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TECHNICAL REPORT

ISO TR 11295

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Techniques for rehabilitation of pipeline systems by the use of plastics pipes and fittings

Techniques de réhabilitation des réseaux de canalisation au moyen de tubes et raccords plastiques

Reference number
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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 11295, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*.

For further information, see "Introduction".

Introduction

This technical report was prepared by TG 1 of ISO/TC 138/WG 12, *Rehabilitation of pipeline systems*.

The technical report describes methods of rehabilitation of pipeline systems which are "state of the art" and those still under technical development. This is the reason which led to the decision to publish this document in the form of a Technical Report type 3.

In the past 10 years rehabilitation of pipeline systems has become increasingly important.

Pipe systems are constantly required to satisfy physical, chemical, biochemical and biological demands. These demands depend on planning, material, construction, type and period of use.

When pipe systems have become operational they need proper system management. Next to inspection and cleaning, rehabilitation of the pipeline may be required. Rehabilitation is carried out when the performance of the pipeline system needs upgrading. It can consist of repair, renovation and replacement.

In September 1988, a task group of ISO/TC 138/WG 12 started preparing drafts for the standardization of plastics pipes and their constituents (fittings) used for rehabilitating pipe systems.

This Technical Report is meant to be a reference document for future ISO system standards on this matter. It will therefore have to be updated regularly.

The future International Standard will specify the characteristic requirements and methods to test pipes and fittings and/or their constituents used in renovating pipe systems. The International Standard will contain several subdivisions depending on the field of application.

Techniques for rehabilitation of pipeline systems by the use of plastics pipes and fittings

1 SCOPE

This Technical Report outlines methods of rehabilitation of non-pressure or pressure pipeline systems by the use of plastics pipes and their constituents involving:

- Renovation of existing pipeline systems, using one of the optional lining techniques, or
- Replacement of existing pipeline systems, using one of the optional trenchless techniques

2 DEFINITIONS

For the purpose of this Technical Report, the following definitions apply:

Pipeline system	The interconnecting pipe network for the conveyance of fluids e.g. water, sewage, gases, industrial flows (including slurries)
Rehabilitation	All aspects of maintaining or upgrading the performance of existing pipeline systems (maintenance, repair, renovation, replacement)
Maintenance	Maintaining the performance of pipeline systems (e.g. inspection, cleaning)
Repair	Rectification of local damage to the fabric of the pipelines or their joints (e.g. sealing)
Renovation	Methods by which the performance of pipeline systems is improved by incorporating the original fabric. (e.g. by inserting or applying a lining into the existing pipeline)
Replacement	Methods by which a new pipeline is constructed by replacing the original fabric

Design category	Categorisation of the behaviour of lining systems (see clause 6)
Grouting	Filling of the annular space between existing pipe and lining

3 SURVEY, PLANNING AND PRE-CONSTRUCTION

It is necessary to consider the condition of the existing pipeline in order to determine any required actions that must be taken to rehabilitate the pipeline system i.e. repair, renovation or replacement.

These measures would:

- Assess the hydraulic and structural condition of the pipeline system.

- Establish position, line and level of the existing system with regard to cross-section, length, material, junctions and laterals.
  . The system plan should be suitably amended when these facts are known.

- Establish the type of soil strata and expected changes in the groundwater table.

- Select the design category and the most appropriate technique.

- Set up planning and timing of construction so that the work proceeds efficiently.

- Allow for maintenance of continuity of flow during construction when considered advisable (e.g. methods and provision for storm flow).

- Inform residents of the possible environmental effects such as noise, traffic congestion and interruptions.

- Define costs and requirements of maintenance after completion.

4 MATERIALS

For rehabilitation the following plastics pipes reinforced or non reinforced or their constituents are generally used:

