loaded fittings. Where anchorage is considered necessary, the pipe work should be anchored by means of concrete blocks or a load bearing frame clamped to the main (see Figure 6).

The Competent Person under a Routine or Non-Routine Operation must ensure that all relevant personnel are aware of the hazards of a joint or fitting failure due to inadequate anchorage.

Good planning and preparation must provide adequate time to prepare anchorage systems including concrete anchor blocks.

When a main is stopped off by stopples, Iris stop, bag stop, squeeze-off or valve operation, a longitudinal thrust force is imposed on the stopper and mains system. Pipe joints and fittings near to the stopper will also be subjected to this longitudinal thrust force, which may require to be restrained. If using a stopple advice maybe required as flow stopping performance can improve with increased gas pressure. The benefit of maintaining a higher pressure for the operations must be balanced against the need for pipe anchorage and in these circumstances a three hole system must be used.

When connections are to be made to medium pressure systems, the pressure in the system should be reduced to the lowest possible to minimise the risk. This will reduce the resultant thrust force, and hence anchorage requirements.

No external anchorage is normally required when stopping off and cutting out mains which are part of a low pressure system. However, if it is felt that joint slippage could occur due to weak ground or steep incline conditions, anchorage must be taken into account.

Mains systems that are all welded steel or fused PE need not normally be restrained during stopping off or cut-out operations. Anchorage must be provided on these mains systems whilst at medium pressure when non-end load fittings are incorporated. Mains which may have had circlips must be treated as if no circlip is present and anchorage installed.

11.2 Steel Load Bearing Frame

Where a steel restraining frame is used, care must be taken to ensure that the main is properly supported against the weight of the frame and flow stopping equipment. Any protective coating should be removed to ensure the clamp gains a frictional resistance to the pipe wall. A clamp will need to be installed either side of the cut-out section.

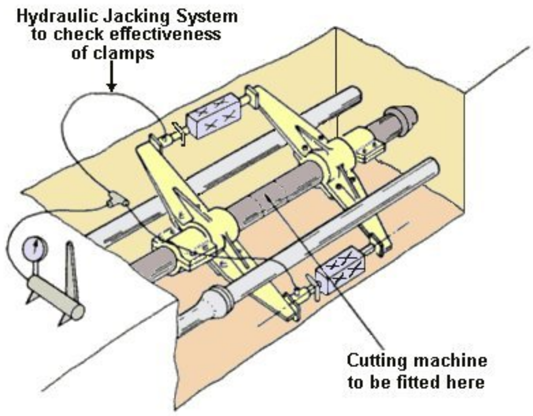


Figure 6 – Design of steel load-bearing frame

NOTE: For clarity pipe supports are not shown.

11.3 Three Trench System

Whenever possible a three-trench system of working must be used during cut out operations see Figure 7 and 8. The advantages of using a three-trench system of working are:

- The friction resistance of the soil between the trenches provides additional axial restraint.
- Vertical support is provided to the main, whilst work is being carried out.
- The effects of any accident are limited by isolating the three work sites from each other whilst allowing access to the stopping off equipment.

When a three trench system is used the pipes in each trench must be confirmed as being the correct pipes to be worked upon, e.g. place pressure gauge on each to confirm that the pipework configuration has not changed between each excavation.

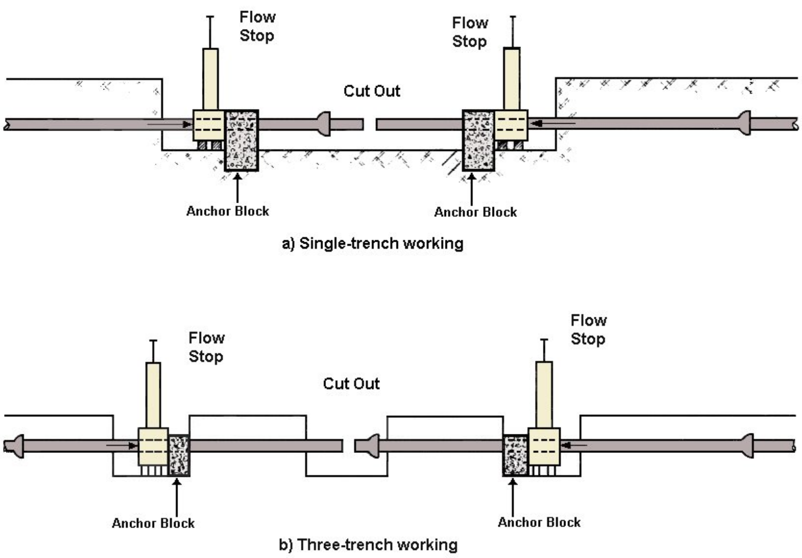


Figure 7 - Single and Three Trench Working

Whether a single or three-trench system of operation is used, there are alternative methods of restraining the pipe work, for example: -

- Undisturbed soil
- Concrete anchor blocks may be constructed to support and restrain the flow stopping equipment and pipe work, see Figure 7 and 8.
- A suitably designed temporary anchorage using timber beams, as shown in Figures 3 and 4, or timber beams with steel struts/props, as shown in Figure 5. Depending on the thrust to be restrained, additional timber shoring or steel trench plates may be installed (see Figure 12).
- Suitably designed temporary anchorage using wooden railway sleepers, steel trench plates and steel screw struts may be used (see Figures 3, 4 and 5).

When preparing for 'cut out' operations, due regard must be taken of the likely position of pipe joints adjacent to the cut out to minimise the potential for failure or leakage.

When stop off equipment (Iris, Stopple etc) is used, care should be taken to ensure that the main is properly supported and, if necessary, concrete base supports should be installed. Restraint applied to pipe during the use of Iris Stop equipment must not be placed on to the equipment itself.

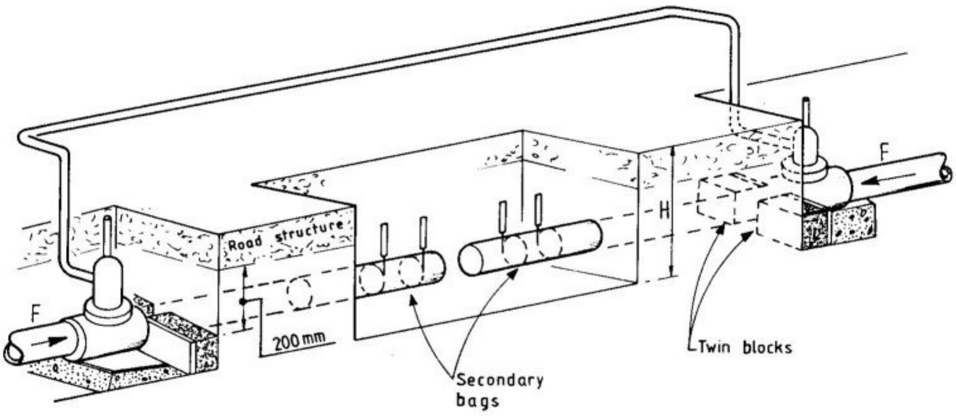


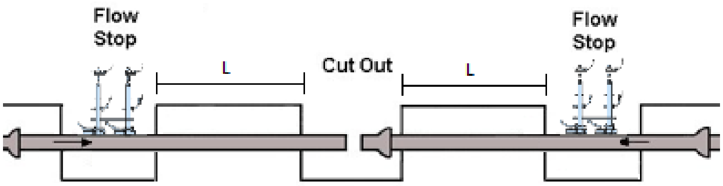
Figure 8 – Three Trench System with Secondary Bags

11.4 Concrete Blocks to Support and Restrain

Concrete thrust blocks may be constructed to support and restrain flow stopping equipment and pipework see Figure 9. Where concrete anchor blocks are constructed to provide temporary anchorage, their size and design should be based on the guidelines given for permanent anchor blocks. When concrete blocks are used to provide permanent support and anchorage, care should be taken to ensure that they do not form long term hard spots in the pipe bed.

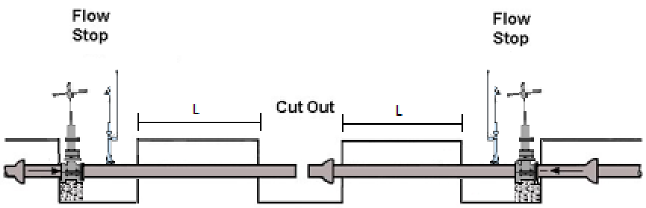
11.5 Unsupported Ground

Table 8 gives guidance where restraint is to be provided during iris stop operations using the resistance to movement of undisturbed buried pipe. If this technique is used during cut-out operations, anchor blocks will not be required. Support to the main must, however be maintained. For other operations up to 2 bar see Table 9 for the minimum undisturbed ground between excavations to be allowed.



Pipe Diameter	Maximum pressure during iris stop (P1)	Minimum length (L) of undisturbed buried pipe to provide restraint during iris stop and other Flow Stop operations
In/mm	bar	m
4 /100	1.0	1.7
6 / 150mm	1.0	2.8
8 /200	1.0	3.6
10 / 250	1.0	4.4
12 / 300	0.850	4.4
15 / 375	0.600	3.7
18 / 450	0.350	2.4
24 /600	0.350	2.9
30 /750	0.100	1.0
36 /900	0.070	0.8
42 / 1050	0.035	0.4
48 / 1200	0.035	0.3
NOTES: 1 A minimum depth of cover of 600mm has been assumed		

Table 8 – Minimum Undisturbed Ground on Iris Stop and other Flow Stop Operations



Mains dia In / mm	Minimum length (L) of undisturbed buried pipe to provide restraint during cut out operations
4”/100mm	1.7m
6”/150mm	2.8m
8”/200mm	3.6m
10”/250mm	4.4m
12”/300mm	5.1m
15”/375mm	6.3m
18”/450mm	7.0m
24”/600mm	8.4m
30”/750mm	7.8m
36”/900mm	10.9m
42”/1050mm	11.6m
48”/1200mm	14.3m

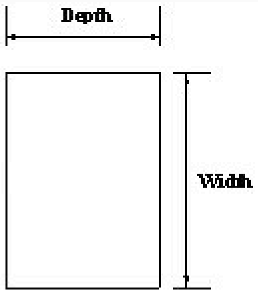
Table 9 – Minimum Undisturbed Ground on Cut-out Operations Up to 2 bar.

12.SELECTION OF TEMPORARY ANCHORAGE MATERIALS

12.1 Sizing of Transverse Beams

12.1.1 Timber Beams

Structural timber beams with a minimum strength of 40kN/m^2 and complying with BS EN 338 can be used for temporary anchorage (see Table 10). Suitable beams are available from most timber merchants. If there is any doubt that the beam does not meet the requirements of BS EN 338 then rectangular hollow sections should be used see Table 11.



Dimensions for Timber Beams		
BS EN 338 – Structural Timber Wide range of sizes available		
BS EN 13145 – Wood Sleepers & Bearers Typical UK railway sleeper dimensions		
Depth	125	mm
Width	250	mm
Length	2600	mm

Trench width mm	Maximum allowable thrust forces on beams		
	Single beam kN	Two beams kN	Three beams kN
500	11	45	100
750	9	36	80
1000	7	30	65
1250	6	25	50
1500	5	20	45

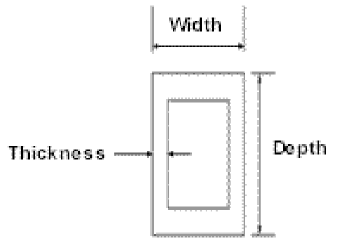
Table 10 – Maximum Allowable Loads on Timber Beams

Timber (Railway) sleepers with a minimum strength of 40kN/m^2 and complying with BS EN13145 may also be used for temporary anchorage. Old wooden railway sleepers are usually pressure treated with creosote or coal tar. Where beams have or are believed to have been treated with creosote or coal tar due to the health hazard in handling and cutting, they must not be used.

The maximum allowable thrust force for one or more transverse beams can be found in Table 10 by selecting the trench width on site and find the appropriate thrust force required to determine the number of beams required.

12.1.2 Rectangular Hollow Sections (RHS)

Rectangular hollow sections (RHS) with a yield strength of 235N/mm^2 and conforming to EN 10210-2 can be used for temporary anchorage. Steel beams strengths are classed from A to E and for a given a known trench width and thrust force Table 11 can be used to select the appropriate beam.



