



high density polyethylene pipe

Sclairpipe®

Marine Pipeline Installation



**KWH
PIPE**

Introduction

Since its conception in Europe in 1959, large diameter polyethylene pipe has been used successfully in many marine pipeline installations all over the world. In North America, where large diameter SCLAIRPIPE® high density polyethylene pipe was introduced in 1968, it has been installed for varied marine applications, including river, lake and salt water crossings; both municipal and industrial fresh and salt water intakes and effluent outfalls. SCLAIRPIPE has also been used in underwater pipeline repair and rehabilitation situations.

Advantages of SCLAIRPIPE For Marine Installations

The following characteristics of SCLAIRPIPE make it particularly well suited for marine pipeline installations.

Flexibility – The flexibility of SCLAIRPIPE allows it to adapt to unconsolidated river bottoms and excavated underwater trenches without the need for expensive foundations or minor degree elbows.

Corrosion Resistance – Polyethylene is inert to salt water and to chemicals likely to be present in sanitary sewage effluent and it is highly resistant to levels of chlorine that are typically added to water intake lines.

Light Weight – SCLAIRPIPE's weight is approximately $\frac{1}{10}$ that of a similar sized concrete pipe. Handling it therefore requires a minimum of heavy equipment and can easily be assembled on ice and through wet marshy areas.

Floats – SCLAIRPIPE floats even when full of water. Long lengths can therefore be assembled on shore and then floated into position.

Integral, Waterproof Joints – The butt fusion method of joining provides an integral pipe-to-pipe joint without the need for mechanical connections. The integral fused joint provides continuous long lengths of SCLAIRPIPE without fittings, thereby eliminating the risk of joint leakage due to shifting of unstable river bottoms.



Continuous fused lengths of SCLAIRPIPE weighted with cylindrical concrete collars and stored floating in the water.

Contents

Introduction	2	Launching	8
Advantages	2	Pipe Without Ballast Weights	8
Planning the Job	3	Pipe with Ballast Weights	9
Joining Site Selection	3	Sinking of the Assembled Pipeline	10
Assembly	3	Preparation	10
Installation of Ballast Weights	4	Sinking the Floating Pipeline	11
Amount of Weight	4	Extra Buoyancy Requirements	12
Design of Weights	6	Post-Installation Survey	13
Protective Wrapping	6	Diffusers for Effluent Dispersion	13
Installation of Weights	7	Intake Structure	14
On-Shore	7	Underwater Mechanical Joints	14
On-Water	7	Installation of Marine Lines under Winter Conditions	15

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Planning the Job

As in all construction programs, it is necessary to adequately plan the operation to minimize delays. It is recommended that the Engineer/Contractor meet with a KWH Pipe representative to pre-plan the joining and installation segments of the contract. In this pre-planning meeting, it will be necessary to agree on the joining site selection and installation procedures to be followed.

Nearly all installations involve the following steps:

- 1) **Joining Site Selection** – pre-planning meeting.
- 2) **Assembly** – assembly of the individual lengths of pipe into a continuous (or a number of continuous) string(s) of pipe.
- 3) **Installation of Ballast Weights** – to assist in sinking and holding the submerged pipeline in the specified location.
- 4) **Launching** – moving the joined pipe into the body of water.
- 5) **Sinking** – locating the pipeline on the bottom.



Figure 1. Ballast weights being attached to a 48" SCLAIRPIPE line on shore, prior to launching of the pipe.

Joining Site Selection

The choice of a joining site is dictated by the general conditions of the surrounding terrain. A marine pipeline is usually assembled on land adjacent to the body of water in which it is to be installed. If this is not practical, the pipe may be joined at another more accessible location and then floated to the installation site. Long lengths of large diameter pipe have been towed up to 25 kilometers to the installation site. A joining site should be relatively flat to facilitate aligning the pipe in the joining machine. Sufficient area must be available to allow for the set-up of the joining machine and associated equipment and to provide a minimum of two pipe lengths between the fusion machine and the water's edge.

Pipe lengths delivered to the joining site should be stockpiled to one side prior to the arrival of the joining equipment. Details on recommended handling methods, stacking heights and ground preparation are detailed in the SCLAIRPIPE Construction Brochure.

Assembly

A pipeline fabricated from SCLAIRPIPE high density polyethylene pipe consists of individual pipe lengths joined by thermal fusion using specialized joining equipment. (See SCLAIRPIPE Construction Brochure for details of the joining process).

The actual assembly method will depend upon the nature of the joining site, i.e. profile, area available and ground stability. Any of the following techniques may be used:

- 1) Total assembly of the pipe on land into continuous lengths of convenient size for handling and launching. These lengths are often pre-flanged for connection on the water.
- 2) Assembly on land, with the joined pipe being launched into the body of water as it is joined. In this scenario, the contractor must provide adequate storage space for the continuous long lengths. Ballast weights are added later.
- 3) This method is similar to method (2), however, the ballast weights are added at the shoreline, immediately following the joining operation, before the pipe is launched into the water. (See Figure 1).

Where long continuous lengths of pipe are stored floating in a body of water, they must be protected from potential navigational hazards by installing flags and warning lights. Care should be taken to ensure that the floating pipe is not allowed to drift against rocks or structures which could damage both the pipe and any installed ballast weights. Consideration must be given to wind, tidal action or currents, with anchoring provided as required, to prevent any damage which could cause flooding and sinking. In a "join-and-launch" operation, care must be taken to ensure that the joining machine is located far enough back from the shoreline that movement of the pipe due to wave action will not affect the stability of the fusion machine or quality of the joints.

Installation of Ballast Weights

Amount of Weight:

Since polyethylene has a specific gravity slightly less than water, SCLAIRPIPE will continue to float even when full of water. For this reason, it is necessary to add ballast weights to provide sufficient negative buoyancy both to sink the pipe and to hold it in position on the bottom. The actual weight required, located at regular intervals along the pipe, depends upon several factors:

- 1) **The operating conditions** – The designer should consider whether or not the line may be emptied, producing a powerful positive buoyancy. This may be caused by air accumulation from pumps or dissolved air and/or by gases given off from chemical reactions.
- 2) **The action of currents and tides** – These actions can produce lift and drag forces on the submerged pipeline which must be compensated for.
- 3) **The stability of the bottom material** – The size of the ballast weights must be compatible with the bearing characteristics of the bottom. A heavy weight may cause the pipeline to sink into a soft bottom.

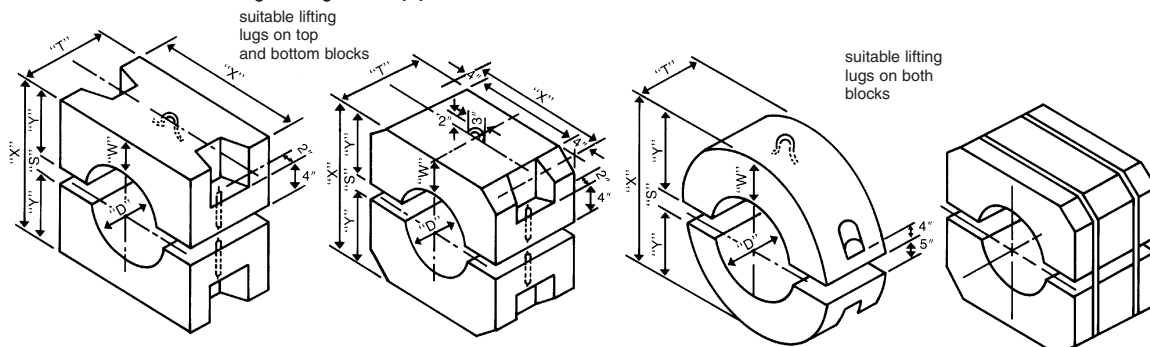
Tables 1 and 2 are designed to assist the Engineer in determining the degree of weight required to compensate for specific percentages of entrapped air.