- Thermoplastics e.g. polyvinylchloride, polyethylene, polypropylene

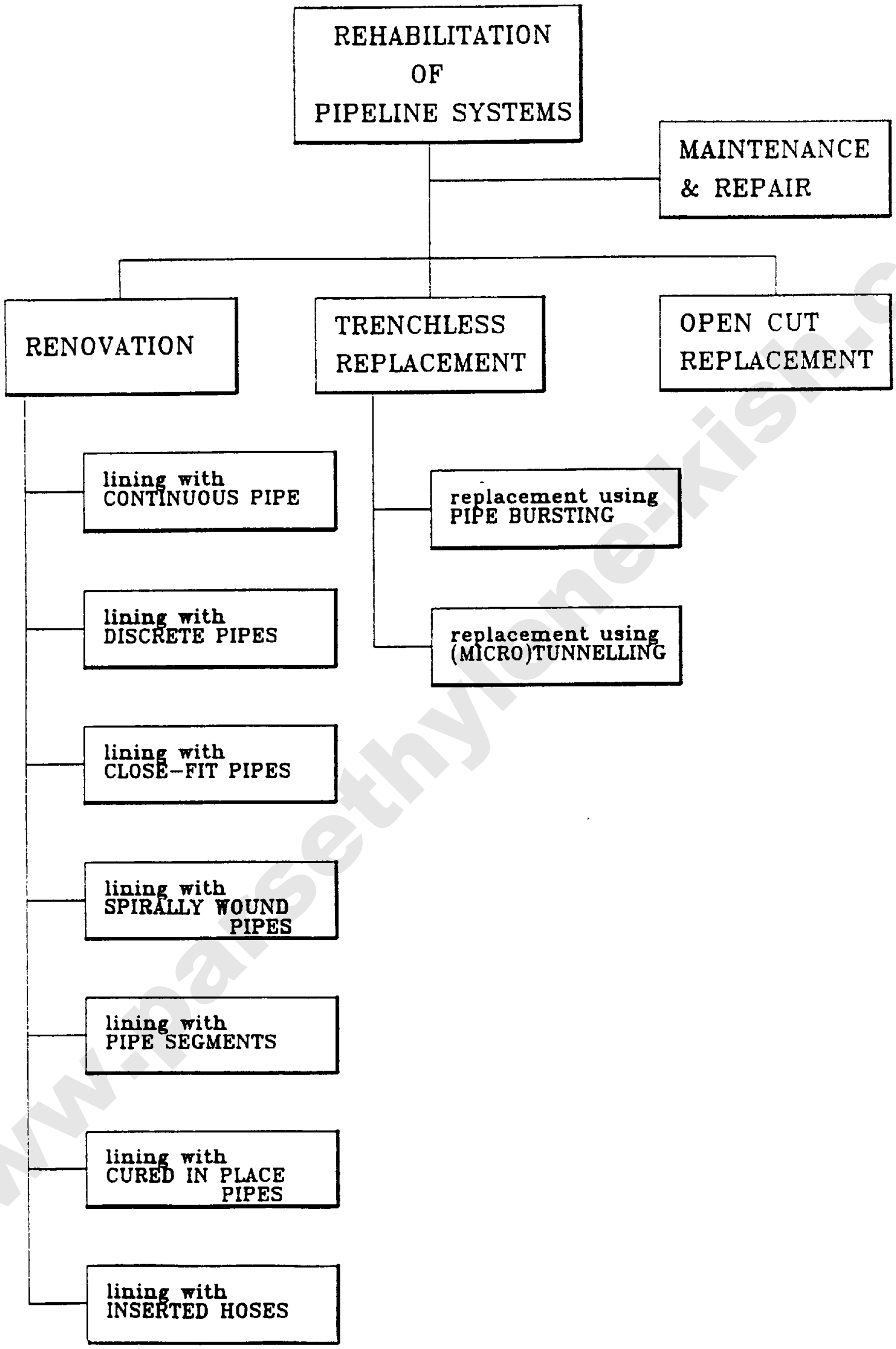
- Thermosets e.g. polyesters and epoxies

Combinations of the above are possible.

5 TECHNIQUES

5.1 General

This sub clause decribes the features of relevant rehabilitation methods. The various rehabilitation groupings are shown diagrammatically as follows:



A distinction has been made between:
- Renovation techniques (5.2) and
- Replacement techniques (trenchless) (5.3)

Note: Maintenance & repair and (traditional) open cut replacement techniques are not further dealt with in this document.

A further subdivision has been made into the following "families":

- Lining with continuous pipe lengths (5.2.1)
- Lining with discrete pipes (5.2.2)
- Lining with close-fit pipes (5.2.3)
- Lining with spirally wound pipes (5.2.4)
- Lining with pipe segments (5.2.5)
- Lining with cured in place pipes (5.2.6)
- Lining with inserted hoses (5.2.7)

- Replacement using pipe bursting (5.3.1)
- Replacement using micro-tunnelling (5.3.2)

The families are presented schematically on the following pages in the form of tables.

Note: The materials referred to are those in general use but not intended to be exclusive.

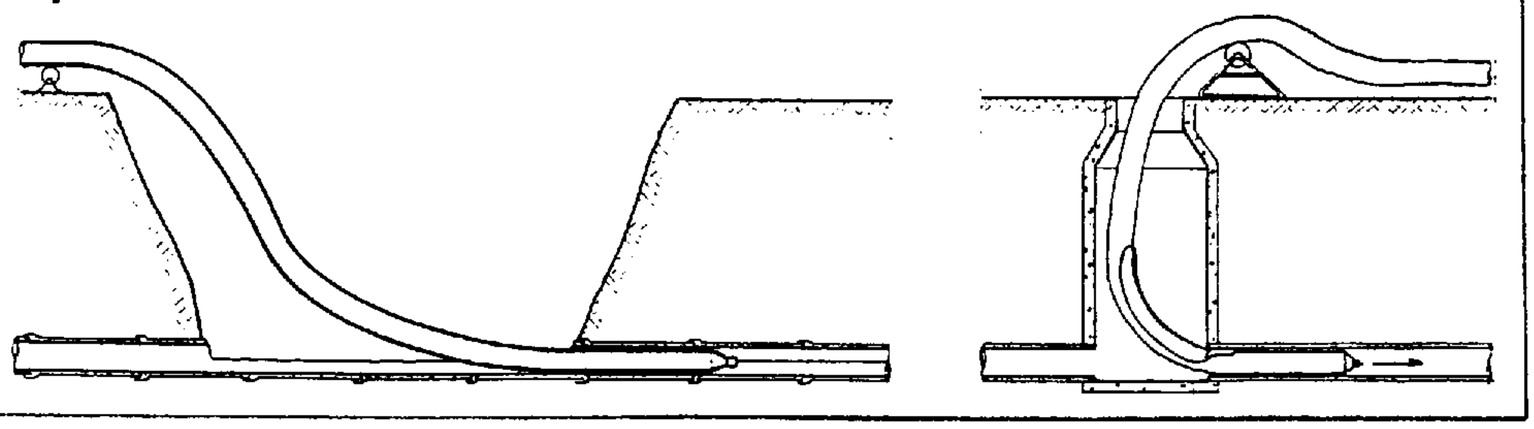
5.2 RENOVATION (LINING) TECHNIQUES

5.2.1 LINING WITH CONTINUOUS PIPE

FAMILY	: Lining with continuous pipe
DESCRIPTION	: Insertion into the existing pipeline of a single continuous pipe lining or jointed sections to form a continuous pipe
GENERAL APPLICATION	: Gravity and pressure pipelines