Transverse Steel (RHS) Beams to BS EN 10210-2							
				Dimensions for Beam types A to E			
				Class of Beam	Depth mm	Width mm	Thickness mm
				A	120	60	5
				B	150	100	5
				C	200	100	5
				D	250	150	6.3
				E	300	200	6.3
Trench Width mm	5kN	10kN	15kN	20kN	25kN	40kN	60kN
50	A	A	A	B	B	D	D
750	A	A	B	B	C	D	D
1000	A	B	B	C	C	D	D
1250	A	B	B	C	C	D	E
1500	A	B	C	C	D	D	E

Table 11 – RHS steel beams dimensions and Maximum allowable Thrust Force

12.2 Steel Struts and Props

Steel struts and props (see Figure 9 and 10) are adjustable telescopic steel beams used in the construction industry. They can be used for temporary work by being placed longitudinally within a trench to react thrust often with a transverse beam and or the trench end.

Struts are often referred to as trench struts which are essentially smaller or shorter props. BS EN 1065:1998:2000 covers trench struts which are sized 0 to 3; they have turned up corners, termed claws.

12.2.1 Props are often referred to as Acrow props or acrows, are essentially long struts with flat end plates i.e. no claws as is struts. BS EN 1065:1999 now covers adjustable telescopic steel props which are classified in to strength classed A to E and a 2 digit numbers which refers to the maximum extended length e.g. C30 = Class 3 prop 3000mm when fully extended.

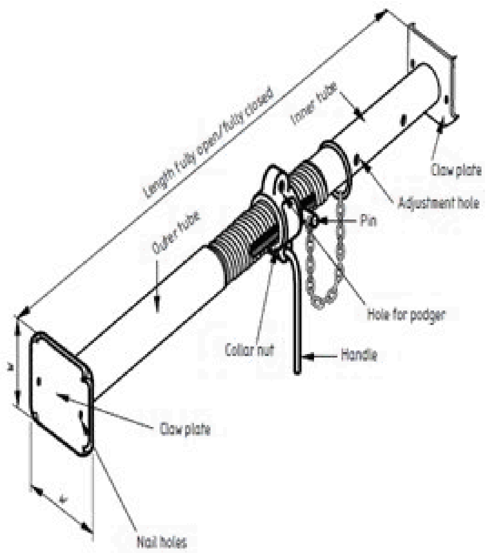


Figure 9 Adjustable Telescopic Steel Prop

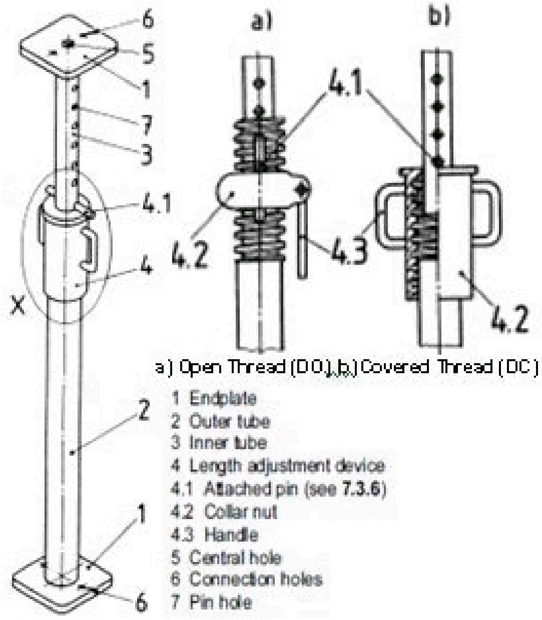


Figure 10 Steel trench strut

Note: An earlier standard BS EN 1065:1998:1982 classified struts and props in size numbers 0 to 4 and are still widely available and are suitable for anchorage.

12.3 Selecting Adjustable steel Struts and Props to BS EN 1065:1998

Adjustable telescopic steel struts and props* to BS EN 1065:1998 are all rated to 30kN however SGN has applied a safety factor of 1.5 to the use of these items reducing the BS rating of 30kN to 20kN for SGN.

*NOTE: Earlier standard BS EN 1065:1998:1982 applied to both Struts and props

By determining the approximate strut/prop length required to suit the transverse beam and trench end distance within the excavation Table 12 can be used to identify the correct strut/prop to be used. The strut or prop must be placed on timber or steel shoring as shown in Figure 11.

A single strut/prop must not be used to restrain a calculated thrust force exceeding 20kN and where thrust forces exceed 20kN it may be possible to install twin parallel struts/props each reacting via timber or steel shoring.

Trench Struts	Lengths (m)		Maximum Load Capacity (kN)*
	Closed (Min)	Open (Max)	
No. 0 Strut	0.32	0.47	20 kN
No. 1 Strut	0.49	0.73	
No. 2 Strut	0.69	1.09	
No. 3 Strut	1.03	1.73	

Steel Prop	Lengths		Maximum Load Capacity (kN)*
	Closed (Min)	Open (Max)	
No. 0 Strut	1040	1700	20
No. 1 Strut	1750	2250	20
No. 2 Strut	1980	2250	20
No. 3 Strut	2590	3960	If used below 20 kN consult Manufacturer literature.
No. 4 Strut	3200	4880	
No. 5 Strut	3650	6100	
If using above 20 kN consider using 2 props and consult manufacturers Literature			

Table 12: Sizes of Adjustable steel Struts and Props to BS EN 1065:1998.

For loads less then 20kN, it may be possible to increase the length of a single strut or prop, but the manufacturer's literature or expert must be consulted. Where the thrust force is up to 20kN, and where the required length is not appropriate for a single strut/prop, it may be possible to install a double strut/prop arrangement as shown in Figure 12.

12.4 Selecting Adjustable steel Props to BS EN 1065

Adjustable telescopic steel struts to BS EN 1065 are classified by maximum length and nominal characteristic strength, with a recommended safety factor of 1.5.

Determine the approximate prop length to suit the transverse beam and length of trench. The Nominal Characteristic Strength is the resulting thrust to be restrained.

Sizes of Struts, Props and Shores		
Class	**Length at maximum extension (metres)**	**Nominal Characteristic Strength (kN) –** (Includes SGN's Factor of safety of 1.5)
A 25	2.50	20.4
A 30	3.00	17.0
A 35	3.50	14.6
A 40	4.00	12.8
B 25	2.50	27.2
B 30	3.00	22.7
B 35	3.50	19.4
B 40	4.00	17.0
B 45	4.50	15.1
B 50	5.00	13.6
B 55	5.50	12.4
C 25	2.50	40.8
C 30	3.00	34.0
C 35	3.50	29.1
C 40	4.00	25.5
C 45	4.50	22.7
C 50	5.00	20.4
C 55	5.50	18.6
D 25 to D55	2.50 to 5.50	34.0
E 25 to E55	2.50 to 5.5	51.0

Table 13: Classification of Telescopic Steels Props – Taken from EN 1065:1998

Note: Table 13 includes the recommended safety factor of 1.5.

Any prop of the required length and strength shown in Table 13 may be used as a temporary thrust restraint, provided that the thrust is reacted via timber or steel shoring as shown in Figure 11.

For loads exceeding the nominal characteristic strength shown in Table 13, it may be possible to install twin parallel struts, each reacting via timber/steel shoring. Consult manufacturer's literature or obtain expert advice.

For loads less than the nominal characteristic strength shown in Table 13, it may be possible to increase the length of a single prop. Consult manufacturer's literature or obtain expert advice.

12.5 Installation of Steel Trench struts and Props

Adjustable steel struts/props must only be used at the instruction of the Operational Manager. The follow checks must be made before use:

- Ensure the inner and outer tubes are straight, telescope easily and are in good condition
- Ensure the pin, attached to the prop by a chain, is in good condition.
- Ensure struts/props are supported, from the trench bed or from the ground surface.
- Ensure struts/props end plates cannot move laterally.
- Ensure that end plate corners are bent over for maximum grip on timbers beams.
  or secure struts to timber with nails.

Where struts/props are used at the end of a trench, the end face of the trench must be vertical and shored with timber or steel plates over a minimum width of 500 mm. If shoring is timber, the cross section of vertical timbers should be similar to the transverse beam - see Table 10. The minimum shored area required must be based on the face areas determined from Table 4.

Care must be taken to ensure that any apparatus buried within the trench bed or behind vertical shoring is not damaged or put under excess force. The bed and/or end of the trench should be surveyed with the CAT and Genny prior to installing any lateral restraint.

Struts/props should be used to react forces in line with the direction of thrust only and should be central and perpendicular to timber/steel shoring to ensure the thrust force is spread evenly. If an offset arrangement is unavoidable, for example on a bends then obtain specialist engineering advice from your Senior Manager . If no Senior Manager can give appropriate guidance, obtain expert advice via SGN's Technical Service Contract.

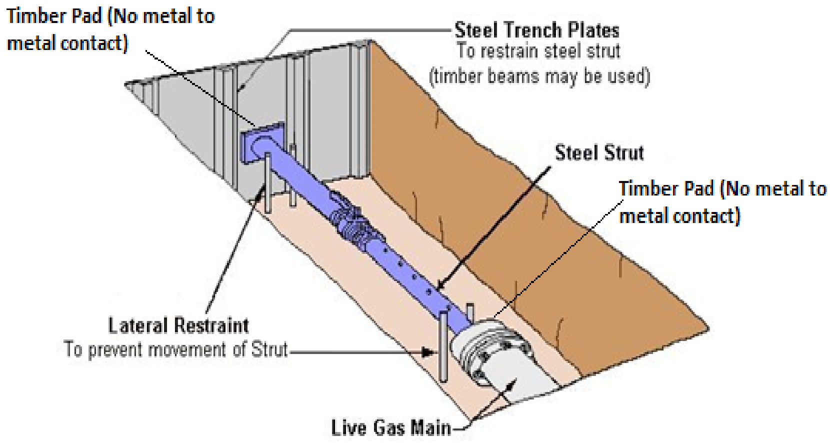


Figure 11 – Use of steel Strut Restraining Against Steel Trench Sheet

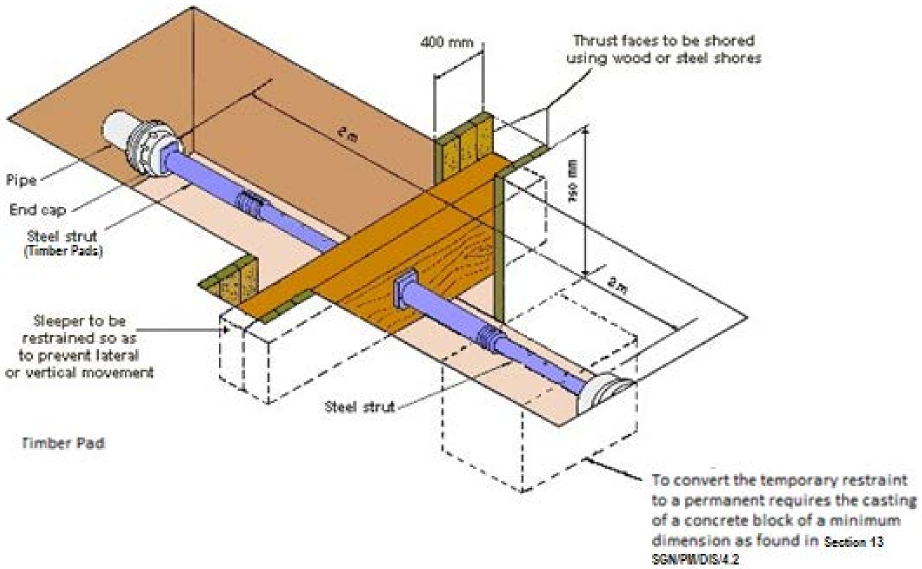


Figure 12 - Double Strut Arrangement Where Distance Between Anchorage and Thrust Force Point is Greater than One Strut

Note: Total face area of transfer beam support to be as defined in Table 4 lateral trenches may be shored where necessary.

13.PERMANENT ANCHORAGE SYSTEMS

Permanent anchorage is required wherever the thrust forces on bends, tees, and end caps etc., may be sufficient to cause movement and possible failure of the pipe system.
Concrete anchor blocks are not usually necessary when the thrust block face area, calculated in accordance with Sections 6 is equal to or less than 0.1 m^2.