TABLE 1 SUGGESTED CONCRETE WEIGHT DIMENSIONS (ALL DIMENSIONS IN INCHES UNLESS OTHERWISE STATED)

Nominal Pipe Size	Mean Outside Diameter (inches)	Spacing of Weights To Offset % Air (feet)			Approx. Weight of Concrete Block (pounds)		Approximate Block Dimensions (inches)						Bolt Dimensions (inches)	
		10%	15%	20%	In Air	In Water	"D"	"X"	"Y"	"T"	"S" (Min)	"W"	Dia.	Length
3 IPS	3.50	10	6 3/4	5	12	7	4	9	3 3/4	2 1/2	1 1/2	2 1/2	3/4	12
4 IPS	4.50	10	6 3/4	5	20	10	5	11	4 3/4	2 1/2	1 1/2	3	3/4	12
5 IPS	5.56	10	6 3/4	5	30	18	6	12	5 1/4	3 1/2	1 1/2	3	3/4	12
6 IPS	6.63	10	6 3/4	5	35	20	7 1/8	13	5 3/4	3 1/2	1 1/2	3	3/4	12
7 IPS	7.13	10	6 3/4	5	45	26	7 5/8	13 1/2	6	4 1/4	1 1/2	3	3/4	12
8 IPS	8.63	10	6 3/4	5	55	30	9 1/4	15 1/4	6 7/8	4 1/4	1 1/2	3	3/4	12
10 IPS	10.75	10	6 3/4	5	95	55	11 1/4	19 1/4	8 5/8	4 1/2	2	4	3/4	12
12 IPS	12.75	10	6 3/4	5	125	75	13 1/4	21 1/4	9 5/8	5	2	4	3/4	13
13 IPS	13.38	10	6 3/4	5	175	100	13 7/8	24	11	5 1/4	2	5	3/4	13
14 IPS	14.00	15	10	7 1/2	225	130	14 1/2	24 1/2	11 1/4	6 1/2	2	5	1	13
16 IPS	16.00	15	10	7 1/2	250	145	16 1/2	26 1/2	12 1/4	6 1/2	2	5	1	13
18 IPS	18.00	15	10	7 1/2	360	210	18 1/2	28 1/2	13 1/4	8 1/4	2	5	1	13
20 IPS	20.00	15	10	7 1/2	400	235	20 1/2	30 1/2	14 1/4	8 1/4	2	6	1	13
22 IPS	22.00	15	10	7 1/2	535	310	22 1/2	34 1/2	16 1/4	8 1/2	2	6	1	13
24 IPS	24.00	15	13 1/2	7 1/2	610	360	24 1/2	36 1/2	17 1/4	8 3/4	2	6	1	13
28 IPS	28.00	20	13 1/2	10	900	520	28 1/2	40 1/2	19 1/4	11 1/4	2	6	1	13
32 M	31.59	20	13 1/2	10	1,140	660	32	44	21	12 1/4	2	6	1	13
36 IPS	36.00	20	13 1/2	10	1,430	830	36 1/2	48 1/2	23 1/4	13 1/2	2	6	1	13
40 M	39.47	20	13 1/2	10	1,770	1,020	40 1/8	52	25	15 1/4	2	6	1	13
42 IPS	42.00	20	13 1/2	10	1,925	1,125	42 1/2	54 1/2	26 1/4	15	2	6	1	13
48 M	47.38	20	13 1/2	10	2,500	1,460	48 1/4	60 1/4	29 1/8	17	2	6	1 1/8	13
55 M	55.30	20	13 1/2	10	3,390	1,980	55 3/4	68	33	18 3/4	2	6 1/8	1 1/8	15
63 M	63.21	20	13 1/2	10	4,450	2,600	63 3/4	78	38	18 1/2	2	7 1/8	1 1/8	15

Notes:

1. Suggested underpad material
1/8" black or red rubber sheet
1/4" neoprene sponge padding
Width to be "T" + 2" minimum to prevent concrete from contacting pipe surface.
2. Concrete interior surface should be smooth (3000 psi - 28 days).
3. Steel pipe sleeves may be used around the anchor bolts (1" for 3/4" bolt, etc.). Hot dip galvanize bolts, nuts, washers and sleeves.
4. A minimum gap, "S", between mating blocks must be maintained to allow for tightening on the pipe.
5. To maintain their structural strength some weights are more than the required minimum.
6. Additional weight may be required for tide or current conditions.
7. Weights calculated for fresh water.
8. All concrete blocks should be suitably reinforced with reinforcing rod to prevent cracking during handling, tightening, and movement of weighted pipe.
9. See Table II for alternative weight design and suggested reinforcement for use with 28" to 48" SCLAIRPIPE.



The designs contained herein are based on calculations, information and experience believed to be reliable. KWH Pipe makes no guarantee of results and assumes no obligation or liability whatsoever in connection with these designs or their application.

Typical block fastened with stainless-steel strapping. All sharp corners must be suitably chamfered, with grooves to hold strapping in place.

TABLE 2 SUGGESTED DIMENSIONS AND REINFORCING FOR BOTTOM-HEAVY CONCRETE WEIGHTS

(for extra stability) (ALL DIMENSIONS IN INCHES UNLESS OTHERWISE STATED)

Nominal Pipe Size	Mean Outside Diameter (inches)	Spacing of Weights To Offset % Air (feet)			Approx. Weight of Concrete Block (pounds)		Approximate Block Dimensions (inches)						Bolt Dimensions (inches)	
		10%	15%	20%	In Air	In Water	"D"	"X"	"Y"	"Z"	"R"	"T"	Dia.	Length
28 IPS	28.00	20	13 1/2	10	900	520	28 1/2	44	19 1/2	26 1/2	48	7 1/2	1	54
32 M	31.59	20	13 1/2	10	1,140	660	32 1/8	48	21	28	51	8 1/2	1	57
36 IPS	36.00	20	13 1/2	10	1,430	830	36	52	23	30 1/2	55 1/2	9 3/8	1	61 1/2
40 M	39.47	20	13 1/2	10	1,770	1,020	40 1/8	56	25	33	60	10 1/4	1	66
42 IPS	42.00	20	13 1/2	10	1,925	1,125	42 1/2	59	26 1/2	34 1/2	63	10	1 1/8	69
48 M	47.38	20	13 1/2	10	2,500	1,460	48 1/4	64	29	39	70	11 1/2	1 1/8	76
55 M	55.30	20	13 1/2	10	3,390	1,980	55 3/4	72	33	43	78	12 3/4	1 1/8	84
63 M	63.21	20	13 1/2	10	4,450	2,600	63 3/4	80	37	47	86	14 1/2	1 1/8	92

Notes:

1. Minimum cover of rebar to be 2 1/2".
2. Rebar to be rail steel or equivalent.
3. Anchor bolt material to be ASTM A307.
4. It may be desirable to increase the amount of reinforcing used in the 55" and 63" pipe weights.
5. See recommended bore detail below.