MATERIALS	: PE, PP, PE/EPDM, PVC
CHARACTERISTICS (GENERAL)	: - diameter range: up to 1600 mm - pipes manufactured or prior assembled into the continuous length required - in the case of pressure lines, so-called live insertion is optional; supply is continued via a by-pass or through the annular space - reduction in capacity : may be significant, dependent on liner pipe diameter and wall thickness (may be compensated e.g. by increasing the pressure) - lining can be accomplished either via an insertion pit or via a manhole (in the case of sewers); the latter requires a pipe with sufficient axial flexibility - in the case of gravity lines annular space usually grouted - lining is capable of accommodating (large radius) bends - method can be carried out by any pipe contractor relatively low degree of skill
OTHER CONSIDERATIONS	: . simple method . low investment . few joints

INSTALLATION METHOD (GENERAL) :



5.2.2 LINING WITH DISCRETE PIPES

FAMILY : Lining with discrete pipes

DESCRIPTION : Installation of individual pipes which are shorter than the section to be renovated and which may be jointed outside or in the pipeline to form a continuous lining

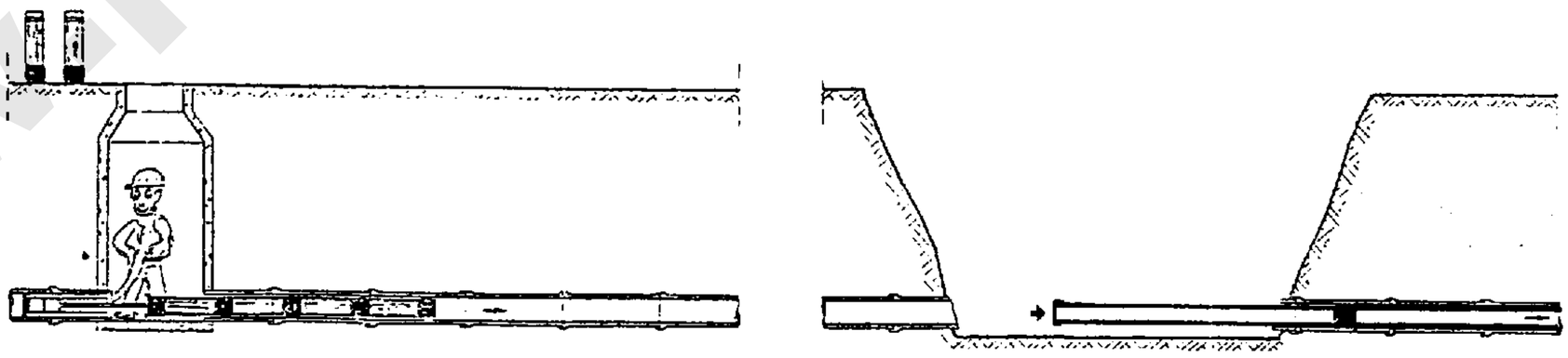
GENERAL APPLICATION : Gravity and pressure pipelines

MATERIALS : PE, PP, PVC, GRP (-EP & -UP)

CHARACTERISTICS (GENERAL) :
- diameter range: from 100 mm up to 4000 mm
- pipes assembled with sealed, loose or tensile resistant (locked) joints
- insertion pit can be avoided (with short lengths), so no-dig possible
- reduction in capacity: may be significant by applying purpose made shaped pipes (oval, obovate) the reduction can be kept to a minimum
- annular space generally grouted
- method can be carried out by any pipe contractor/ by any municipality : relatively low degree of skill

OTHER CONSIDERATIONS : . simple method . many joints
. low investments

INSTALLATION METHOD (GENERAL) :



5.2.3 LINING WITH CLOSE-FIT PIPES

FAMILY : Lining with close-fit pipes

DESCRIPTION : Insertion of a temporarily reduced diameter or reshaped pipe which is reverted to provide a lining with a close fit with the existing pipe

GENERAL APPLICATION : Pressure and gravity pipelines

MATERIALS : PE, PVC

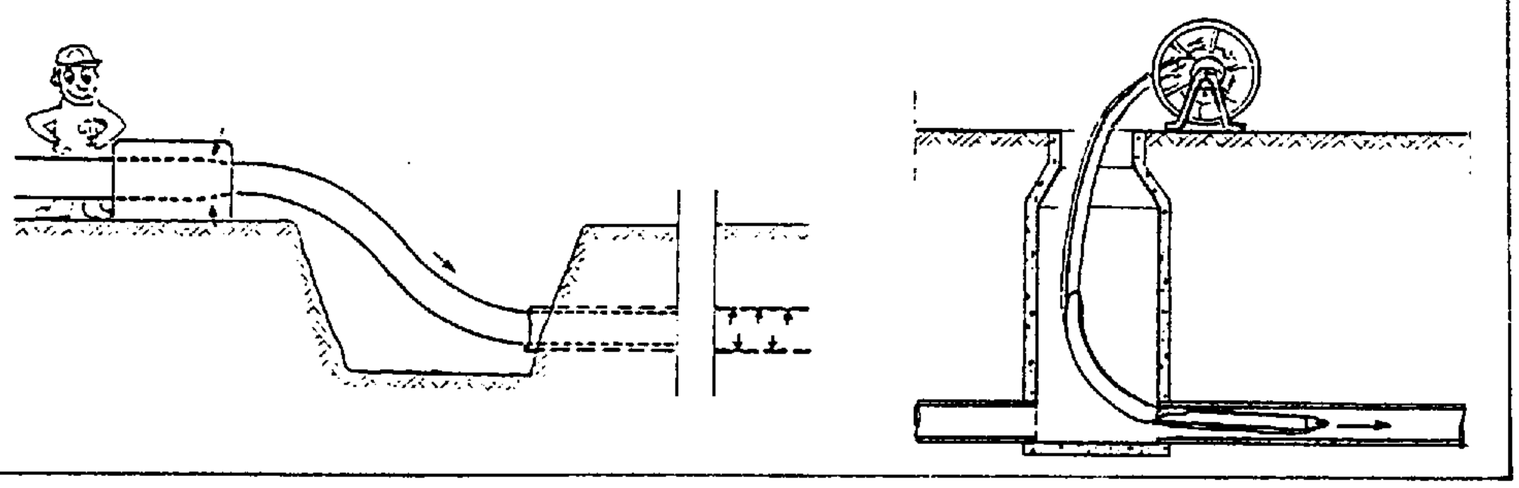
CHARACTERISTICS (GENERAL) :
- diameter range: up to 600 mm
- lining pipe first reduced in size (on site or in the manufacturing plant) inserted and then reverted by heat/pressure or naturally
- reduction in capacity: minimal, if any
- lining can be accomplished either via an insertion pit or via a manhole (in the case of sewers), the latter requires a pipe with sufficient axial flexibility
- no grouting required
- lining is capable of accommodating (large radius) bends
- methods differ substantially in required degree of expertise