13.1 General Requirements

All LP mechanically jointed mains greater than 450 mm diameter and mechanically jointed MP mains and IP mains must be restrained against pressure induced thrust. Permanent anchorage should be provided using concrete thrust blocks, external mechanical clips (see Figure 13) or a combination of these (see Figure 14).

Whilst mains are no longer constructed in these materials, they may be uncovered during excavation work on new systems (See Section 15). Where this is the case and existing anchorage does not meet these requirements, the Operational Manager must arrange an upgrade to the anchorage system. The same principles also apply to situations where non-end-loaded fittings are used on PE systems, for example bends, tees and end caps etc.

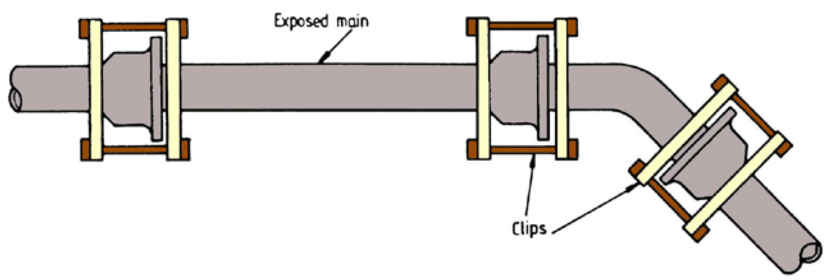


Figure 13 – Joint Restraint Clamps

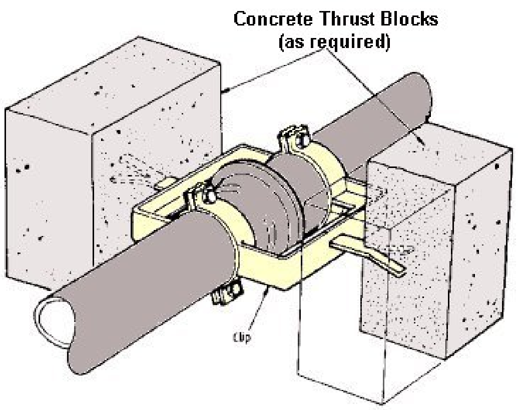


Figure 14 – Restraint Clamps with Concrete Blocks

There is no requirement to anchor straight runs of LP mains except where they are laid on a steep gradient (1 in 6 or steeper) or in ground which is liable to move. In these situations a concrete block must be constructed in accordance with Figure 15.

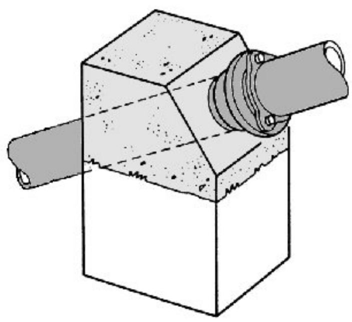


Figure 15 – Anchorage on Gradients (1 in 6 or steeper) or Exposed Mains

13.2 Positioning of Concrete Anchor Block

The positioning of the anchor block depends on the direction of thrust at bends, tees, ends, etc., due to gas pressure see Figure 1. Typical block locations are shown in Figure 16.

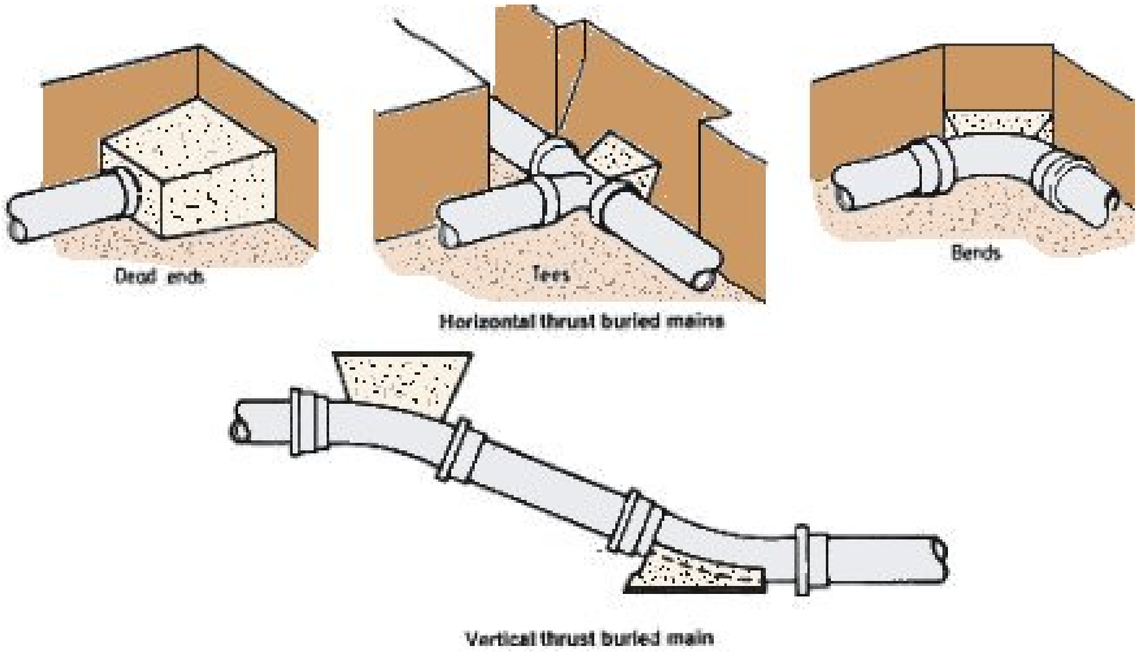


Figure 16 –Positioning of concrete blocks to restrain bends and other fittings

13.3 Permanent Anchorage of a Cap end

Where permanent anchorage of an end cap is deemed necessary, a concrete block, as shown in Figure 17, will need to be cast.

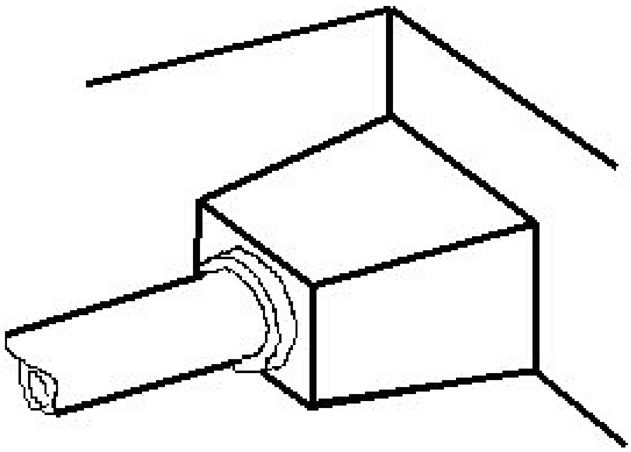


Figure 17 - Concrete block anchorage –End cap

13.4 Anchorage of Bends

Permanent anchorage at bends may be provided by concrete anchor blocks. Individual angled blocks may be located at the outside of the bend (see Figure 18 and 19) or located at the inside of the bend and providing anchorage by tension straps attached to the bend (see Figure 20). Where the thrust face is formed into the corner of a trench, the thrust face area determined from Section 4 and Table 4 must be applied.

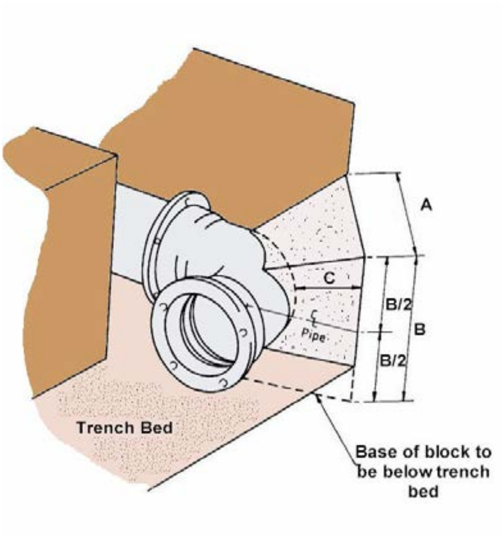


Figure 18 – Square Faced Block

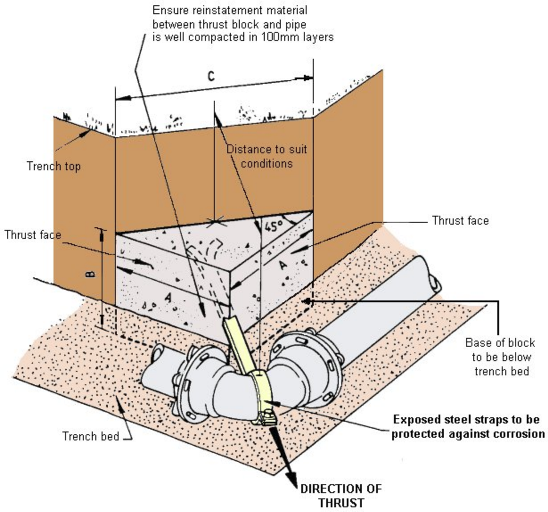


Figure 19 – Angle Faced Block

13.4.1 Block dimensions for restricted spaces

Where anchorage space is limited on the outer radius of the bend, a tension block may be used. The thrust face area determined from Section 4 and Table 4 must be applied as shown in Figure 20. The thrust faces should be considered to be operating against 'made up' ground.

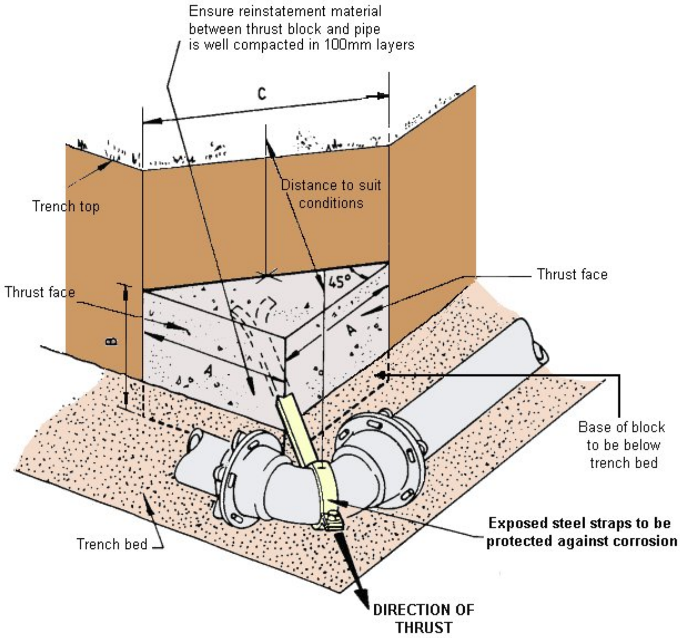


Figure 20 – Tension Anchor Block at Trench Corner

The steel tie bar must have a minimum cross-sectional area, expressed in mm^2, and calculated using the following formula:

Minimum area = Thrust force (from Table 1) x Shape factor (from Table 3) x 40.

The end of the bar in the anchor block should be split and spread for good keying into the anchor block and should be protected against corrosion in accordance with SGN/PM/ECP/2.

Tie bar minimum cross-sectional area = Thrust (from Table 1) x Shape Factor (from Table 3) x 20. See Appendix C for an example calculation.

The end of the tie bar, within the concrete anchor block should be split and spread for good keying into the block and should be protected against corrosion in accordance with SGN/PM/ECP/2. Where space in or around a trench is very limited or in very soft ground, two separate anchor blocks may be installed see Figure 21.

The blocks should be the same approximate size, and the combined thrust face area of both blocks should be in accordance with Section 9. Where double tension blocks are used; the minimum cross-sectional area of each tie bar should be calculated as above.