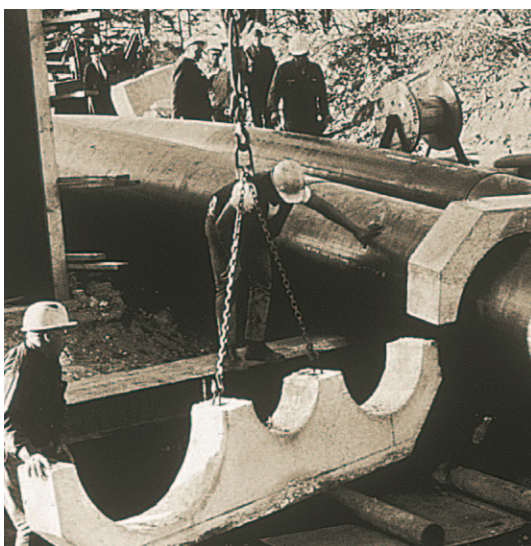
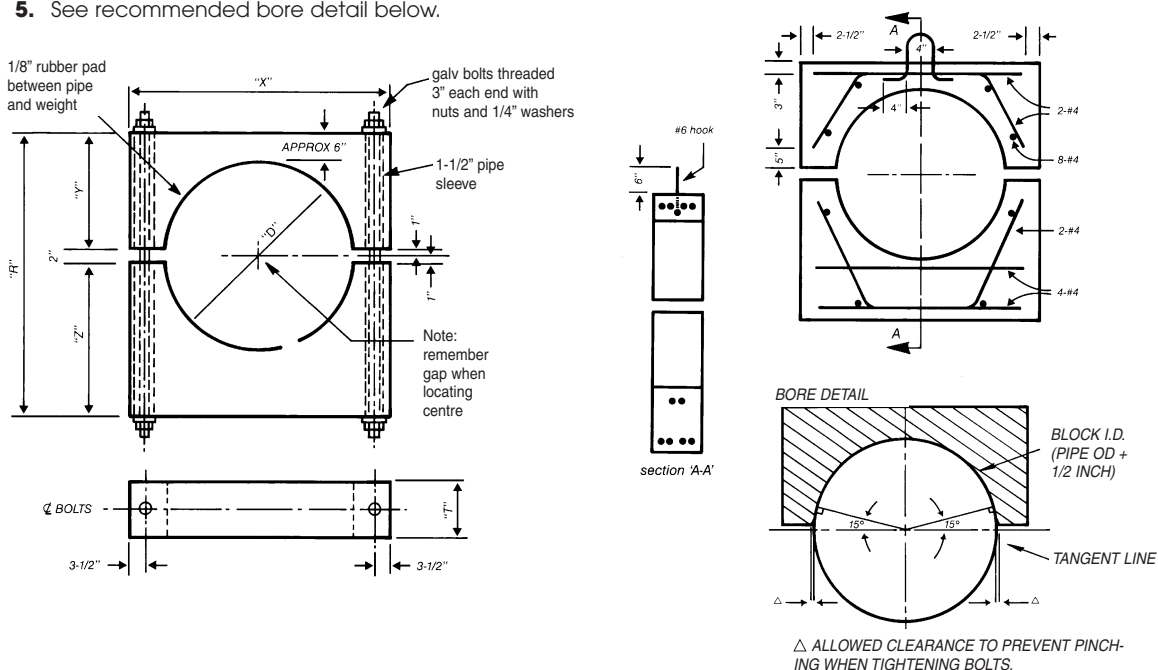


Figure 2: Lifting lugs incorporated into the top and bottom blocks assist in handling of concrete weights.



Figure 3: Installation of 24" SCLAIRPIPE for twin sewage siphon in Victoria, B.C. Specially designed concrete weighting collars, embracing the two pipes, were attached on the water and the lines were floated into position and gradually sunk.

Design of Weights:

While the actual design of the ballast block is the responsibility of the Engineer, some suggestions are outlined in Tables 1 and 2.

- 1) All concrete ballast blocks must be suitably reinforced with steel reinforcing rods to prevent cracking of the blocks as they are being fastened on the pipe.
- 2) The bore diameter of the block should be larger than the outside diameter of the pipe to allow for the protective wrapping (see following section). The pipe should therefore not be used as a form during the manufacture of the blocks without some allowance for this increase in diameter.
- 3) It is imperative that there be a gap between mating blocks to allow for tightening and compression of the protective wrapping. A gap of 1 1/2" for sizes up to 8" nominal diameter and 2" for all larger sizes, is recommended.
- 4) The ballast blocks may be fastened to the pipe in a number of ways. Stainless steel strapping or bolting is practical for sizes up to 8" nominal diameter and bolting is preferable for the larger sizes to provide a means of post-tightening the blocks a minimum of 24 hours after initial installation of the blocks.
- 5) Where a submerged line may be subject to currents or tidal effects, a round weight design should not be used as it may allow the pipe to "roll" on the bottom.
- 6) Where it is important that the line remain in a definite attitude, e.g. for an effluent line diffuser section which must float and sink with the diffuser risers in a vertical position, the engineer should design ballast collars with the lower block heavier than the top block. This lowers the center of gravity and provides an effective "keel" for the line, ensuring a stable configuration (see Table 2). Blocks of equal size and weight tend to twist because the submerged block is lighter in the water and this "top-heavy" condition can twist the pipe.
- 7) For all pipe other than small diameter pipe, it is advantageous to incorporate lifting lugs into the structure of the weights to assist in handling. (See Figure 2).
- 8) Where twin or even triple lines are installed together, one-piece ballast weights can be designed to embrace all the pipes, thus enabling the multiple lines to be sunk as a unit (see Figures 3 and 4). The installation of multiple pipes is limited to applications where the pipes are installed in the same horizontal plane.

Protective Wrapping:

To protect the surface of the polyethylene pipe and to provide some frictional resistance to prevent the weights from sliding along the pipe during sinking, the pipe should be wrapped with a suitable compressible material before the weights are installed. This protective wrapping should extend at least one inch beyond both edges of the concrete weight.

Some suggested materials for wrapping the polyethylene pipe are:

- 1) 1/4" thick neoprene sponge material (wet-suit material used by scuba divers).
- 2) Several wraps of 1/8" rubber sheet.
- 3) Suitable rubber carpet underpadding.

Note: Do not use polyethylene film as a wrapping material because of its slipperiness and non-compressibility may allow a ballast weight to shift and slide along the pipe.



Figure 4: Triple inverted sewage siphon of 20, 28 and 40 inch SCLAIRPIPE being installed in Galt, Ontario. Concrete weighting collars, embracing the three pipes, were attached on shore and the lines were floated into position and gradually sunk in a single operation.



Figure 5: Use of a skidway to convey 40" pipeline of SCLAIRPIPE to the water, allowing the weights to be moved along with the pipe with minimum drag.

Installation of Ballast Weights:

The concrete ballast weights may be installed either on shore or on the water; the choice of technique will depend upon the assembly operation and its limitations.

On-Shore Installation:

The ballast weights are installed on shore, usually as the pipe is launched from either the joining site or a subsequent storage location.

Depending upon the manpower available, a number of work stations can be set up to install weights at the same time. A suitable ramp or skidway, made from railroad track or steel beams, is normally required to allow the weights to be moved along with the pipe with minimum drag. (See Figure 5).

The concrete ballast weights should be stockpiled adjacent to the work station. Except for small diameter pipe, it is necessary to have adequate lifting equipment available to handle the weights from the storage area to the work station and to lift the pipe to allow for the weights to be positioned below it.

The following steps should be followed where possible:

- 1) Wrap the protective material around the pipe and tape the free end into position.

Note: On large diameter pipe, it has been found advantageous to install the protective pad material in two pieces. For the lower weight, a suitable piece of material is laid in the ballast block and the block lifted up against the pipe. The other half of the pad material is placed on the top of the pipe and the upper ballast weight lowered onto the pipe.

- 2) Position the lower ballast weight under the pipe and lift into position against the pipe.

Note: For small diameter pipe, this can be accomplished by simply lifting the pipe, but it is necessary to excavate under large diameter pipe to provide space to position the ballast weight.

- 3) Position the upper ballast weight on the pipe.

- 4) Tighten the mechanical connection (strapping or bolts) so that the weights are not free to move on the pipe.

For large diameter pipe, it is common practice to install more than one weight at a time. Usually, three or four weights are installed between lifts. The weights are positioned under the pipe using the excavated pocket and then moved along the pipe to their proper locations.

On-Water Installation:

The ballast weights are installed on the water, using low profile marine equipment (a barge or raft). This applies to pipe already in storage on the water.