OTHER CONSIDERATIONS :

. few or no joints
. can be installed in long lengths

. structural damage (collapse/misalignment) to existing pipe can cause problems
. lateral connection may be difficult

INSTALLATION METHOD (GENERAL) :



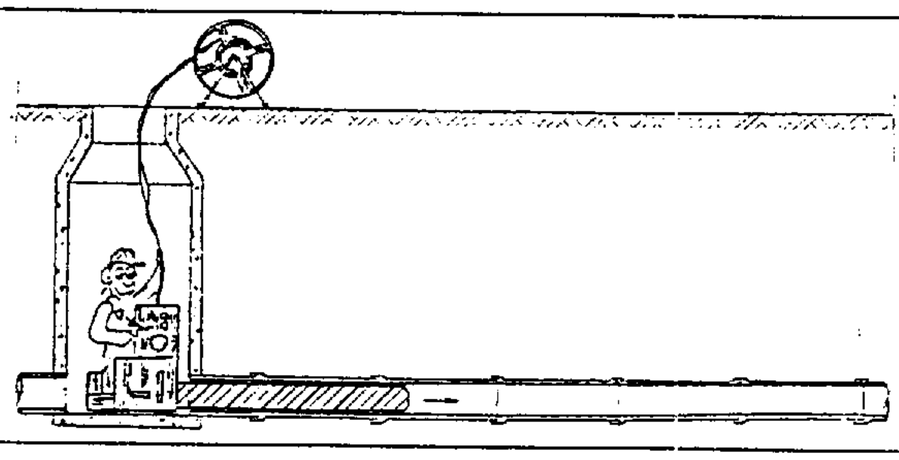
5.2.4 LINING WITH SPIRALLY WOUND PIPES

FAMILY	: Lining with spirally wound pipes
DESCRIPTION	: Installation of a lining made from profiled strip spirally wound to form a continuous pipe
GENERAL APPLICATION	: Gravity pipelines only

MATERIALS	: PE, PVC, PP, PVDF
CHARACTERISTICS (GENERAL)	: - diameter range: from 100 mm up to 2500 mm - lining pipe formed on site by spirally winding a strip - access via manholes possible - reduction in capacity may be significant*) - grouting of annular space required*) - lining is capable of accommodating (large radius) bends - method requires some skill; trained personnel to operate the winding equipment
OTHER CONSIDERATIONS	: . no pipe storage on site . any diameter can be selected (within range of winding machine) . trained personnel . continuous fusion or solvent welded or mechanical joint

*) For a specific, expandable lining method, which is under technical development, these items may or may not apply.

INSTALLATION METHOD (GENERAL) :



5.2.5 LINING WITH PIPE SEGMENTS

FAMILY : Lining with pipe segments

DESCRIPTION : Installation of a lining made up of at least two pieces with longitudinal and circumferential joints

GENERAL APPLICATION : Gravity pipelines only

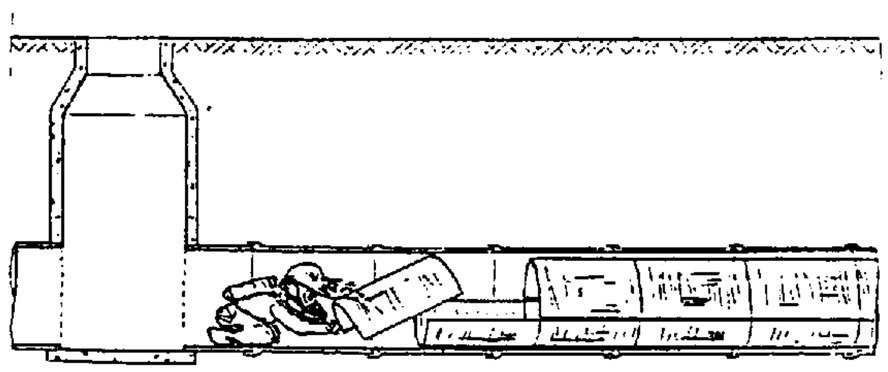
MATERIALS : GRP, PE, PP

CHARACTERISTICS (GENERAL) :
- diameter range: from 900 mm
- segments assembled by hand inside a man-entry pipe line
- non-circular capability
- entry via (existing) manholes
- reduction in capacity may be significant
- grouting of annular space generally required
- lining is capable of accommodating (large radius) bends
- method can be carried out by any pipe contractor: relatively low degree of skill