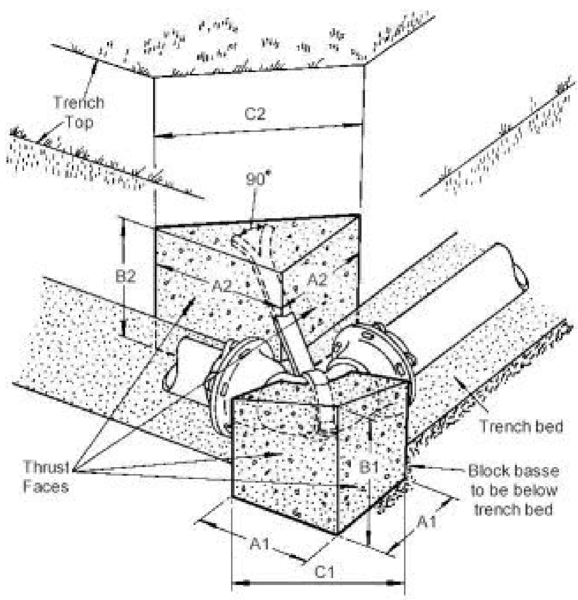


Figure 21 - Anchor Block Sizes for Typical Two-Block Arrangements

For clarity, PE sleeving is not shown. The required thrust force area is provided by the two projected thrust faces, i.e. Thrust face area = B1C1+ B2C2.

13.5 Anchor Block Design for Mains and Large diameter services

The design procedures within Sections 9 and 10 and Appendix D assume that all pipework is approximately horizontal and laid at 600 mm depth or greater; this allows permanent anchor blocks to be sized for LP, MP and IP pipe systems.

Additionally, undisturbed ground is better able to restrain any thrust force, therefore anchor blocks, whenever possible, should be constructed with the thrust face of the block reacting against undisturbed ground i.e. the excavated face of the trench. This may require some additional excavation beyond the normal trench confines. Where a thrust block is to be built within previously excavated ground, the soil type should be considered as being 'made ground'. Reinforced concrete anchors should be used where anchorage is required in soft or unstable ground conditions that have been purposely designed for the site conditions.

13.5.1 Anchor Block Dimensions

The width: depth ratio of a typical anchor block should be selected to suit the site conditions (see Figure 22):

i) The thrust faces of a block should be square but may be rectangular provided the block width W (horizontal dimension) is greater than the depth H (vertical dimension) a maximum ratio of 3:1 (W:H) and Width W to thickness T with the same maximum 3:1 ratio.

ii) The centre line of a block should coincide (approximately) with the centre line of the fitting or pipe that the block is restraining, in order to prevent rotation of the block.

iii) The thickness of a block must be at least 50% of the block height (vertical dimension), with an absolute minimum thickness of 300 mm. The block thickness may be reduced only if the block incorporates structural reinforcement via conventional steel rebars (reinforcement bars). For rectangular blocks the dimensions can be varied providing a maximum ratio of 3:1 is maintained for the thickness to height dimensions.

If the required thrust block dimensions i.e. width, depth or thickness, are found to be operationally unacceptable, suitable mechanical restraint may be provided by welding or joint circlips or external mechanical clamps. Alternatively, the use of reinforced anchor blocks incorporating steel reinforcement should be considered, - expert civil engineering advice should be sought.

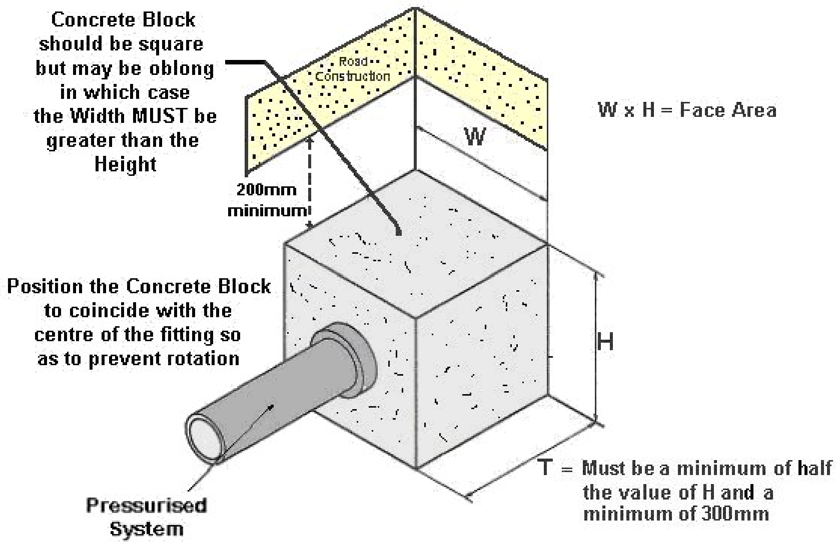


Figure 22 – Anchor Block Dimensions

13.5.2 Block Construction in Disturbed Ground

Free-standing anchor blocks in made-up ground must be cast into shuttering - see Figure 23.

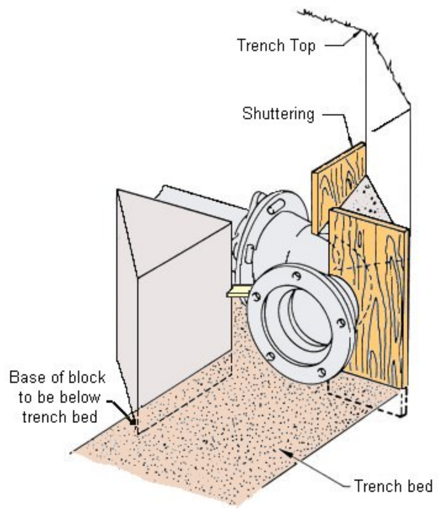


Figure 23 – Shuttering for Concrete in Contact with Pipework or Fitting

13.6 Forming the Anchor Block

The anchor block should be located according to the design conditions and observing the requirements of Section 10.

Excavations for anchor blocks should be square cut to the prescribed shape, taking care to minimize disturbance to adjacent ground. Anchor blocks constructed against a trench wall or end, or as freestanding structures remote from the side of any excavation, should be shuttered with plywood or sheet metal - see Figure 23. The shuttering should be appropriately shaped, to suit the profile of the pipe or fitting, and should be firmly located to withstand poured concrete.

It is important that the shuttering provides a rough surface on the thrust face to ensure that the anchor blocks and adjacent soil are keyed together, allowing full restraining strength to be developed. Anchor blocks and anchorages must not be attached to or built round other utilities existing apparatus.

The concrete of anchor blocks and anchorages must not encase the joint area and the pipework must be first protected against corrosion by either painting and wrapping or plastic sheeting. Sufficient clearance must be allowed for bolt removal whilst re-making such joints and for access during resealing. A clearance of not less than 200 mm from the top of the anchor block to the underside of any road foundation must be maintained in all cases.

Reinforced concrete anchors should be used where anchorage is required in soft or unstable ground conditions that have been purposely designed for the site conditions.

Care should be taken to ensure that anchor blocks are constructed on stable ground, able to support the mass of the block. Expert advice should be sought where any doubt exists.

13.7 Concrete for Anchor Blocks

Concrete used within SGN should normally be constructed in accordance with T/SP/CE/3, however in the specifications stated below may be applied in this instance. Where concrete anchor blocks are constructed, a cure time of at least two days should be allowed for adequate strength to develop in the concrete before backfilling and allowing thrust forces to be applied. Where rapid hardening cement has been used account must be taken of the manufacturers' advice.

The concrete must comply with the recommendations of the relevant Parts of BS 1992-1. Typically 1: 2: 4 mix of cement: sand: aggregate should be used to give a minimum crushing strength of 20 MN/m^2 after 28 days. The cement must be OPC (Ordinary Portland Cement) complying with BS EN 197-1, aggregate must comply with BS EN 12620:2002 + A1:2008.

The cement must be stored in dry conditions. Any cement that becomes contaminated or has deteriorated must not be used. During frosty weather the newly cast concrete anchor block should be protected with dry sacking or straw. In hot weather a newly cast concrete anchor block should be protected with wet sacking or straw.

13.7.1 Backfilling Around Concrete Blocks

It is essential that any backfilled ground against the thrust face of any anchor block must be replaced in 100 mm layers, each compacted by at least three passes of a mechanical rammer/ compactor or hand rammed (or otherwise compacted in accordance with the HAUC Specification of Reinstatement of Openings in Highways) before the next layer is placed. Where backfilling is to be carried out around anchor blocks, suitable reinstatement materials must be used.

13.8 Concrete a Temporary Anchorage to Permanent

Temporary anchorage using steel screw struts may be made permanent by casting the steel strut into a concrete block see Figure 24. The Operational Manager must provide the size and specification of the concrete block. All struts/props must be completely covered in concrete, including the struts/props footings, and the face area of the block should be determined in accordance with Table 4, with a minimum face area of 0.1m^2. On completion of the anchor block construction the integrity of the end cap(s) should be checked.

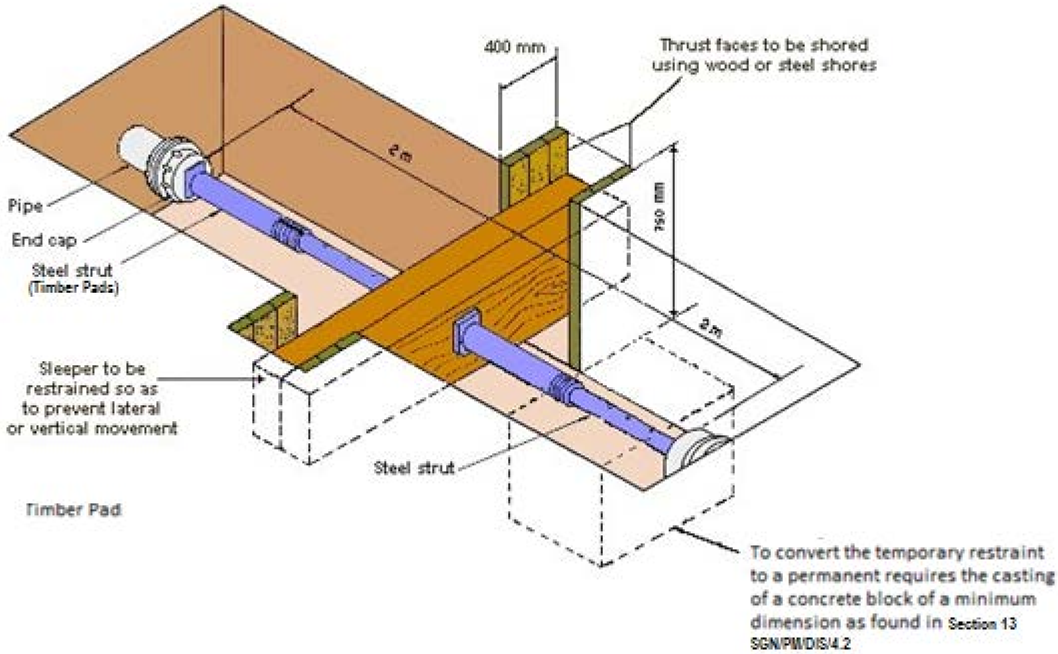


Figure 24 – Conversion of Steels Struts from Temporary Anchorage to Permanent by Casting Concrete Block.

14. PERMANENT ANCHORAGE OF PE PIPE AND INSERTION OPERATIONS

Joints used to connect fusion jointed PE systems to existing cast iron and steel systems need special consideration as the movement of the PE system could cause non-end load-bearing compression joints to be disturbed. All compression jointed pipework should be anchored. Where a PE inserted pipe connects to the existing metallic system, adequate anchorage must be used to protect the main from thrust force being applied to it.

The reaction of thrust forces against live PE pipe or fittings is not permitted. Fittings may be fused on to mains for the purpose of restraining thrust only; such fittings must not subsequently be used as part of the gas carrying system.

14.1 Connection and Reconnection of Fusion Jointed Systems

The tensile force in PE mains with changing ambient temperatures can be large and increases significantly with the diameter of main see section 4.1.3. For inserted PE main with no intermittent connections, the anchorage of non-end loaded fittings must be taken into account. Overnight temperature changes will be much greater for exposed pipe than buried or inserted. The engagement length of non-end loaded fittings must be sufficiently long and pipes must be fully pushed into all fittings for the full engagement length.

When renewing mains by PE insertion, anchor blocks may not be needed if the carrier pipe is secure. Thermal forces on PE mains connected to the metallic system can be restrained using an electrofusion coupling with a loose slip on flange or Steve Vicks Anchor Plate against the carrier pipe, see Figure 25. The slip-on flange/Anchor Plate may need to be cut from a blank flange and the carrier pipe end must been cut square.