The pipe is usually brought alongside a raft or low profile barge. The actual installation is similar to an on-shore operation except that the pipe is floating on the water and must be lifted to the raft to install the weights.

As each set of weights is installed, the pipe is returned to the water and another section moved onto the raft. The floating platform should be as close to water level as possible to reduce the need for lifting the weighted pipe. (See Figures 7 and 8).



Figure 6: Floating SCLAIRPIPE line complete with concrete weights being prepared for the sinking procedure.

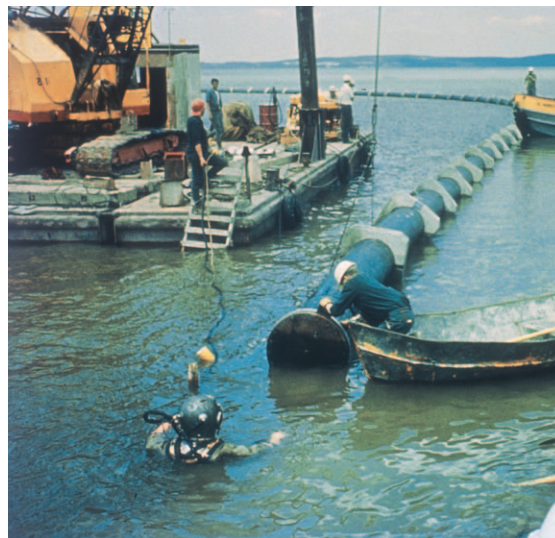


Figure 7: Installation of a 32" municipal outfall of SCLAIRPIPE at Prince Rupert, B.C. Concrete weighting collars were attached to the line by lifting successive sections of the pipe onto the raft.

Launching

Since the pipeline is expected to support the ballast weights in the water until the sinking operation, it is necessary to provide a “bulkhead” on each end of the pipeline to prevent water from entering the pipe. This is best accomplished by using a flange assembly and blind flange at each end. The flange assembly consists of a polyethylene stub end, butt fused to the pipe end and a slip-on metal flange. The blind flange, together with a compressible gasket, is bolted to the slip-on flange to provide an airtight seal. (See Figure 9).

Note: A number of tapped holes are required in each blind flange to allow for the installation of valves and other fittings required for the sinking operation. This is covered later in this brochure under the “Sinking of the Assembled Pipeline” section.

The pipeline is now ready to be launched into the water.

Pipe without Ballast Weights:

When the bulkheads are installed and the joined pipeline is stretched out on land adjacent to the water, the following steps should be followed:

- 1) Ensure that the ground over which the pipe must be moved is free of rocks and debris which might damage the pipe. If this is not possible, the pipe should be raised off the ground and installed on wooden dunnage or wooden rollers.
- 2) The pipeline should be moved to the water using suitable mechanical equipment. Under no conditions should the flange assemblies be used to pull the pipe. The operation is best accomplished using a combination of equipment pushing on the inboard end and other equipment lifting and pulling along the pipeline.
- 3) The pipe should be lifted using belly-band nylon slings, inverted “y” ropes or spreader beams with rope slings.
- 4) Suitable marine equipment will be required to control the floating pipeline as it moves out into the water.

Note: For a water crossing, it is often possible to install a winch on the opposite shore to assist in moving the pipe.

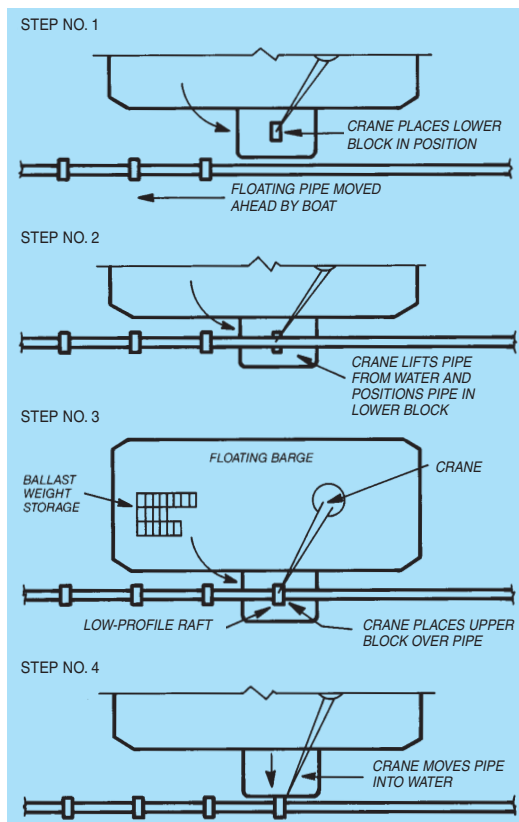


Figure 8: Installation of ballast weights from a raft.

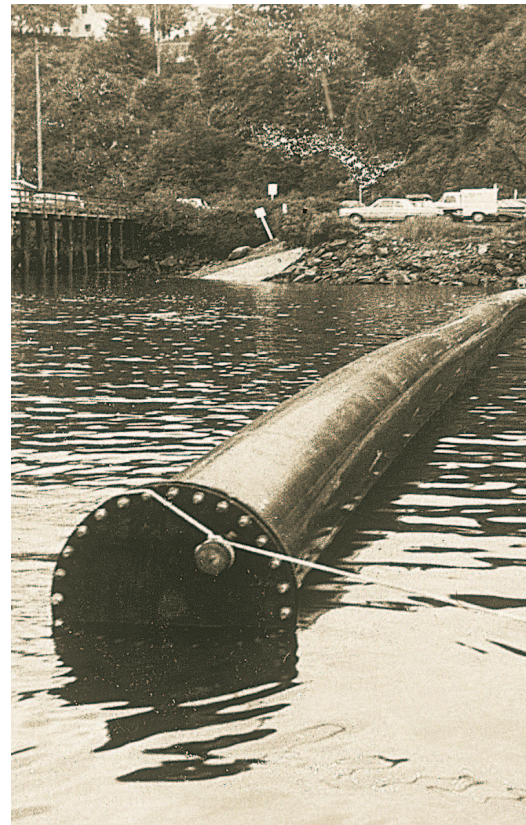


Figure 9: Use of bulkheads, consisting of flange assemblies and blind flanges, to prevent water from entering the line until the sinking operation.

Pipe With Ballast Weights:

The same steps apply, except that provision must be made for a ramp or a rail skidway arrangement to allow the ballast weights to move easily into the water without hanging up on the ground. This ramp must extend into water sufficiently deep that the ballast weight is supported by the floating pipe at the exit of the ramp, at various tide levels. Where pipe is being launched into a body of water subject to high currents, tidal currents or high wave action, it may be necessary to provide a positive anchoring system to hold the pipe while it is being launched. This anchorage system could consist of one or all of the following:

- 1) A system of guide cables (particularly for river crossings) - the pipe is tethered, at regular intervals, to a guide cable (or cables) which controls the amount of movement from any lateral thrust. (See Figure 10 (a)).

This system may also be required to hold the pipeline over the right-of-way while it is being sunk.

- 2) A system of heavy block anchors, positioned at intervals along the right-of-way, with tethers to the pipeline. (See Figure 10 (b)).
- 3) A system of piles, driven at intervals on either side of the proposed right-of-way, to which the pipeline is tethered as it is moved out into the water. (See Figure 10 (b)).

If it is not possible to delay navigation long enough to launch and sink a pipeline, it will be necessary to use other methods.