OTHER CONSIDERATIONS :

. simple method	. many joints
. low investment	. only in man-entry pipelines
. non-circular shapes can be coped with	. low productivity
	. products differ per project
	. high integrity grouting required

INSTALLATION METHOD (GENERAL) :

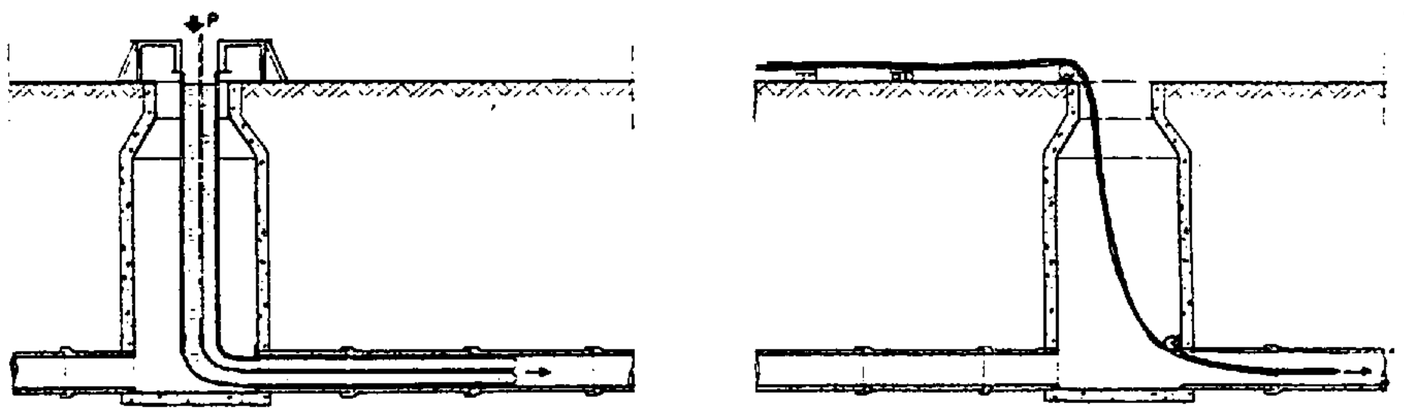


5.2.6 LINING WITH CURED IN PLACE PIPES

FAMILY	: Lining with cured in place pipes
DESCRIPTION	: Insertion of a resin impregnated hose*) which produces a lining after resin cure
GENERAL APPLICATION	: Gravity pipelines and pressure pipelines

MATERIALS	: A composite consisting of a reinforced or unreinforced fabric matrix, coated with thermoplastic material, impregnated with thermosetting resin
CHARACTERISTICS (GENERAL)	: - diameter range: up to 2500 mm - a specially prepared hose is impregnated with resin fed into the existing line, inflated and cured - entry via existing manhole or small excavation - reduction in capacity: minimal, if any - no grouting - lining is capable of accommodating bends - relatively high degree of skill; trained personnel with special equipment required
OTHER CONSIDERATIONS	: . no joints . non-circular shapes can be accommodated . trained crew of operators . purpose-made hoses . groundwater infiltration to be controlled during lining process . sealing may be required when cut . curing period could be extensive

INSTALLATION METHOD (GENERAL) :



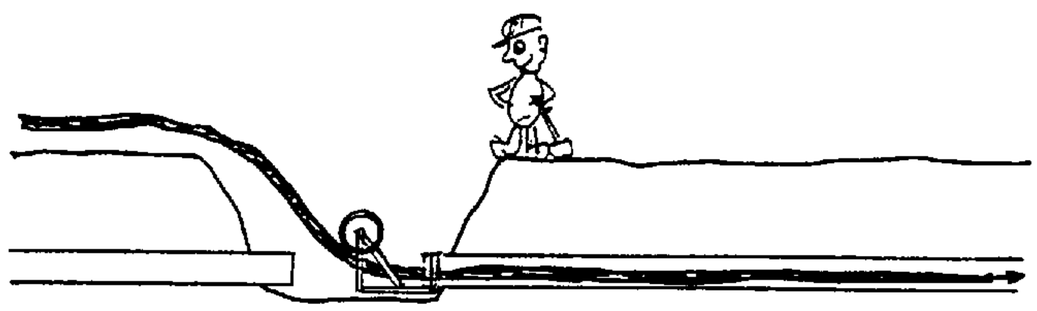
*) Coatings are not in the scope of this report.

5.2.7 LINING WITH INSERTED HOSES

FAMILY	: Lining with inserted hoses
DESCRIPTION	: Insertion of a loose fit reinforced hose to provide a pipelining when fluid is transported under pressure
GENERAL APPLICATION	: Pressure pipelines only, relying on integrity of existing pipe

MATERIALS	: PE or polyurethane hose with textile reinforcement
CHARACTERISTICS (GENERAL)	: - diameter range from 100 mm up to 355 mm - lining to provide leakage prevention - loose hose pulled into existing pipeline and remains collapsed until pressurized - entry via existing access or small excavation - lining is capable of accommodating (large radius) bends - reduction in capacity: minimal, if any - no grouting
OTHER CONSIDERATIONS	: . simple method . no joints . lining can be reeled . leak prevention only . lateral reconnection may be difficult . lining collapses when non-pressurized

INSTALLATION METHOD (GENERAL) :