In Figure 25, the electrofusion coupling must not be used to join the PE pipe, instead, it is used to restrain thrust only; the coupling is fused onto a continuous length of pipe to push the slip-on flange ring up against the end of the carrier pipe. It is advisable to have a short section of PE pipe emerging from the carrier pipe, in order to minimise any contamination of the electrofusion surfaces as the coupler is pushed into position up against the flange. Scrape or peel the PE pipe to ensure it is not contaminated when the coupling is slipped over the inserted pipe to the required position.

The carrier pipe (i.e. old metallic main) should be used for anchorage, and it is important that the carrier pipe is cut squarely. A length of undisturbed main, typically 3 m, should be left at the dead end of the carrier pipe.

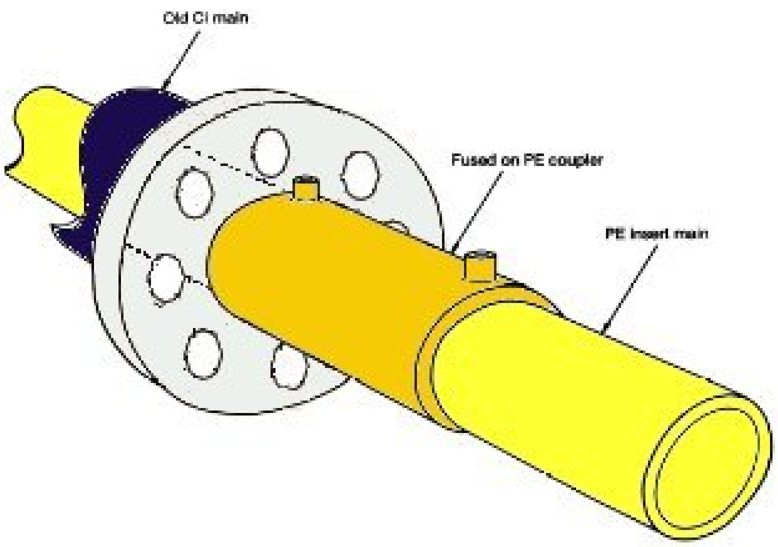


Figure 25 – Anchorage with an Electrofusion Coupler and Flange

14.2 Anchorage of Fusion Jointed Systems by Anchor Block.

PE mains may require permanent anchorage, using concrete anchor block(s) where:

- The carrier pipe on inserted mains is not suitable for anchorage.
- Connecting a new pipe to existing swaged or inserted pipe that is in tension to anchor the pipework when it is cut.
- If laying by open cut, connecting PE pipe to a metallic main with a non-end load bearing joints.
- Where no other forms of anchorage is practicable.

When any of the above conditions apply on systems up to 2 bar a concrete anchor block must be used as shown in Figures 25 and 26. The anchor block must be constructed by casting concrete over undrilled saddles or service tapping tees fused to the PE main.

The saddles or tapping tees should be fused to the inserted main at a point near to the end of the inserted main, as shown. The number of service tees to be used is given in Table 14 the minimum separation distance between the edge of any tapping tees or saddle should be 100mm as shown in Figure 26.

Before encasing the saddles or tees with concrete, the annular space within the carrier pipe should be sealed with an approved grout / sealant and an end seal fitted. The PE pipe to be encased in concrete should be protected by first wrapping the pipe with a heavy duty polyethylene membrane, which should extend outside of the concreted section of the pipe.

PE fittings used for gas containment i.e. an integral part of the gas transportation system MUST NOT be encased in concrete and the Tapping Tees must be capped to prevent future use.

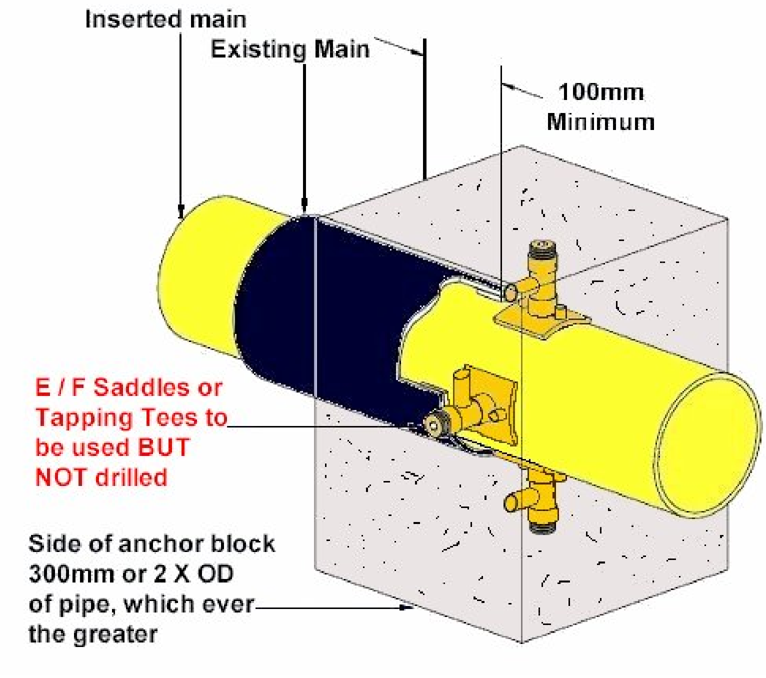


Figure 26 Anchorage by the use of tapping Tee's

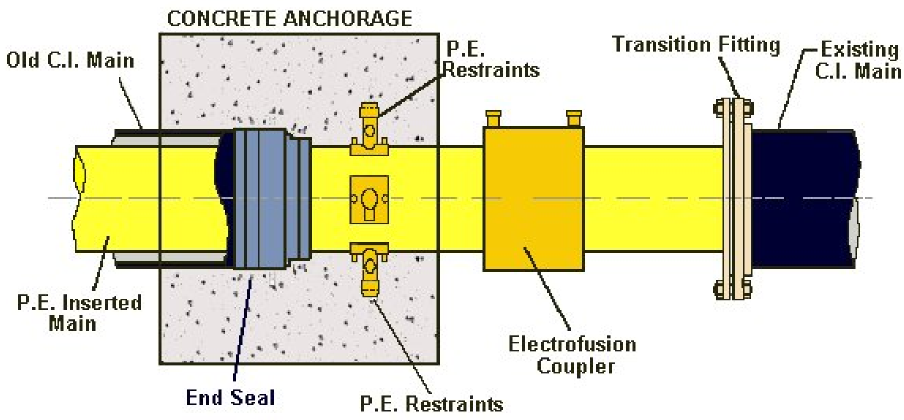


Figure 27 – Side View of Anchorage by use of Tapping Tee's

Pipe Diameter (mm)	Number of Saddles / Tapping tees	
	SDR 11	SDR 17.6/ 21
90	2	2
125	2	2
180	3	2
250	4	3
315	5	4
355	6	4
400	8	6
500	12	8
630	16	10

Table 14 – Number of Tapping Tees Needed for Anchorage on Systems up to 2 bar

14.3 Connections to Swage-lined pipes

Direct connections to swage-lined pipes must be carried out in accordance with Section D3 of SGN/WI/ML/2. Extreme caution must be exercised as the PE main is likely to be in tension and when cut may retract into the carrier pipe if adequate anchorage has not been provided.

Direct mains connections must not be made if the pipes SDR is not known (i.e. cannot be established by the markings on the pipe or is greater than SDR 26. In this event a metal insert may be required for a swaged mains connection and this should be confirmed with the supplier of the electrofusion coupling.

Where a concrete anchor block is to be constructed to restrain a swaged pipe, the number of service tees or saddles to be fused to the main should be double the number shown in Table 14 with a minimum separation distance of 150mm.

15. EXCAVATING ONTO EXISTING INSTALLATIONS AND PIPEWORK

15.1 General

When excavating on to existing installations, including other Utilities, care must be taken to ensure existing anchor blocks, or their supporting ground are not disturbed, unless proper precautions have been taken to restrain pressure and loads created by temperature change.

Site personnel must be made aware of the hazards of a joint or fitting failure due to inadequate anchorage.

The possible consequences may be:

- Fitting and debris flying through air causing fatality /injuries and/or property damage.
- Large gas escape (potential gas ingress into buildings, ignition of gas, closure of road / rail / flight routes).
- Loss of supply
- Damage to adjacent exposed services
- Equipment damage

15.2 SGN Plant

If, whilst excavating on to existing plant, the need for installation or upgrading of anchorage becomes apparent, this work must be carried out before any excavation work continues. The assumption should be made that the anchorage is not adequate unless there is evidence to confirm otherwise.

DO NOT

- Remove concrete from around pipes and fittings
- Remove ground supporting anchor blocks or mass concrete
- Remove any steel spikes or wooden stakes which may have been installed as anchorage, whilst these are not acceptable as anchorage removing them will increase the danger.
- Assume that circlips, which in some cases were installed on ductile iron systems, are suitable to restrain and or anchor the joints. Reliance on these systems must not be made and alternative anchorage applied.
- Assume that bolts on flanged fittings are secure and fit for purpose. The bolts may have corroded since original installation.

DO

- Check that pipes and fittings including couplings (particularly medium and intermediate pressure systems) have anchorage in place (but DO NOT remove or disturb existing anchorage).
- Check the size of anchorage and use this Management procedure to determine if it is adequate for the use it has now been put to.
- Provide an alternative system of anchorage before removing any existing anchorage.
- Consider the need to reduce pressure to allow safe working practice.
- Consider the need to provide anchorage when none is present but is required. Reference should be made to Section 13 of this Management procedure.

15.3 Other Utilities Plant

Follow the general advice given in Section 15.2 but where other utilities plant is concerned their advice should be obtained as soon as a problem is identified.

Appendix A - REFERENCES

This Management Procedure makes reference to the documents listed below

A.1 Internal Documents

SGN/PM/MSL/1 – Part 1	-	Management Procedure for Distribution Mainlaying and Servicelaying Activities
SGN/WI/ML/2	-	Work Instruction for Mainlaying up to and including 630 mm diameter at Pressures up to and including 7 bar
GDN/PM/SCO/1	-	Management Procedure for Safe Control of Operations.
GDN/PM/SCO/2	-	Management Procedure for the Safe Control of Operations – Issue of Permits to Work and Forms of Authority on the Gas Network.
GDN/PM/SCO/4	-	Management Procedure for the Safe Control of Operations – The Control of Non-Routine Gas Supply Operation.
GDN/PM/SCO/5	-	Management Procedure for the Safe Control of Operations – Control of Routine Gas Supply Operations.
GIS/TE/P6.3	-	Specification for Equipment used in testing gas mains and gas services with operating pressures not greater than 7 bar.
SGN/PM/ECP2	-	Management Procedure for Cathodic protection of buried steel systems.
SGN/WI/ANC/4.2.1	-	Work Instruction – Anchorage on systems up to and including 7 bar - Managers
SGN/WI/ANC/4.2.2	-	Work Instruction – Anchorage on systems up to and including 7 bar - Operatives

A.2 External Documents

BS 12 replaced by BS EN 197	-	Specification for ordinary and rapid-hardening of Portland Cement Cement. Composition, specifications and conformity criteria for common cements
BS 338	-	Structural timber. Strength classes
BS EN 1065:1998:2000	-	Steel trench Struts
BS 5930	-	Code of practice for site investigations
BS 8110 replaced by BS EN 1992	-	Structural use of concrete: Part 1 – Code of practice for design and construction Part 2 – Code of practice for special circumstances Part 3 – design charts for singly reinforced beams, doubly reinforced beams and rectangular columns

BS EN 1065:19989	-	Adjustable telescopic steel props Đ Product specifications, design and assessment by calculation and tests
BS EN 12620:2002+A1:2008 Replaces BS 882BS 882	-	Specification for aggregates from natural sources for concrete Aggregates for concrete
EN 10210-2	-	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties
EN 13145	-	Railway applications. Track. Wood railway sleepers and bearers

A.3 Reports and other material used in the development of this Management Procedure

ERS R 4009	-	British Gas Engineering Research Station report dated August 1988 – Design guide for methods of restraining longitudinal thrusts on pipe and fittings during and after connections – Authors – P Hunter and R C Owen
Advantica R5356	-	Advantica report dated July 2002 – Restraint loads for temporary and permanent mains anchorage
AESL - RP2697	-	Advanced Engineering Solutions reports dated Nov 2008 – Assessment of methods for the design of pipe end restraints – Author - I Martin
AESL - RP 2898	-	Advanced Engineering Solutions reports dated March 2009 – Assessment of simplified methods of designs for thrust restraint – Authors – I Martin and I Bell.
CIRIA report R128	-	Guide to the Design of Thrust Blocks for Buried Pressure Pipelines.
Excel calculator for end restraint	-	Excel spreadsheet for the determination of end restraint on pipes dated October 2008 - Author - P R Pearson
T/PM/DIS 4.2 :2005	-	Management Procedure for Section 4 – Excavations Module 4.2 – Permanent and temporary Anchorage for Mains and Large Services.