One method, which has been used successfully in such circumstances, is to launch the pipe without bulkheads and provide only sufficient ballast to ensure that the pipeline follows the river bottom profile as it is winched across. The leading end of the pipeline is equipped with a special "sled" arrangement clamped to the pipe itself. This sled provides both protection for the flange assembly and a means of streamlining the pipe leading edge to follow the river bottom profile. (See Figure 11 (a) and (b)). The best way to provide the ballast is by the addition of an external flexible steel plate running continuously under the bottom of the pipe, fastened at intervals by stainless steel strapping or by special low profile external weights. Thus, the ballast remains with the submerged pipe, helping to prevent entrapped air or gas from raising the pipe to the surface. If the threat of excess air or gas entrapment exists, additional ballast must be added after the sinking. (See Figure 12). Alternatively, the ballast can consist of steel reinforcing bars, suitably wrapped in burlap material and carefully pulled into the bore of the pipe prior to the launch. This ballast is subsequently dragged out after the pipe has been externally weighted and the pipeline trench has been suitably backfilled.

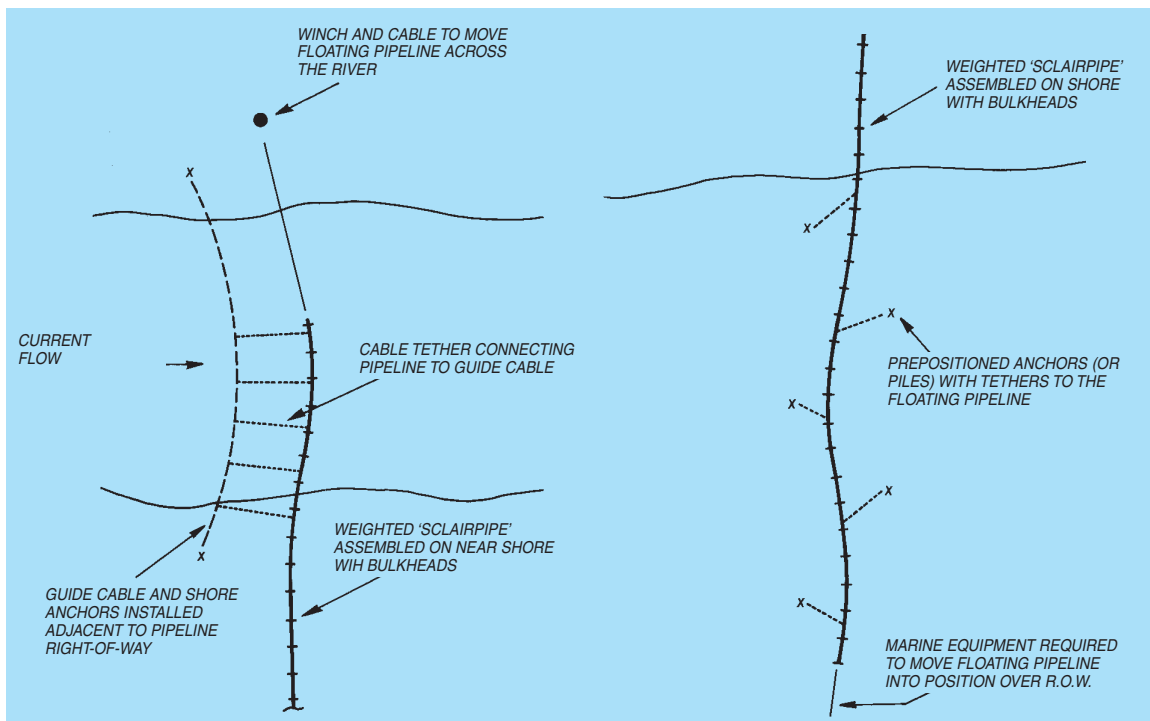


Figure 10: Suggested anchoring systems to assist with launching of marine pipelines of SCLAIRPIPE

(a) System of guide cables - useful for river crossings where high currents are a problem.

(b) System of positioned anchors (or piles) - useful for applications where prevailing winds and/or currents hinder the positioning of the floating pipeline.

Note: Pipeline must be held by the tethers during the sinking operation. Tethers must therefore be adjustable to allow pipeline to follow the bottom profile.

Note: Tethers must be adjustable so as not to restrict movement of pipeline as it travels out into the water, or during the sinking operation.

Where navigational problems prohibit the “float-and-sink” technique, a “bottom-pull” installation has been successfully used.

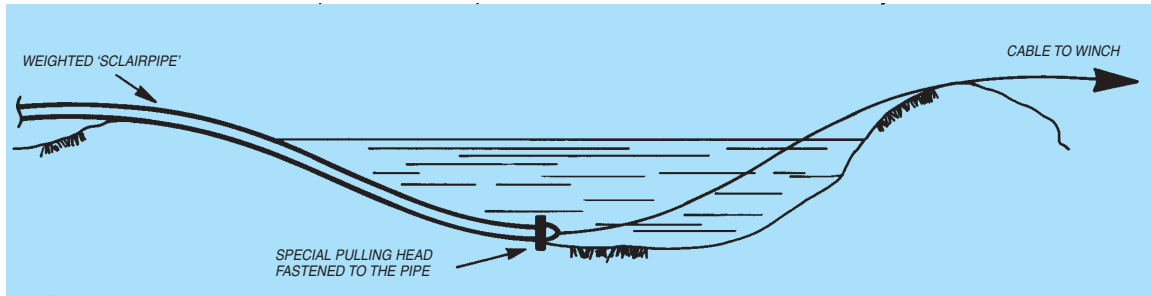


Figure 11(a): Alternative “bottom-pull” installation technique for marine line of SCLAIRPIPE

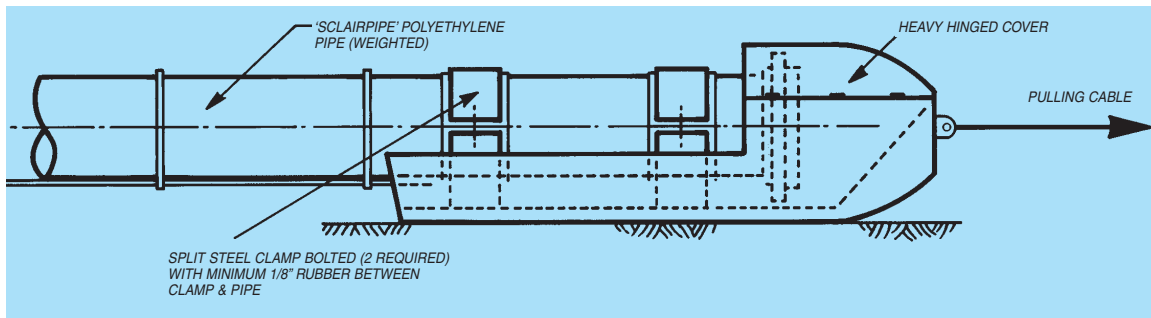
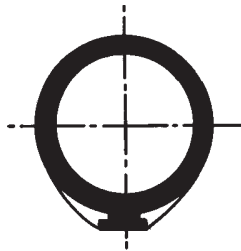


Figure 11(b): Suggested pulling head design for “bottom-pull”.

A. EXTERNAL STRIP WEIGHT

A continuous strip of steel plate is fastened to the bottom of the pipe by means of stainless-steel straps around the outside of the pipe. The pipeline must be adequately backfilled to offset any buoyancy effect due to the pipe itself and/or trapped air.



B. INTERNAL REMOVABLE WEIGHT

A continuous, flexible weight (wrapped to protect the surface of the pipe) which is removed once the pipeline is in place. The pipeline must be adequately backfilled to offset any buoyancy effect due to the pipe itself and/or trapped air.

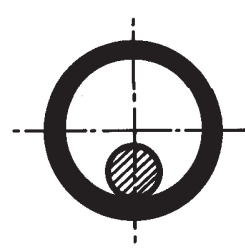


Figure 12: Methods of weighting SCLAIRPIPE for “bottom-pull”.