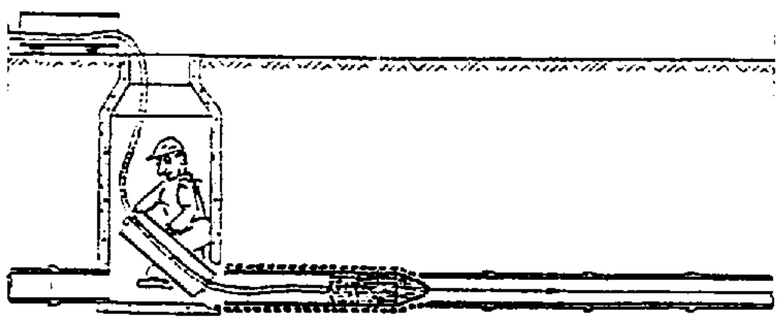
5.3 REPLACEMENT TECHNIQUES (TRENCHLESS)

5.3.1 REPLACEMENT USING PIPE BURSTING

FAMILY	: Replacement using pipe bursting
DESCRIPTION	: Replacement of an existing pipeline by breaking and displacing it to form a cavity to allow a new pipe to be installed in that cavity
GENERAL APPLICATION	: Pressure and gravity pipelines

MATERIALS	: PE, PP, PVC, GRP
CHARACTERISTICS (GENERAL)	: - diameters: up to 450 mm - old pipe is burst or cut (hydraulically or pneumatically) by radial jacking forces and a new pipe is pulled or pushed in behind - with insertion pit (continuous length) or via a manhole (discrete pipes) - no reduction in capacity; even increase possible - a crew of trained operators is needed - in replacement of metal pipe systems a sleeve pipe is usually employed (to protect the inserted pipe lining from damage)
OTHER CONSIDERATIONS	: . structural damage of existing line no problem . no-dig possible . laterals have to be disconnected beforehand lateral connection carried out from excavation . change in surround conditions (loading) . risk of damaging services and building constructions

INSTALLATION METHOD (GENERAL) :



5.3.2 REPLACEMENT USING MICRO-TUNNELLING

FAMILY	: Replacement using micro-tunnelling
DESCRIPTION	: Installation of a new pipe using (remote) steerable excavation or displacement equipment
GENERAL APPLICATION	: Gravity or pressure pipelines (depending on method)

MATERIALS	: PE, PVC, PP, GRP
CHARACTERISTICS (GENERAL)	: - diameter range up to 900 mm - remote excavation by tunnelling machine, fluid jet cutter, soil displacement equipment to remove the old pipe to create a cavity into which a new pipe can be installed - shaft or insertion pit required depending on method - lining is capable of accommodating (large radius) bends - relatively high degree of skill (specialized crew with special equipment)
OTHER CONSIDERATIONS	: . a new pipe is installed using a trenchless technique . little surface disruption . shaft or insertion trench required . obstacles may cause problems

INSTALLATION METHOD (GENERAL) :

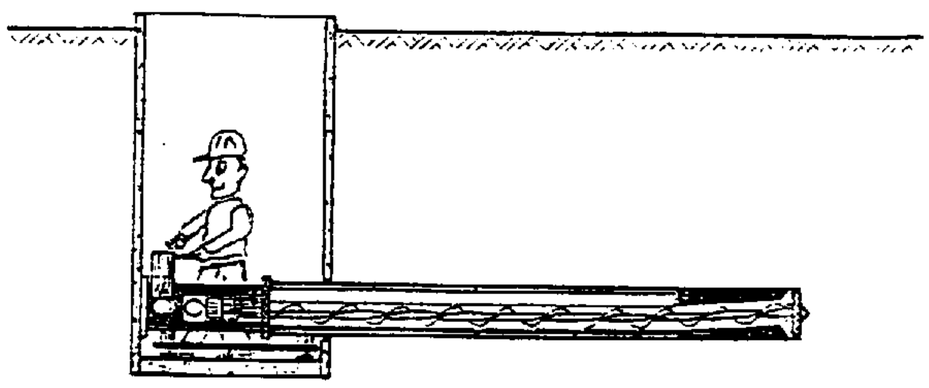


Table 1 - General application area per Technique Family

Techniques (families)	Gravity pipelines	Pressure pipelines
Lining with continuous pipe lengths	v	v
Lining with discrete pipes	v	v
Lining with close-fit pipes	v	v
Lining with spiral wound pipes	v	
Lining with pipe segments	v	
Lining with cured in place pipes	v	v
Lining with inserted hoses		v
Replacement using pipe bursting	v	v
Replacement using micro-tunnelling	v	v

6 DESIGN ASPECTS

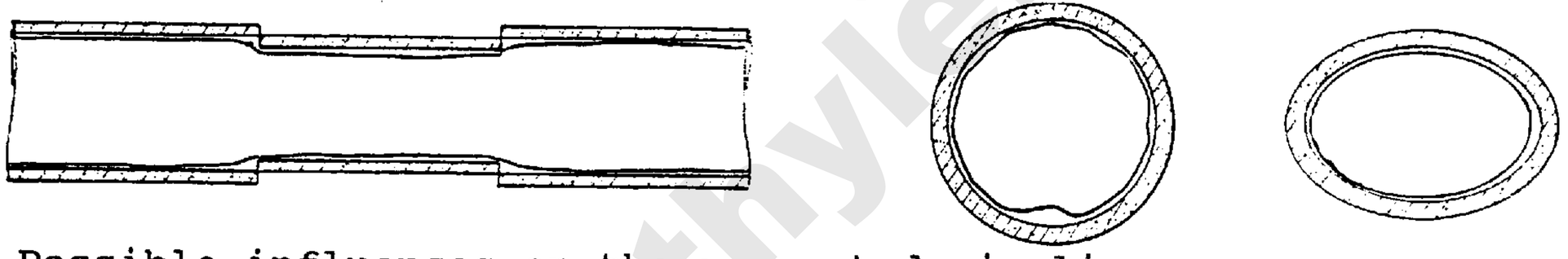
Note:
The renovation and replacement of pipelines requires a range of solutions to solve a range of problems. A technique which offers an ideal solution to one problem may be totally inappropriate for another. Therefore, it is important to categorise the behaviour of lining systems. This will assist specifiers to select solutions appropriate to their needs whilst appreciating design assumptions.