Appendix B - DEFINITIONS

The definitions applying to this Management Procedure are given below

Anchor	-	A means to isolate movement of a pipe or fittings in all three planes.
End-loaded device	-	A fitting that contains a combination of properties and component and joint design such that under any load condition the pipe will fail before the fitting.
Floatation	-	A condition whereby the pipe becomes buoyant
Force	-	A power put in motion
Operational Manager	-	Managers Undertaking Work Duties in the role of Operational Managers or Team Managers (First Line)
Prop	-	Two tubes (an inner and outer tube) which are normally used as horizontal support for building or civil Engineering work. They contain a simple screw mechanism to allow adjustment of total length. At the ends of the prop are flat these end plates are used for securing the prop. Normally but not exclusively used in the vertical plane.
Restraint	-	A means to isolate movement of pipe or fittings in two planes and allowing movement in the remaining third plane.
SDR	-	Standard Dimension Ratio - numerical designation of a pipe series, approximately equal to the dimension ratio of the nominal outside diameter, and the nominal wall thickness.
Shore	-	Timber or other material used as a temporary prop for excavations or buildings; may be sloping, vertical, or horizontal.
Strut	-	Two tubes (an inner and outer tube) which are normally used as horizontal support for building or civil Engineering work. They contain a simple screw mechanism to allow adjustment of total length. At one end a claw plate is provided which is used to grip a timber member. Normally used in the horizontal plane.
Technical Services Contract	-	A contract made by SGN with outside agencies for professional expert advice. These contracts are call off contracts for individual projects and costs are charged to each project.
Thrust	-	The force or pressure of one part of a construction against other parts
Transverse beam	-	A horizontally supported crosswise piece of timber used for restraining an end cap
Young's Modulus	-	Is a measure of the stiffness of a given material. It is defined as the ratio, for small strains, of the rate of change of stress with strain. The Young's modulus allows the behaviour of a material under load to be calculated.

Appendix C - EXAMPLE CALCULATIONS

C.1 Basic Thrust Force Calculation

In general, the thrust force should be obtained from Table 1. However, where it is necessary to calculate the thrust force arising under specific circumstances, the following method will apply.

To calculate the thrust force on the end cap of a 4 inch diameter pipe operating at 35mbar.

First, calculate the pressure in bar, 35mbar = 0.035bar

Next, calculate the effective thrust area in square metres (m^2)

A 4 inch pipe has a socket internal diameter of 5.56 inches which is equal to 0.1412 metres (m)

(socket diameters can be obtained from BS 1211)

The inner area of the cap = 3.142 X (0.1412 X0.1412) / 4

= 3.142 X (0.019937 / 4)

= 3.142 X (0.004984)

= 0.01566 square metres (m2)

Therefore the thrust force = 0.035 X 0.01566

= 0.055 kN

(For information 1 kN = 101.969 Kgf, so in this example the thrust force = 5.589Kgf)

C.2 Example 1 - Thrust Force Calculation

A cut and cap operations has to be completed on an 8" dia cast iron low pressure main in firm clay soil conditions, what type of anchorage is required? The main will be isolated for a short time to be reconnected later after local mains replacement is completed. The type of cap to be used will be a standard cap supplied from the SGN stores system (an approved cap) and there are no other exposed joints in the excavation.

Step 1 – From Table 1 identify the force (Fp) created by the pressure and diameter; by looking at the 8" line against the column for 75mbar - the maximum pressure that low pressure mains should see. The result is Fp = 0.38kN.

Step 2 - You can assume that as the mains material is cast iron that the expansion will be nil (Fth=0).

Step 3 – Identify the shape factor (S) for a cap from Table 3. The result is a factor of 1. (S=1)

Therefore take the values from step1 and step 2 and add them together and multiply by the shape factor.

(Fp+Fth) X S = (0.38 +0) X 1 = 0.38kN to be restrained.

Step 4 – The total force to be restrained does not exceed 60kN so this step can be omitted.

Step 5 – From the details provided temporary anchorage is required. But for the record the soils type is Firm clay (soil type 4).

Step 6 – Review section 11 to determine what system can be used to restrain a force of 0.38. System type 1 is suitable for restraining forces up to 10 kN but consider section 10.4.1 where an 8" cap can be fitted without anchorage on a main operating at a pressure no greater than 75mbar if an approved cap is used and there are no other exposed joints in the excavation.

In practicable terms managers should be aware of Section 10.4.1 and therefore no need to make the calculations above.

C.3 Example 2 – Basic Calculations

A 4m long cut out is to be carried out on a 6 inch diameter MP ductile iron main within a 1 metre wide trench; the ground type is soft clay. Initially, temporary anchorage is required between the end caps, using a steel strut/prop, which is then to be converted into a permanent anchorage by casting a shuttered concrete block around the strut/prop.

C.3.1 Creation of a Temporary Anchorage

Step 1 - From Table 1 identify the force (Fp) created by the pressure and diameter by looking at the 6" line against the column for 2bar the maximum pressure the result is Fp = 6.1kN.

Step 2 - You can assume that as the mains material is cast iron that the expansion will be nil (Fth = 0).

Step 3 – Identify the shape factor (S) for a cap from Table 3. The result is a factor of 1. (S=1)

Therefore take the values from step1 and step 2 and add them together and multiply by the shape factor. (Fp + Fth) X S = (6.1 +0) X 1 = 6.1kN to be restrained.

Step 4 – The total force to be restrained does not exceed 60kN.

Step 5 – From the details provided temporary anchorage is required but will need to be a suitable type to be converted at a later date. So treat as permanent. Soil type is known to be soft clay (soil type 7)

Step 6 – Work out the ground reaction area by using Table 4, look up the total force against the soil type the result is 0.35m^2.

Step 7 – Determine type of anchorage required - Temporary

Step 8 - Determine the type of temporary anchorage which can be converted to a permanent anchor block. Review section 8.1 and see Figures 11 and 12. Figure 12 fits the requirements so both the Beams and the Struts/Props need to be identified.

Beam: Table 10 gives the details of wooden beams and Table 11 for RHS sections

a) Wooden beam for 6.1kN on a 1 metre wide trench from Table 10 a single beam is suitable for up to 7 kN.

b) RHS section for 6.1kN on a 1 metre wide trench a class B beam is suitable for up to 10kN up to a trench width of 1.5m.

From step 6 we know that the bearing area needs to be 0.35m^2 and so each end of the cut out needs to have a bearing area of half of this amount e.g. 0.35/2 = 0.18m^2.

The vertical height is calculated by dividing the required bearing area of 0.18m^2 by the useable cut out measurement of 0.4m (400mm) as follows:-

0.18m^2 / 0.4m = 0.45m (450mm).

Struts/Props: For a thrust force of 6.1kN and 4 metres long, From Table 12 a Prop sized No 4 can be used although a fully extended size No 3 could also be considered but subject to manufacturers' literature which should be consulted to confirm. From Table 13, A40, B40, C40 etc Props could be used. Use can also be made of a double span arrangement as shown in Figure 24.

C.3.2 Conversion into a permanent Anchor Block

From the details in section C3.1 we know the thrust to be 6.1kN and the face area to be 0.35m^2 and in soft clay.

The anchor width =A, depth = B and Length = L, and for a square block A can be equal to B.

So if the area = 0.35m^2, A = B so the square root of 0.35 = 0.59 (say 0.6 – 600mm).

The minimum required anchor block should be half the depth or no less than 300mm; which means the block should be 300mm by 600mm by 600mm. Details on the construction are shown in Figure 24 in section 13.8.

C.4 Example – 2 – More Complex Anchor Blocks

Problem: An 8 inch diameter IP main is laid in soft clay and must be anchored. Determine the size of a permanent anchor block required at a 90°bend. Note: Section 13.5.1 says the block thickness should be at least 50% of the block height with an absolute minimum of 300mm.

C.4.1 Solution for Square Faced Anchor Block (see Figure 18)

Step 1- From Table 1 the thrust force to be restrained for an 8 inch main at 7bar operating pressure is 35kN.

Step 2 – You can assume that expansion is zero.

Step 3 – From Table 3 the shape factor is 1.5, therefore the total force to be restrained = 35kN X 1.5 = 52.5kN.

Step 4 – The Force is not greater than 60kN

Step 5b – The Anchorage is to be permanent

Step 5 – The soil type is Soft clay

Step 6 – The ground reaction action from Table 4 = 3.0m^2 (using 50.1 to 60kN row)

Step 7 – Permanent

Step 8 – Not PE Anchorage

Sizing the block

See Figure 18 for a square faced block where Width = W, Depth = B, and contact length = C we assume that A=B if space permits.

So Face area (FA) = 3.0m^2 = A X B = square root of 3.0 = 1.732 m (say 1.75 m each)

If Anchor block thickness C = 50% of A then C = 5-% of 1.75 =0.9 m (rounded up)

The Anchor block thickness dimensions are therefore A=1750mm, B=1750mm C=900mm

C.4.2 Solution for Angle Faced Anchor Block at Trench Corner

There is no need to repeat the steps 1 to 8

Assuming the pipe centre line is 800mm below ground level, Section 13.6 requires a clearance of not less than 200mm from the top to the underside of any road foundation. Therefore assuming the road foundation to be 200mm thick, the maximum anchor block height above the pipe is 800 – (200+200)=400mm

Anchor blocks should be constructed with a centreline at the same depth as the pipe centreline therefore B, the depth of the anchor block = 2X400mm=800mm

See Figure 19 for angle faced anchor block, calculate the anchor block dimensions as follows:-

FA=3.0m2 = C X B and B = 800mm then C = 3000/800= C = 3750m

A = C/2 then A = 3750/2= 1875mm and Anchor block thickness A/2 = 937.5mm

The Anchor Block dimensions are therefore

A= 1875mm, B = 800mm, C = 3750mm and the block thickness A/2 = 940mm (rounded up)

C.4.3 Alternative Solution for Angle Faced Anchor Block at Trench Corner

Where a main is laid at a greater depth, an alternative solution to this design is as follows:

See Figure 19: The calculation is as follows:-

Side Width = A, Depth = B, Face length = C and assume that A=B (if space permits)

C2 = A2 + A2 = $2A^2$ (from Pythagoras) therefore C = $\sqrt{(2A^2)}$ = √2A

IF FA = $3.0m^2$ = C X B and B=A, then √2A =3.0/A

If C = √2A and C = 3.0A, then √2A = 3.0A therefore √2A2= 3.0A or A = √(3.0/√2)

So A = √(3.0/√2) = 1.456 and A +B then both A and B = 1.460 (rounded up)

If C = 3.0/A then 3.0/1.456 = 2.060 (say 2.1)

Then the block size =

A = 1460mm, B = 1460mm and C= 2100mm

The required block is A/2 = 750mm rounded up from (0.730)

C.5 Example 3 - Combining pressure and temperature thrust force

A 90mm PE 80 pipe is to be connected to a 4” diameter cast iron pipe operating at low pressure and the temperature is expected to fall from 20^O C and fall to 5^O C. The soil is unknown. What Temporary and permanent anchorages should be made?

Step 1 - From Table 1 using 4” diameter at a maximum of 75mbar = 0.12 kN

Step 2 - Where both thermal and pressure thrust Forces are likely to be encountered then both thrust Forces will need to be added together in order to determine the total thrust Force as follows:

From Table 2.1 using 90mm SDR 17.6 for 15 X 1^O C = 15 X 0.16 kN = 2.4kN

Total Thrust Force is the two = 0.12 kN + 2.4 kN = 2.52 kN to be restrained.

Step 3 – There are no fittings this step can be omitted.

Step 4 – The total force is less than 60kN

Step 5 - The soil type is unknown, so the worst case Soil 7 must be used.

For temporary Solution

Step 6 - If temporary anchorage were required System Type 1 can be used and for thrust forces up to 4kN a cut out of 300mm either side is required (see Table5).