Sinking of the Assembled Pipeline

Preparation:

Regardless of whether the pipeline is to be buried in a trench or allowed to lie on the bottom, it is important that the “transition zone”, i.e. the area where the pipe leaves the shore and enters the water, be suitably trenched before starting the sinking operation. This trench should be large enough (both in depth and in length) to ensure that the pipeline is adequately protected from tidal scour, undertow action, drifting ice and wave action.

The basic sinking operation involves the addition of water to the floating line, through one end and the evacuation of the entrapped air through the opposite end. This operation requires suitable control over the water entry to ensure that:

- 1) The water does not run the entire length of the line and cause the outboard end or mid portions of the line to sink first.
- 2) Air does not become entrapped, forcing the line to “hump” between the point of entry and the end of the line.
- 3) The pipeline sinks at a rate which will allow it to adjust to the bottom profile without bridging.

For river, lake or salt-water crossings, the pipe extremities are usually positioned on opposite shores. It should be remembered that as the pipe sinks to take up its new position on the bottom, additional pipe will be required from the shore to make up the difference. Therefore a length greater than the width of the crossing will be required to provide sufficient pipe to cross the gap. Some of this additional pipe will require ballast weights.

If the pipe ends are to be attached to fixed connections on shore, one end should be fastened to one of the fixed connections (without the bulkhead) and arrangements should be made to feed water to the pipe to control its rate of sink.

The opposite end may be fastened to the connection if accurate surveys have established the exact amount of pipe required to cross the gap, following the bottom contours. This information is not usually available, however, and it is therefore necessary to leave the end unconnected with allowance for additional pipe onshore. The final connection can only be made once the submerged line has taken up its actual position on the bottom.

Making the final connection may involve the addition or removal of pipe; this can be accomplished in several ways:

- 1) Estimate the length required and install a flange assembly on the pipe end. Any discrepancy will require either the use of a flanged spool piece to add to the length of the pipe or the removal of an excess of pipe and the installation of a new flange assembly using the fusion equipment.
- 2) Leave the pipeline longer than required with the intention of adjusting the length once the pipe is in position. This will also require the fusion equipment.
- 3) Where permitted, provide more pipe than required and allow it to snake in a curve on the bottom to accommodate the difference.
- 4) Install the final manhole after the pipeline is in place.

Sinking the Floating Pipeline By Filling with Water:

Once the pipeline has been located over the allowable right-of-way, the sinking operation may begin. Where both ends of the pipeline are located on land, the water may be introduced through either end, whichever is most convenient. It is recommended that an intake or outfall should always be sunk by introducing the water at the shore end. If the line must be sunk from the off shore end, final adjustments to the overall length of the pipe will be necessary. The terminating flange assembly must be connected after the pipeline has been sunk. Often this is a difficult and time consuming procedure.

It is important that the water be added to the pipeline at a controlled rate (with some allowance for water shut-off), so that the rate of sink can be kept under control. For a pipeline crossing a body of water, the water can be added very simply by pumping into the open pipe end on the shore. Where the shore end connection is located below water level, it is very important that the water entry be kept under control to prevent a rush of water into the pipeline. This can be accomplished in several ways:

- 1) Installing a blind flange inside the connecting structure, such as a manhole, with appropriate valves to introduce water at a controlled rate.
- 2) If the flow of water into the connecting structure can be controlled, the rate of sink of the pipe can be controlled by simply adding water to the structure.
- 3) If the flow cannot be controlled and there is no provision for adding a blind flange, it may be necessary to fabricate and install an inflatable plug in the end of the pipe, with appropriate fittings to allow for the addition of water at a controlled rate; or, alternatively, to provide a wooden bulkhead nailed to the pipe end with holes to allow for water entry.

To prevent water from running the full length of the pipeline, it is necessary to induce a water pocket at the shore end. This is normally accomplished by lifting and holding the pipeline at a point off shore, so that it is just clear of the water. The water introduced into the pipeline fills the inboard end, allowing that section of the pipe to sink. Once the pocket is filled with water and the inboard section has sunk, the pipe is slowly released and allowed to seek equilibrium in the water. (See Figures 13 and 14). Additional water can then be added at a controlled rate to continue sinking the pipeline.



Figure 13: Sinking of a SCLAIRPIPE outfall line at Gravenhurst, Ontario. Pipe was lifted at a point off shore to induce a water pocket in the line. This controlled the rate of sink by preventing water from running the full length of the pipeline.

Note: The rate at which water is added to the pipeline is important, as too fast a rate will cause the pipeline to sink without being able to take up the bottom contours. As a result, the pipeline will “bridge” between high spots, leaving the pipe subject to movement from underwater currents. A rule of thumb is a sinking rate maximum of 1000 ft./hr. for large diameter pipe.

While water is being added at the on shore end, air must be allowed to escape from the opposite, or seaward, end. This is best accomplished by installing one or more valves in the blind flange bulkhead. As a safety measure against water gaining entrance to the pipe through these valves, a length of air hose is often connected to the valve and the end is supported by a float (or boat) above water. This can be removed later by a diver.

Note: In case of emergency, these valves can be used to assist in refloating the line: compressed air can be pumped into the submerged line to force out the water and thus assist in raising the line.

With sufficient planning and careful operation, this sinking procedure will minimize the time required for placing the pipe on the bottom.

Example: A 2,600 foot 40 inch nominal diameter outfall of SCLAIRPIPE was sunk without difficulty in a two-hour period using two pumps delivering a total of 1,250 gallons/minute.

Caution:

If an air pocket or “hump” develops in the pipeline during the sinking operation, it will be necessary to remove the entrapped air before continuing with the sinking operation. The flow of water to the pipeline should be shut off immediately and arrangements made to carry out the appropriate corrective action, as outlined below:

1) Minor Air Pocket - in Early Stages of Development

If the information of the air pocket is noticed early in its development, it should be possible to eliminate the entrapped air by providing a vent in the top of the pipe. This is best accomplished by drilling a $\frac{1}{2}$ "- $\frac{5}{8}$ " hole (or holes) through the pipe wall. If necessary, these holes can be plugged or sealed with a wrap-around clamp once the pipeline is in position on the bottom.

Note: This technique is intended for use with non-pressure lines and should not be used for marine lines intended for use at moderate or high pressures.

2) Major Air Pocket - Pipe Sunk on Either Side of the Hump

In this situation, the drilling of holes through the pipe wall should be discouraged as it may result in one or all of the following:

- a) an uncontrolled rate of sink
- b) with its longitudinal movement restricted, the pipe will tend to fall to one side, thus imparting some torsional loading
- c) the displaced pipe may fall outside the allowable right-of-way
- d) the discharge end (or intake structure) may be seriously dislocated

One proven technique used to correct this problem involves pumping compressed air through the outboard bulkhead, forcing the water back over the hump. (**Caution** - under no circumstances should the air pressure in the line exceed half the rated working pressure of the line). With its water content reduced, the pipe is allowed to rise. Once sufficient water has been evacuated and the pipe is back in position on the surface, the sinking operation can be continued.

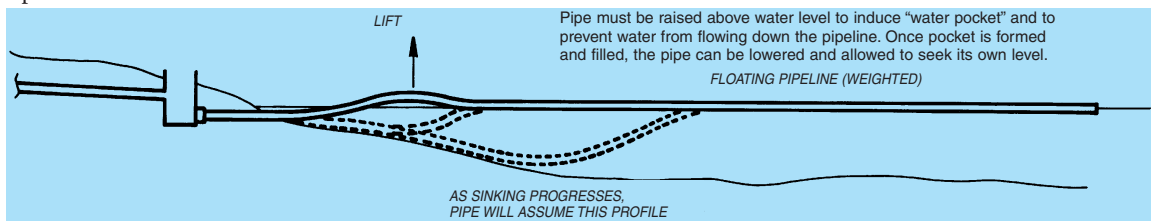


Figure 14: An induced water pocket is required when sinking a line of SCLAIRPIPE

Note: Position of lift to start water pocket should be as close to shore as possible but will depend on pipe size and flexibility. Lift can be made from shore or from a barge-mounted crane.