6.1 General

Note:
This clause concerns interactive forces between the existing pipeline and the lining which may influence the behaviour of the renovated pipe.

6.1.1 Geometry

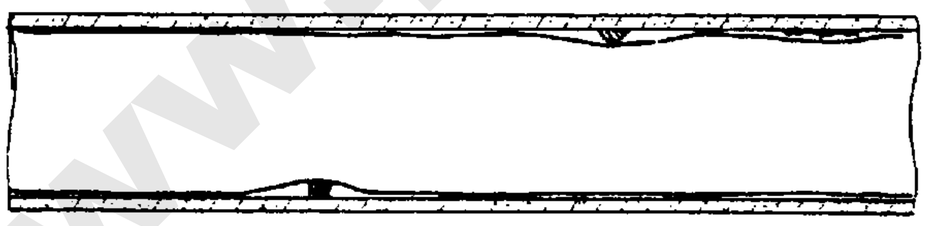
Geometrical consideration include:
- internal diameter of the existing pipeline
- cross sectional shape (ovalization)
- variations of the diameter along the pipe axis



Possible influences on the renovated pipeline:
- undesired/innappropriate annular space
- wrinkles
- excessive stresses or strains in the lining

6.1.2 Surface characteristics

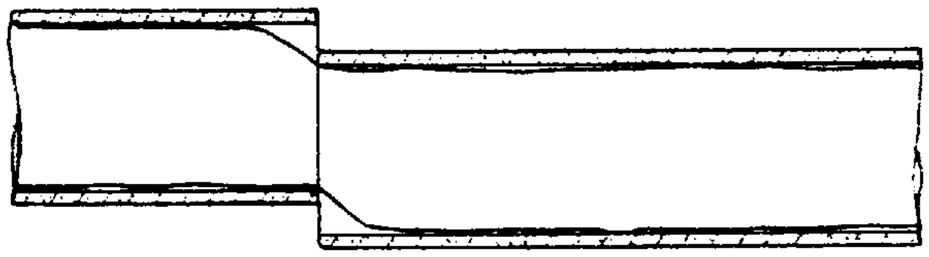
Surface consideration include:
- surface cleanliness
- obstacles (e.g. roots, dust, welds, connections)



Possible influences on the renovated pipeline:
- undesired friction or interference to the lining during installation or operation
- insufficient bond between existing pipeline and lining

6.1.3 Relative displacement between different parts of the existing pipeline

Displacement considerations include:
- joints and assemblies
- misalignment before and after installation
- differential thermal expansion of the existing pipeline and the liner



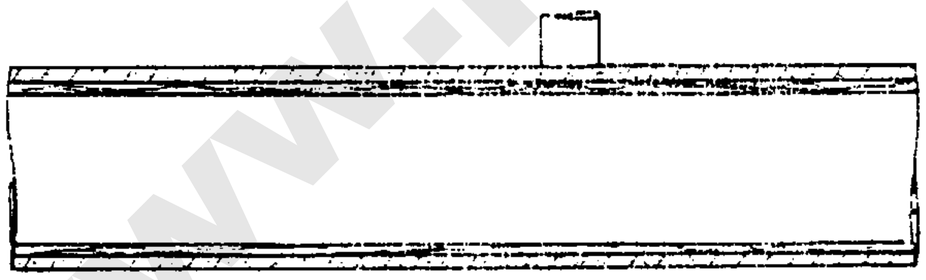
Possible influences:
- additional loads generated (tension, shear...)
- lining exposed to the soil
- alteration of stress distribution in the renovated pipeline

6.1.4 Leaks

Leakage may occur from outside (existing pipeline/ground water) and from inside (conveyed fluid) due to damage of lining.

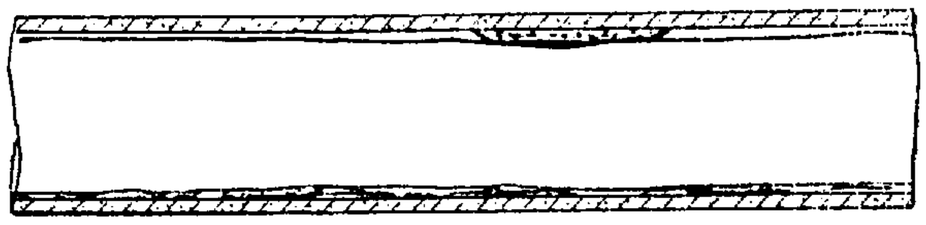
Possible influences on the renovated pipeline:
- difficulty to locate leaks
- fluid accumulation in the annular space/damage of the existing pipeline/liner

Difficulties may arise after installation of the lining due to necessary access through the existing pipeline (e.g. to connect laterals).



6.1.5 Chemical degradation

Degradation of the existing pipeline and the lining may occur because of the effect of the environment inside or outside.



Possible influences on the renovated pipeline:
- ageing or weakening of the lining due to chemical attack by internal or external environment
- loss of bond between the existing pipeline and the liner

6.2 Design Categories

Four different design categories have been defined, as given in table 2. Distinction has been made primarily according to the structural loading conditions which may be expected.