For Permanent Solution

Step 6 – From Table 4 the ground reaction area is $0.2m^2$

Step 7 – Permanent Solution Required

Step 8 - The pipe network is to be reconnected then the PE pipework will need to be restrained by following the advice given in section 14. i.e. 2 tapping Tees placed in an anchor block sized from Table 4 as $0.2m^2$ for a 2.52kN force.

Block Dimensions

Dimensions of the block are calculated as follows: - (square root of 0.2 = 0.447 – say 0.45)

The minimum required anchor block should be half the depth or no less than 300mm; which means the block should be 300mm by 450mm by 450mm.

C.6 Ground Assessment for higher thrusts

Where the thrust force exceeds 60 kN, pressurised end caps should, wherever possible, be restrained in a trench separate to that used for other works. If this is not possible, guidance given in Section 8.5 is applicable, if a more detailed assessment is made of the ground's ability to provide anchorage. Anchorage systems, shown in Sections 8.2. to 8.4 are based on the assumption that restraint is provided by weak ground i.e. Table 4 Soil Type 7.

From Table 4, in order to restrain a thrust of 60kN in soil type 6 the required anchor block face area is 2.22m^2.

Where it is known that the actual ground condition is soil type 4 then

From Table 4, in order to restrain a thrust of 60kN in soil type 4 firm clay then the required anchor block face area =1.12.m^2.

From Table 4, the 2.22m^2 anchor block face area determined assuming soil type 6, is actually capable of restraining 100kN in soil type 4, firm clay.

By referring to Table 1 it is possible to determine that this force is equivalent to

14" at 7bar, 22" at 3 bar and 48" at 350mbar is just less than half this force.

C.7 EXAMPLE 4

A cut and cap operations has to be completed on an 24" dia cast iron medium pressure main (max 2 bar) in stiff clay soil conditions, what type of temporary anchorage is required? The main will be isolated for a short time to be reconnected later after local mains replacement is completed. The type of cap to be used will be a standard cap supplied from the SGN stores system (an approved cap) and there are no other exposed joints in the excavation. The isolation will use a three hole trench system.

Step 1 – From Table 1 identify the force (Fp) created by the pressure and diameter by looking at the 24" line against the column for 2 bar the maximum pressure that medium pressure mains should see. The result is Fp = 75kN.

Step 2 - You can assume that as the mains material is cast iron that the expansion will be nil (Fth=0).

Step 3 – Identify the shape factor (S) for a cap from Table 3. The result is a factor of 1. (S=1)

Therefore take the values from step1 and step 2 and add them together and multiply by the shape factor. (Fp+Fth) X S = (75 + 0) X 1 = 75kN to be restrained.

Step 4 – The Total force to be restrained is greater than 60kN

Step 4 A – The force is less than 160kN.

Step 5 - The soil type is confirmed as being stiff clay type 2

Step 6 - Establish the ground reaction area required by looking at Table 4 the force is 75kN and found in the range 70.1 to 80kN with a result in stiff clay of 0.53 m^2; the total face area.

Step 7 – The type of anchorage required, is temporary.

Step 8 - System type 3 is suitable for restraining forces up to 60kN in worst case soil type and it may be possible to use this system based on the actual soil type 2.

Selecting Temporary Anchorage System

From Table 4, to restrain 75 kN in loose wet granular ground the anchor block face area required is 4.0 m^2. 75kN in soil type 2 (Stiff Clay) the anchor block face area is 0.53m^2.

System Type 2 can be used with ground assessment up to 80kN and the minimum cut out areas are shown in Table 6 as being 0.60m^2 that is 550mm wide by 550mm depth.

System Type 3 can also be used in soil type 2 but we must half the force for each of the two parts of the system. So we round up 75kN to 76kN and half = 38kN each half and each half needs a face area from Table 4 of 0.27m^2. (say 0.3m^2).

Using Table 7 (System type 3) the minimum face area is 0.6m^2 so the system design is suitable with cut outs of 550mm and depth of 550mm minimum. Struts/Props will be required and the choice dependent on the length of the excavation see Table 11 for the choices. Trench end shoring W2 is also required and must be to the dimensions shown in Table 7, the minimum requirements being 0.500mm wide by 500mm depth.

C.8 Conversion factors:

Unit 1	Unit 2
1 tonne equals	9.80665 kN
	1000 kgf
	0.9842 UK Tons
1kN/m^2 equals	101.9716 kgforce
	0.1019716 tonnes
	0.1003611 UK Tons
1Kgf	2.2 lbforce
	9.81 N
30 mbar	0.003 bar
75 mbar	0.075 bar
350 mbar	0.350 bar

Table C.1

Appendix D - SOIL IDENTIFICATION

D.1 General Requirements

For the purpose of providing adequate anchorage, to prevent the movement of any part of the pipe system under the combined effect of internal pressure and temperature, the design of the anchor will depend on the load bearing capacity of the ground supporting the anchor. In general, for any given force acting along the line of a pipe, the weaker the ground behind the anchor block, the larger the anchor block needed to resist the force.

The load bearing capacity of an area of ground will depend mostly on the type of soil, the size of the soil particles, the degree of consolidation or compaction, the amount of water present and the depth of the natural water table. If the ground has recently been disturbed, the nature and depth of disturbance is also likely to affect its load bearing capacity, along with several other possible factors that may be present, depending on the site location. However, as it is difficult to obtain a precise measure of the load bearing capacity of any ground, it is usual to assess the soil type and incorporate an appropriate safety factor to ensure that the final anchor design provides an adequate degree of support.

In the UK, CIRIA (Construction Industry Research and Information Association) have undertaken a number of studies concerning the identification of soil types and appropriate safety factors for the assessment ground load bearing capacity. The soil type classifications and assumed individual safety factors shown in Table D.1 have been extracted from CIRIA Report 128 Guide to the Design of Thrust Blocks for Buried Pressure Pipelines.

Soil Type Classification		Assumed Factor of Safety
1)	Rock or Very Stiff, Hard Clay	2
2)	Stiff Clay	2.5
3)	Dense Granular Material	3
4)	Firm Clay	3.5
5)	Non-dense Granular Material or Dense Coarse Grained Soil	3.8
6)	Non-dense Coarse Grained Soil	4.2
7)	Soft Clay or Made Ground or Reused Excavated Spoil	4.5

Table D1 – Soil Types and Assumed Factors of Safety

D.2 Basic Ground Materials

For the In general, the HAUC Specification for Reinstatement of Openings in Highways (SROH) includes procedures that identify most of the imported or excavated materials that UK utility companies are likely to use or encounter during street works. The procedures are part of the standard basic training required for all utility street works personnel under the New Road and Street Works Act. However, some materials are not included in SROH, mostly naturally occurring materials that are inherently unsuitable for use in the reinstatement of utility excavations. In this event, the simplest and most reliable way to identify these materials is probably via procedures provided by CIRIA (Construction Industry Research and Information Association) within a number of their documents.

The SROH soil identification procedures in Section D.3 should identify most materials likely to be found within a utility trench as one of the soil types shown in Table D.1. In the event that the soil cannot be readily identified, the soil is likely to be a naturally occurring material and the CIRIA soil identification procedures in Section D.4 should identify the closest soil type from Table D.1.

Many materials can be identified by visual examination, with minimum tools or other equipment. The following basic descriptions should be considered before resorting to the identification procedures within Sections D.3 or D.4.

D.2.1 Soil Type 1 Rock or Very Stiff Hard Clay

Ground classified as rock or very stiff hard clay will be dense and appear to be a single solid mass with no loose material and few visible joints or fissures. The material will usually be consistent in texture and colour, with a surface that is too hard to allow a stake to be driven in; a hammer and chisel will be required in order to extract any sample. Rock or very stiff hard clay is likely to be naturally occurring, undisturbed for very many years and will not often be encountered within the public highway, especially in urban areas.

Rock meeting the above description usually cannot be excavated using a pick and will not noticeably change in hardness when water is poured onto the surface. However, if the rock contains many visible joints, fissures or cracks, or vertical surfaces crumble away when hit with a pick, obtain specialist advice.

Very stiff hard clay meeting the above description can often be excavated using a pick, breaking into brittle flakes that will change noticeably in hardness when saturated with water but will not collapse or turn into a soft sludge.

D.2.2 Soil Type 2 Stiff Clay

Ground classified as stiff clay will be dense and appear to be a single solid mass and may contain particles of rock varying in size from small boulders down to coarse gravel. The material will usually be dark in colour and hard at the surface, but a stake can usually be driven into the surface, albeit slowly; a sample can be extracted using a hammer and chisel. Stiff clay will usually be naturally occurring, undisturbed for many years and will not usually be encountered within the public highway, especially in urban areas.

Stiff hard clay meeting the above description can be excavated by pick and shovel and extracted as clay lumps that may contain rock particles. Lumps will change noticeably in hardness when saturated with water but will not collapse or turn into a soft sludge.

Where any doubt exists concerning Soil Type 2), see Section D.4.

D.2.3 Soil Type 3 Dense Granular Material

Ground classified as dense granular material will appear to be a solid interlocking mass of rock particles varying in size from 75 to 100 mm down to small gravel and fine sand; particles of all sizes should be present, all mixed together with no noticeable open gaps between the larger particles. The material will usually be relatively consistent in colour, usually a mid to dark colour but relatively light colours are not unknown. The surface will be too hard to allow a stake to be driven in, but larger particles can be loosened using a hammer and chisel. If loosened, particles of all sizes can be picked out by hand; there should not be a significant proportion of very fine dust sized particles. Dense granular material is very likely to be man-made, laid and compacted to provide a paved area or other load bearing structure.

Dense granular material, whether within the public highway or in other areas, is likely to have been built up in layers and may be of substantial thickness. Material at the bed of the trench should be compared with that nearer the surface to ensure that all layers are of comparable quality.

Where any doubt exists concerning Soil Type 3), see Section D.3.

D.2.4 Soil Type 4) Firm Clay

Ground classified as firm clay will be essentially similar to Soil 2) Stiff Clay, a relatively dense clay, usually dark in colour and often containing particles of rock from small boulder size down to coarse gravel. The material will not be substantially hard; a stake can be driven into the surface, a sample can be extracted using a spit or narrow shovel and the surface can usually be indented by a shoe heel. Firm clay will usually be naturally occurring, probably undisturbed for a number of years and will not usually be encountered within the public highway, especially in urban areas.

Firm clay meeting the above description can be excavated by shovel, with some difficulty; a clay spit or narrow shovel is usually substantially easier, yielding large clay lumps that may contain rock particles. Lumps will be softer when saturated with water but should not become a soft sludge.

Where any doubt exists concerning differences between Soil Types 2) and 4), see Section D.4.

D.2.5 Soil Type 5) Non-dense Granular or Dense Coarse Grained Soil

Ground classified as non-dense granular material is essentially Soil 3) Dense Granular Material with a lesser degree of compaction. The surface will be relatively hard but a stake may be driven in; when loosened, dense granular and non-dense granular materials are identical in all respects.

Ground classified as dense coarse grained soil will be similar to Soil 3) Dense Granular Material, except that the interlocking mass of rock particles will include some clay or silt material, perhaps 25 to 50%, and the largest rock particles may be substantially smaller, perhaps 50 mm to 75 mm in size. The material may not be consistent in colour, usually quite dark, light colours are possible but quite uncommon. The surface will not be substantially hard and larger particles can usually be loosened by hand and the clay or silt material will usually be clearly visible. Dense coarse grained soil could be naturally occurring or may have been man-made, laid and compacted to provide a low cost load bearing structure.

Where any doubt exists concerning differences between Soil Types 3) and 5), see Section D.3.

D.2.6 Soil Type 6) Non-dense Coarse Grained Soil

Ground classified as non-dense coarse grained soil is essentially Soil 5) Dense Coarse Grained Soil with a lesser degree of consolidation or compaction. The surface is unlikely to be hard or tight and larger particles may be relatively loose and easy to remove; the clay or silt content is likely to be clearly visible. When loose, dense coarse grained and non-dense coarse grained soils are identical in all respects.

In general, non-dense coarse grained soil could be naturally occurring or man-made and should not usually be encountered within the public highway.

Where any doubt exists concerning Soil Type 6) that appears to be excessively loose or poorly consolidated, obtain specialist advice or classify ground as Soil Type 7).