Extra Buoyancy Requirements:

Where it is necessary to install ballast weights of a heavier design than recommended in Table 1 to compensate for bottom currents and undertow, it has been found advisable to provide some positive buoyancy to ensure that the minimum bending radius of the pipe is not exceeded during the sinking operation. This additional buoyancy is released once the pipeline has been located on the bottom.

Buoyancy can be provided by use of a variety of equipment including:

- a) metal buoyancy tanks
- b) empty 45 gallon drums
- c) large blocks of rigid plastic foamed material

This extra buoyancy is usually attached to the pipeline at the ballast weight location, in a manner permitting convenient underwater detachment.

Post-Installation Survey

Once the pipeline has been lowered to the bottom, it is advisable to have the complete line surveyed by competent divers to ensure that:

- 1) The pipeline is located within the allowable right-of-way.
- 2) The line has been allowed to follow the bottom contour, and is not seriously bridging any depressions on the bottom. All ballast weights should be on the bottom to best resist any lifting forces due to currents.
- 3) For an outfall line, all diffuser risers are intact and in a vertical position.
- 4) Any lines fastened around the pipe during the sinking process have been removed together with any other apparatus required (e.g. air hoses and buoyancy blocks).
- 5) For a pipeline lowered into a prepared trench, the pipe is located in the centre of the trench and is not resting on any debris or rocks which could harm the pipe. Any such debris should be removed.

It may also be necessary to check the grade of the submerged line and adjust the depth of the trench as required.

- 6) Where the pipeline is backfilled, the backfill operation has not damaged the pipe and the required depth of cover has been provided.
- 7) In the transition zone, where the pipe leaves the shore and enters the water, the pipe is well positioned in the trench, at the proper depth required for protection from tidal scour and drifting ice.

Diffusers for Effluent Dispersion

Effluent outfall pipelines usually terminate in one or more diffuser sections. These are of many different designs, such as:

- 1) **Y or T outlet**, consisting of a pre-fabricated end structure bolted to the pipe end. (See Figure 15 (a)).
- 2) **Simple diffusers**, consisting of straight lengths of pipe with circular holes (3"-6" diameter) cut in the pipe wall, either at the 12:00 o'clock position or at a variety of locations above the "springline" between the 9:00 o'clock and 3:00 o'clock positions. (See Figure 15 (b)).
- 3) **Diffusers with vertical risers**, located usually at the 12:00 o'clock position, terminating in a variety of fittings. This design is usually intended for use in areas where the diffuser section is to be backfilled leaving the risers exposed (to reduce the possibility of damage from navigational hazards), or where the diffuser section is subject to heavy silting action. (See Figures 15 (c), 16 and 17).

When the "simple diffuser" is used, it is necessary to support the weighted diffuser section with some additional buoyancy apparatus as a precaution against water entering the diffuser holes and causing the pipe to sink prematurely. As the pipe is sunk into position, this additional buoyancy is released. Some protection against filling through wave action is also required, e.g. with wrapping or temporary plugs strapped to the pipe.

When vertical risers are installed, no additional buoyancy is required. However, to prevent an in-rush of water as each diffuser is submerged, the diffuser outlets should be covered with a temporary, watertight material to be removed when the pipeline is safely on the bottom.

To ensure that the diffuser assumes and maintains the correct attitude on the bottom, it is advisable to use a ballast weight design which incorporates a heavier section for the bottom half of the two-part weight. (See Section under "Installation of Ballast Weights").

Outfall assemblies that lie on the bottom without backfill stability and are subject to the actions of currents and/or tides should have ballast weighting in excess of that recommended in Table 1. Where weights cannot be attached directly to the line, external ballast blocks may be used with tethers to the line.

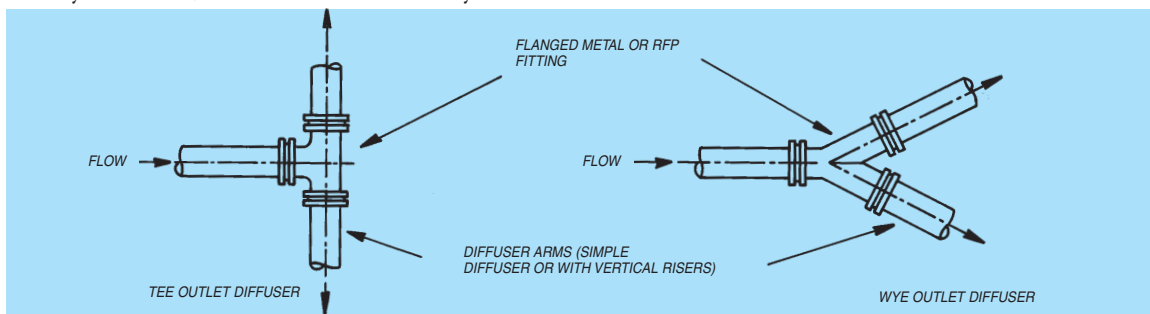


Figure 15 (a): Tee and Wye Outlet.

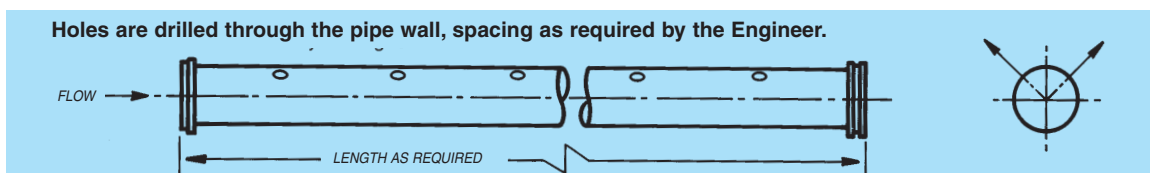


Figure 15 (b): Simple diffuser.

An all-polyethylene riser is fused to the diffuser to allow for burial of the diffuser and/or for possible silting.

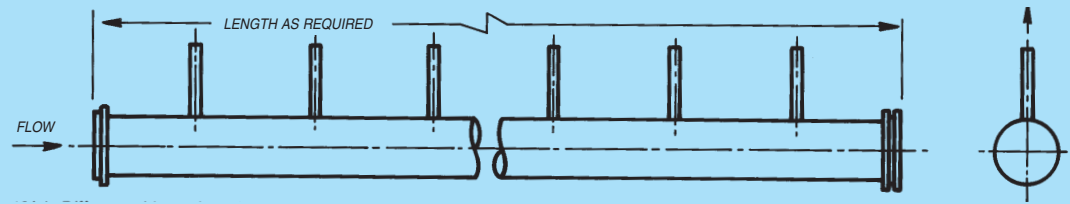


Figure 15 (c): Diffuser with vertical risers.

Note: 1) Diffuser can be made up of any number of pipe lengths which can be joined by butt fusion into a continuous length.

2) Diffusers are usually designed to be connected to the outfall line by a flange assembly and usually terminate with a flange assembly and blind flange. This allows for clean out and/or future extension.



Figure 16: Typical vertical riser construction. The all polyethylene riser is socket fused to the line of SCLAIRPIPE and an additional section of larger diameter SCLAIRPIPE is placed over the riser and extruder welded to the outfall pipe for reinforcement.