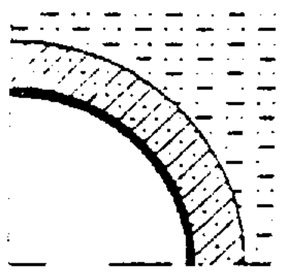
Table 2 - Characteristics of Design Categories

Loads on New Pipe	Surround Situation	Design Category
none	no annular gap	1 a
	filled gap	1 b
	unfilled gap	1 c
partial	no annular gap	2 a
	filled gap	2 b
full	no annular gap	3 a
	filled gap	3 b
full	broken pipe	4 a
	no pipe	4 b

The surround situations can be represented schematically as follows:

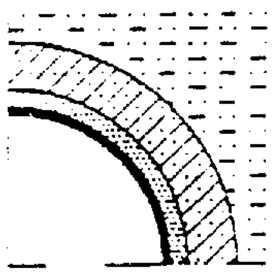
- no annular gap:

  (categories 1a, 2a, 3a)



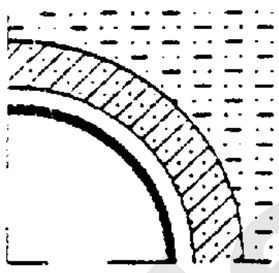
- filled gap:

  (categories 1b, 2b, 3b)



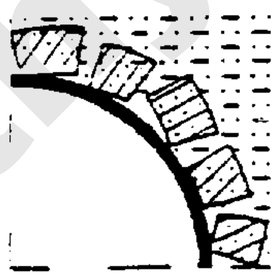
- unfilled gap:

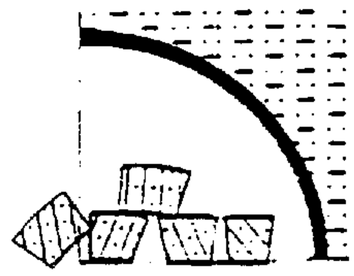
  (category 1c)



- broken or no pipe:

  (categories 4a, 4b)





The techniques can have the categories indicated in table 3.

Table 3 - Design Categories per Technique Family

Family	Design category
Lining with continuous pipe	1b,1c,2b,3b
Lining with discrete pipes	1b,1c,2b,3b
Lining with close-fit pipes	1a,2a,3a
Lining with spirally wound pipes	1b,1c,2b,3b*)
Lining with pipe segments	1b,1c,2b
Lining with cured in place pipes	1a,2a,3a
Lining with inserted hoses	1c
Replacement using pipe bursting	4a
Replacement using micro-tunnelling	4b

*) With expandable liners 1a, 2a, 3a achievable.

Before considering the structural design of a lining or replacement pipe it is necessary to consider whether the lining/replacement pipe will meet the pipeline system's hydraulic requirements after installation.

Following hydraulic considerations, structural requirements have to be met. The system under study needs to be categorized in the previously listed design types.

The forces acting on the lining/replacement pipe both during and after installation need to be considered.

Depending on the appropriate design category these should include:

- Short term forces arising from installation and buckling (e.g. axial bending, shear during insertion, axial tension and compression, temperature, grouting)*
- Long term soil column, traffic & surcharge loads
- Long term (internal and external) hydrostatic pressure
- Long term dynamic loading (water hammer)
- Point loading (especially in case of category 4a, but also to be considered for categories 2a and 3a).

*Clarified in table 4.

Table 4 - Short Term Forces (potentially) arising from Installation per Technique Family

Techniques (families)	Axial bending	Shear	Temp.	Grouting	Point loading
Lining with:					
- continuous pipe lengths	v	v		v	
- discrete pipes		v		v	
- close-fit pipes	v	v	v		v
- spirally wound pipes		v		v	
- pipe segments		v		v	
- cured in place pipe	v	v			v
- inserted hoses		v			
Replacement using:					
- pipe bursting		v			v
- micro-tunnelling		v			v
risk:	collapse elonga-tion breakage	abrasion	elonga-tion	collapse deforma-tion	cracks collapse deformation

6.3 Grouting

Grouting involves filling the annular space (if any) between existing pipe and lining. It is mentioned here in particular because of the influence grouting can have on the structural performance.

The annular space may have to be grouted with a cementitious mix or other applicable materials. Grouting fixes the position of the new pipe, provides uniform support and inhibits further failure of the existing pipe by fulfilling a structural function in stabilizing the soil around the existing pipe.

Depending upon the design, the new pipe may be filled with water prior to grouting in order to limit deflection caused by floatation forces.

6.4 Reconnecting laterals

When the pipeline has been rehabilitated in one way or another, any laterals (service lines) have to be reconnected.

In particular when a no-dig rehabilitation method has been applied, it is desirable to have also a reconnection method that does not require excavations. A number of these methods are under development.

Distinction can be made between:
1) Minimum excavation for lateral reconnection
2) Remotely controlled lateral reconnection

The second option uses inspection and detection equipment (robots in case of small sized pipelines) and cutters to open up the lateral.
Solutions with proper sealing between new pipe and existing lateral are under development. When such a solution is generally available, the potential for no-dig renovation/replacement methods will certainly increase.

6.5 Manholes/Inspection chambers

Rehabilitating pipeline systems may involve work being carried out in the upgrading of chambers or manholes e.g. in the case of sewers. Wherever applicable chambers/manholes can be treated by:

- Repairing critical spots using pressure pointing or chemical grouting
- Renovating the whole structure by applying segments/linings or by installing a new chamber inside the existing and filling up the annular space with suitable material
- Replacing the manhole (chamber) by a new one using the open cut technique

Essential components of a system such as laterals or access points and of course also fittings (e.g. valves) in the case of pressure pipes should not be forgotten so that a successful result to the whole operation may be achieved.

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