D.2.7 Soil Type 7) Soft Clay or Made up ground or Reused Excavated Spoil

Ground classified as soft clay or made ground or reused excavated spoil is the lowest quality ground in which thrust can be restrained without seeking specialist advice. In general, the material may be entirely soft clay, similar to Soil Type 4) but substantially softer, although such material is unlikely to be encountered within the public highway.

Reused excavated spoil is usually a variable mixture of Soil Type 5) non-dense granular material, and Soil Type 6) non-dense coarse grained soil, perhaps with some additional fine materials such as soft clays and silts and/or additional coarse soils, loam etc.

Made ground is essentially a term used to describe materials closely resembling reused excavated spoil that may contain some additional waste materials that are not naturally occurring i.e. rubble, building debris, slate, ash, cinders etc.

Where any doubt exists concerning Soil Type 7) that appears to be particularly loose, or unstable and liable to collapse, obtain specialist advice.

D.2.8 Soil Type Cannot be identified from Section D.2 D Descriptions

Where the soil type descriptions above cannot identify the closest soil type from Table D.1, the examination should have been able to determine whether the soil in question is naturally occurring or man-made.

Soil types 1) Rock or Very Stiff, Hard Clay, 2) Stiff Clay, 4) Firm Clay and 7) Soft Clay are all more likely to be naturally occurring; Section D.4 procedures are most likely to be appropriate.

Soil types 3) Dense Granular Material and 5) Non-dense Granular Material are all more likely to be man-made, especially if encountered within the public highway or urban areas; Section D.3 procedures are most likely to be appropriate.

Soil types 5) Dense Coarse Grained Soil and 6) Non-dense Coarse Grained Soil could be naturally occurring or man-made, but are probably more likely to be man-made, especially if encountered within the public highway or urban areas. Section D.3 procedures should be consulted first.

Soil type 7) Reused Excavated Spoil is essentially a man-made material; Section D.3 procedures should be consulted.

Soil type 7) Made Ground is essentially a man-made mixture of various materials, usually including man-made waste materials; Section D.3 procedures should be consulted.

D.3 SROH Soil Identification Test Procedure

D.3.1 The SROH includes much useful information on identifying ground materials, mostly imported or excavated materials suitable for reinstatement use. The following has been extracted from SROH Appendix A1: Backfill Materials, with minor revisions for use on representative soil samples extracted at several positions around the location where an anchor block is required.

D.3.2 Granular Grading

All unbound granular materials must be reasonably well graded; i.e. must contain a range of particle sizes, from fine to coarse, with an adequate proportion of particles of intermediate sizes. A well-graded material can be compacted to give a dense and stable structure of interlocking particles with a low proportion of air voids within the structure.

Spread out each sample and examine under good light.

i) Class A Graded Granular Materials - should not contain any particles greater than 75 mm nominal size and, in general, should be 50 mm or smaller. Smaller particles down to less than 5 mm nominal size should be present in gradually increasing numbers as the size decreases. Finer particles, from sand size down to dust, should be present and will usually be adhering to the larger particles. Fine particles should be visible adhering to around 30 per cent or more of the surface of the majority of the larger particles.

ii) Class B Granular Materials - should show the same general features as described above but will usually be less well graded overall compared with Class A Graded Granular Materials.

iii) Class C Cohesive/Granular Materials - will usually contain a much larger proportion of fine material. The granular content should still be less than 75 mm nominal size, down to less than 5 mm nominal size and should not be single sized.

D.3.3 Identify Fine Aggregate

i) Take a small sample of representative fine material i.e. individual particles smaller than approx 10 mm in any dimension - squeeze together in one hand and release. If material crumbles away and mostly fails to adhere together into a ‘ball’ - sample is too dry. Any reasonable degree of adherence is acceptable provided no free water is squeezed out.

ii) Separate the fine material and rub between finger tips – sands will feel gritty – silts and clays will feel smooth.

D.3.4 Identify Silt Material

Select moist sample of fine material only - remove all larger particles. Rub sample between palms of clean dry hands, remove excess material by striking palms together. Wait a few minutes for body heat to dry out any material adhering to hands - rub hands together briskly.

i) If palms are relatively clean with no significant material still adhering - material is essentially a silt - not acceptable for use.

ii) If estimating approx silt content of bulk material, consider amount of larger particles removed to make the fine sample and amount of excess material discarded when striking palms together – may be acceptable if great majority of material is not silt.

D.3.5 Identify Clay Material and Condition

Select a sample of small lumps of fine material - remove all larger particles. Select small lumps at a moisture content representative of the bulk material. With clean dry hands, squeeze the sample together in one hand and release.

i) If sample mostly holds together into a ‘ball’ - material is essentially a clay. Break off part of the ball and roll, between palms of hand, into long thin cylinder until it fractures or begins to show transverse cracks. If strand can be rolled into uncracked lengths thinner or longer than a standard pencil (less than 7 mm diameter or more than 175 mm length) - material is too wet or too plastic for compaction – not acceptable for use

ii) If sample crumbles away and mostly fails to hold together into a ‘ball’ - material maybe a clay but is too dry for compaction - acceptable for use if not loose

iii) If the sample shows any result between a ball and a pencil - material can be compacted - may be acceptable for use.

D.3.6 Granular Condition

Examine several of the medium and larger-sized particles from each sample extracted.

Material within acceptable moisture content range will show a dull sheen when viewed obliquely against the light, with all fines adhering to the larger particles, and no free water will be visible. Material at the dry limit will not show the characteristic sheen, fines will not be strongly adherent and many of the fines will be free. Material at the wet limit will begin to show free moisture collecting in surface grooves or amongst the fines, fines will not be strongly adherent and many of the fines will amalgamate as soggy clusters. Any result between the wet and dry limits is acceptable provided the bulk of the sample is reasonably well graded.

D.4 CIRIA Soil Identification Tests

CIRIA advise the use of a standard field procedure to identify ground materials, mostly naturally occurring soils, when encountered during various civil engineering operations. The following has been extracted from CIRIA Report 128 - Guide to the Design of Anchor Blocks for Buried Pressure Pipelines, with minor revisions for use on representative soil samples extracted at several positions around the location where an anchor block is required.

D.4.1 Sample Preparation

Remove an intact lump of material (25 to 50 mm cube) from the undisturbed ground where an anchor block is to be installed.

i) If ground too hard to take sample - material is natural rock or is imported cement/bitumen bound.

ii) If sample will not hold together - material is natural un-cemented sand/gravel or is imported.

D.4.2 Sample Saturation

Gently place intact sample into water (jar/beaker) - avoid turbulence when entering water

i) If sample falls apart with external influence - material is natural un-cemented silt, sand or gravel

ii) If sample hold together for > 1 hour - material is natural fine-grained clay, cemented and/gravel or rock

D.4.3 Sample Remoulding

Remould sample under water – squeeze together using finger pressure

i) If sample can be remoulded - material is natural cemented sand or gravel

ii) If sample can be completely remoulded - go to Step 4

D.4.4 Sample Conditioning

Leave remoulded sample submerged - shake vigorously and allow to settle for 1 hour.

i) If majority of sample remains in suspension - material is mostly clay.

ii) If majority of sample settles on bottom of container - material is mostly loose sand, gravel or silt.

iii) If majority of sample remains floating on water surface - material is mostly organic.

D.4.5 Disturbed, Loose or Saturated Ground

The above procedures identify the soil type from Table D1 that is closest to the ground at the location where an anchor block is to be constructed. However, if the ground has recently been disturbed and is now excessively loose or saturated, the most appropriate soil type should be assumed to be the soil type in the next row down within Table D1.

Example: if soil identification procedures identified the ground as being soil type 4) Firm Clay, but the clay was found to be excessively loose or saturated at the time of construction, then the ground should be assumed to be soil type 5) Non-dense Granular Material or Dense Coarse Grained Soil. The required ground area needed to restrain the thrust force should therefore be determined using soil type 5) rather than soil type 4).

Appendix E – ANCHORAGE - SAMPLE INSPECTION SHEET AND RISK ASSESSMENT

E.1 This inspection sheet should be used where temporary anchorage has been installed and other suitable inspection forms are not available. It assumes that the design of the system has been carried out in accordance with this Management procedure.

LOCATION:	SIZE OF MAIN	PRESSURE IN MAIN	IS MAIN UNDER TEST?	IF MAIN UNDER TEST DURATION OF TEST	IS THE OPERATION A CUT-OUT?
			YES / NO		**YES / NO**

Type of Anchorage System used (Tick box)				
	Wooden Railway sleeper / Wooden Beam	☐	Concrete Block	☐
	Rectangular Hollow Section	☐	Other e.g. Pipe clamps	☐

	ITEM	INSPECTION				**ITEM**	**INSPECTION**		
		1ST	**2ND**	**3RD**			**1ST**	**2ND**	**3RD**
1	Is there heavy traffic adjacent to the works site, e.g. heavy lorries and buses or high numbers of cars and vans?				**7**	Are all PE fittings securely anchored?			
2	Are there any piling or other activities ongoing near the site which may affect the anchorage system?				**8**	Are non-end loaded fittings used on a PE pipe system			
3	Do any Prop, Strut, Shore, Acrow etc show any signs of movement?				**9**	Are there exposed bends in the excavation connected to the pressurised pipe work?			
4	Is there water in the excavation?				**10**	Are exposed bends adequately anchored?			
5	Do any beams, wedges etc show any signs of becoming dislodged?				**11**	Is there any movement of the pipe or fittings?			
6	Has any of the trench support system collapsed and /or moved?				**12**	Has the pressure in the main decreased or increased since the last inspection?			

Enter date of Inspections 1st ………………… 2nd ………………………… 3rd ……………………

Inspection completed by (Name) ………………………… **Signed** ………………………………

Figure E1 – Inspection Form

E.2 Inspection intervals

The Operational Manager should consider the elements above and determine the frequency of the inspections. As a minimum, inspections should be carried out as follows:-

- Immediately after the anchorage system has been completed and before pressurisation.
- Immediately after the pipework has been pressurised

- At the next time of attendance on site whenever the system has been left under test for more than 8 hours (e.g. overnight).
- The pressurised system, particularly in the case of MP and IP mains, should be visually examined at intervals (at least daily) to ensure that all anchorages are secure and that no hazard exists. It may be appropriate, to maintain a presence on site at all times to minimise the impact of failure; a site-specific risk assessment should determine whether or not this is necessary. This will depend on factors such as location, pressure and diameter.

E.3 Safety Considerations

- Inspections must only be visual and from the outside the excavation, on no account must anyone enter the trench whilst a main is pressurised to inspect or adjust the pipework or anchorage system.
- Consideration should be given to marking pipe work with spray paint in a contrasting colour or marker chalk to make it easier to identify any movement.
- Photographs taken of the pipe work and anchorage at every inspection will aid identification of any movement because it will allow comparison to be made more easily.

E.4 Actions to be taken if movement is identified. (Items 3,5,6,10 and 11)

Where it is identified that anchorage has moved from its original state, the operational manager must be informed immediately, and arrangements made to reduce the pressure in the main if it is under test or operating above 75mbar.

No entry into the excavation must be allowed until the Operational manager has confirmed that the pressure has been reduced to a safe level

Tightening of pipe work may commence once the pressure is at a safe level.

Removal and refixing of anchorage can only proceed if the pipe work is no longer pressurised.

E.5 Who should inspect the site

The inspection of the excavation and anchorage should be carried out by the team leader on site or another competent person appointed by the Operational Manger.

E.6 Inspection records

On completion of the inspection the check list must be returned to the Operational Manager who must file this record in the project file.

APPROVAL

This Management Procedure was approved by Bob Hipkiss on 17/12/2019 for use by managers, engineers and supervisors throughout Scotia Gas Networks (SGN).

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KEY CHANGES

Section	Amendments
All	Reports identified in the references section of this Management procedure have been used to completely revise the content of the T/PM/DIS 4.2 and chapter 5 of T/PM/MSL/1 which have been combined in one document. Developed as a replacement to section 26 of SGN/PM/MSL/1 Management Procedure for Mainlaying and servicelaying and T/PM/DIS 4.2
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MANDATORY AND NON-MANDATORY REQUIREMENTS

In this document:

must: indicates a mandatory requirement.

should: indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment must be completed to show that the alternative method delivers the same, or better, level of protection.

END NOTE

Comments

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