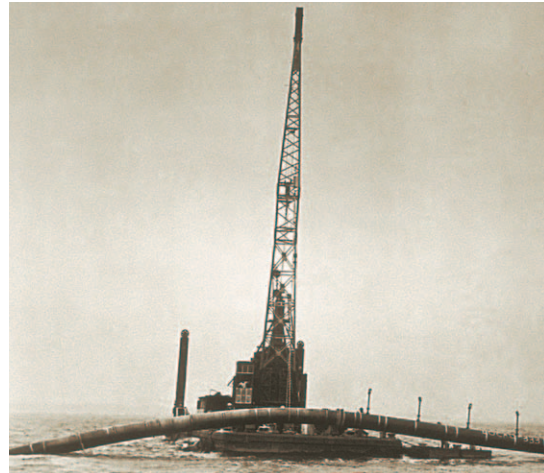


Figure 17: Installation of a 36" outfall of SCLAIRPIPE at Erie, Pa. Vertical risers were fused to the diffuser.

Intake Structures

Intake structures incorporating fish screens, frazil-ice deflectors or inverted water pick-up devices (to minimize silt entrapment) are often heavy, cumbersome assemblies. It is usually not recommended that these structures be lowered with the line. Instead, the structure is normally lowered into place by a barge mounted crane and connected by a flange assembly to the pipeline. When the line is excessively deep for diver safety, it can be lifted at the end to meet the assembly 10 to 15 feet below the surface; buoyancy drums or blocks should be attached to the ballast collars to minimize dead weight on the lift from the bottom. Where intake structures are sunk with the pipeline, additional buoyancy is required to help support the weight. Structures must be designed to rest on the bottom with full support against tipping or current oscillation. This support must be provided by means other than the pipeline. (See Figure 18).

Underwater Mechanical Joints

Because of the flexibility of SCLAIRPIPE and the ability to butt fuse continuous long lengths, the need for underwater mechanical joints is usually eliminated; however, it sometimes will be necessary to join lengths with a bolted connection. The use of a slip-on type metal flange assists in lining up the bolts as the flange can be rotated as required. To simplify the making of an underwater mechanical joint, use of the following equipment is suggested:

- 1) **Special Back-up Flanges** - Special back-up flanges can be fabricated containing a reduced number of bolt holes and/or a slotted bolt hole with a recess to accept the washer.
- 2) **Wooden ring to Help Line Up Bolts** - For the larger pipe sizes, the sub-end flange diameter does not match the bolt circle and for this reason some difficulties have been experienced by divers in attempting to line up the two flanged ends under water. One satisfactory solution is to install a wooden ring over the stub-end flange to assist in lining up the bolts and thus the stub ends. (See Figure 19). This ring is left in place after the connection has been made.
- 3) **Prefabricated Flange Adaptors for Connections to Underwater Structures** - Although the standard mechanical connection for SCLAIRPIPE is a flanged joint, it is advisable to use prefabricated flanged adaptors to make connections to underwater structures. The flanged connection to the SCLAIRPIPE can be made on shore before the pipe is sunk and the tie-in made via a simple connection, i.e., a typical sub-aqueous joint. (See Figure 20).

Note: The installation of the gasket material between the flange assemblies is best accomplished by fastening the gasket to the face of one stub end, using a contact cement, before the pipe is lowered into the water. Care should be taken to ensure that the cement is applied in a smooth coat, free of dirt and bumps.

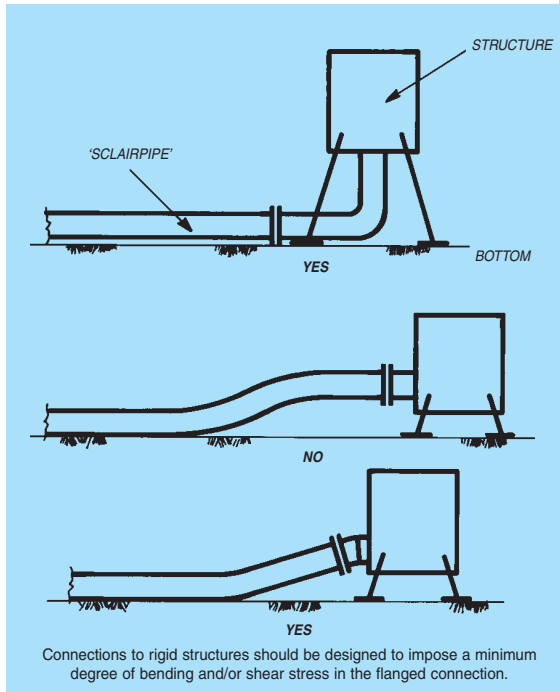


Figure 18: Suggested connections to intake structures.

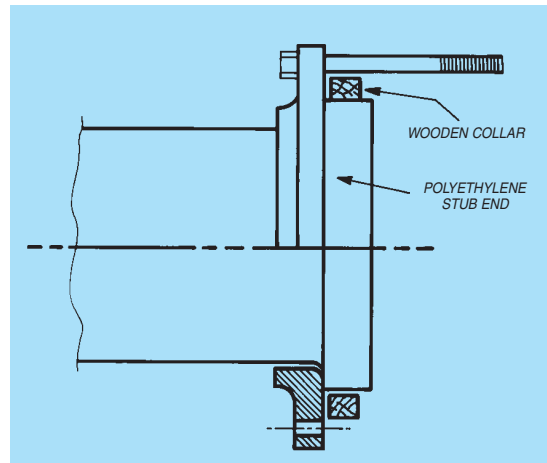


Figure 19: Suggested "collar" to assist in alignment of flanged joints.

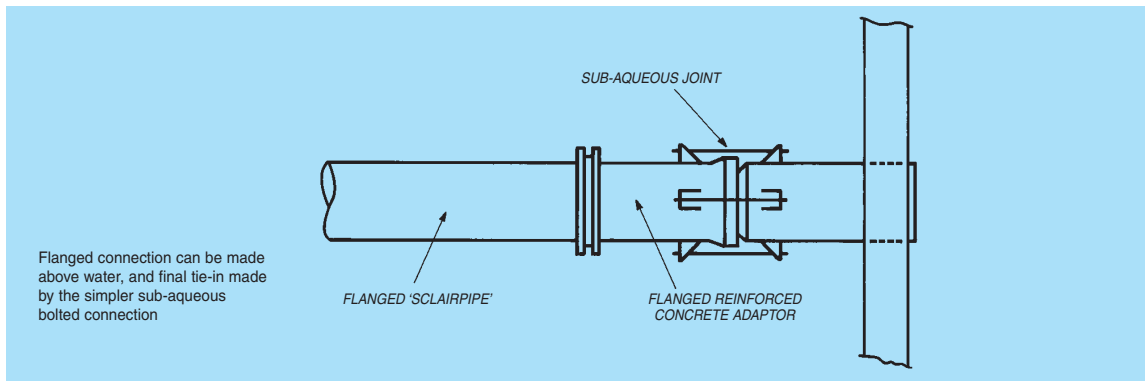


Figure 20: Suggested special underwater connection to structures.

Installation of Marine Lines Under Winter Conditions

Because of the light weight, flexibility and toughness of SCLAIRPIPE, contractors have found it particularly useful for winter installation of pipelines.

Where ice conditions permit, the pipe can be joined on the ice by butt fusion and the assembled pipe pulled easily out onto the ice alongside the right-of-way. Once the pipe joining is completed, the concrete ballast blocks can be installed, as required, along the pipeline by working on the ice.

The ice trench is cut with an ice saw, the ice blocks are removed and placed away from the edge and the pipe is moved into the trench.

The standard sinking technique can be followed. As described in a section under "Sinking the Assembled Pipeline", a "water pocket" must be induced in the pipe to ensure that an air "hump" is not formed during the filling operation. (See Figure 21).

Note: In some installations where the water depth is minimal, a trench has been excavated in the bottom by using machinery working from the ice above.

The only special precaution required when installing the pipe in cold weather is that the butt fusion process should be carried out in an adequately heated shelter to ensure fusion joint quality.



Figure 21: Installation of 28" water intake line of SCLAIRPIPE at Lac-des-Ecorces, Quebec. The pipe was weighted with concrete collars and allowed to sink through a cut in the ice.

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Printed in Canada 03/02