Amiblu®

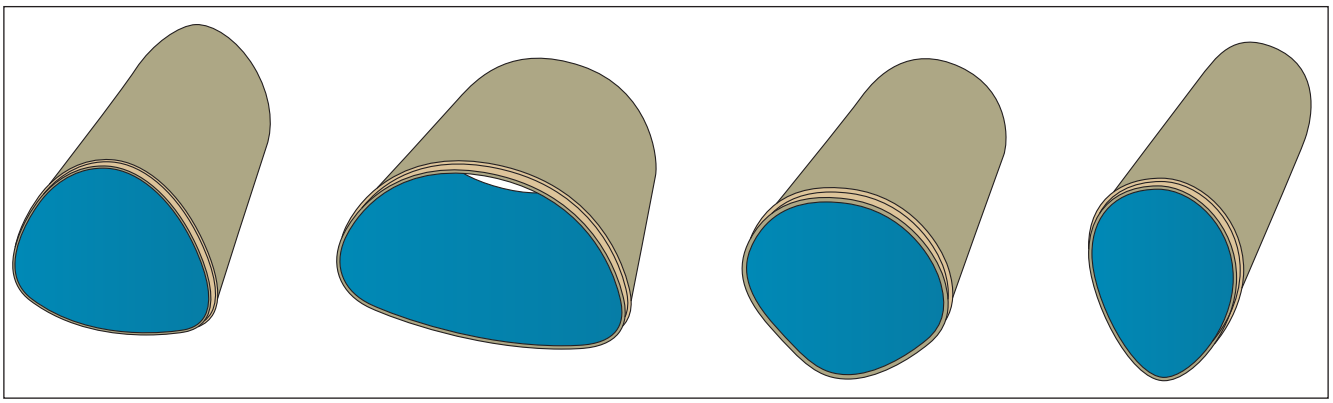
Amiblu Pipe Systems
Engineered for the next generations

Amiblu NC Line

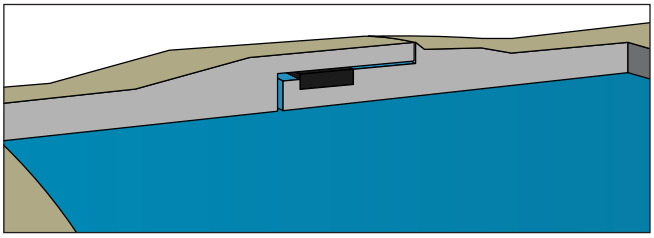
Installation Manual - Relining With Annular Grouting

Non-Pressure Sewer Rehabilitation

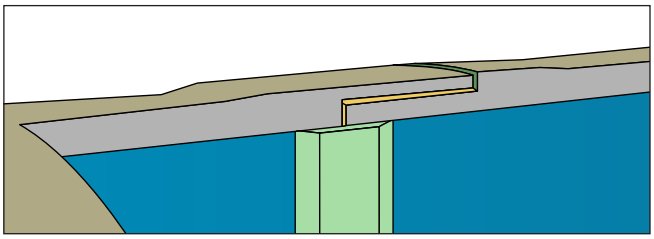
Amiblu NC Line pipes with their non-circular cross-sections are ideal for relining old city sewers, culverts and channels that often hold non-circular shapes. Non-circular pipes are also used for open trench applications. They can be customized according to customer demands and easily be adapted to different types of shapes and geometries. Amiblu NC Line meets the requirements of ISO 16611.



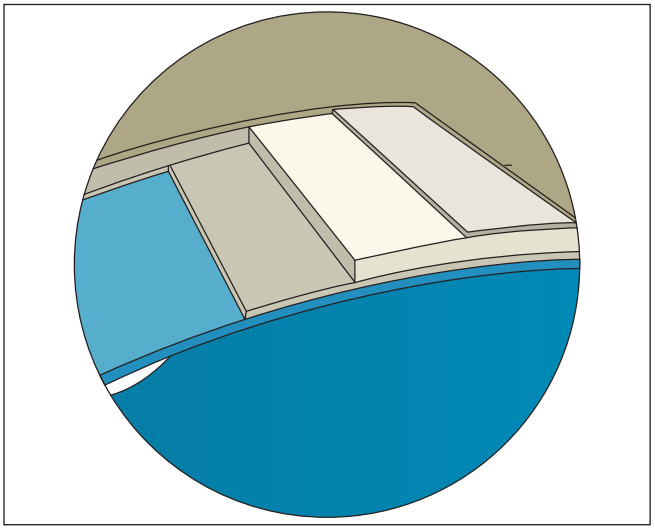
Non-circular profiles: parabolic, arch, kite, egg.



Bell and spigot elastomeric seal.



Bell and spigot glued joint.



Pipe profile wall

Click HERE or scan the code to watch a video about sewer rehabilitation with Amiblu NC Line.

Disclaimer Pipe Manufacturer

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Contents

1. Preliminary information

1.1. Foreword

Currently, a lot of the existing sewer systems, some built as early as the end of the nineteenth century, do not meet the technical requirements for their proper operation due to their progressive structural degradation and increased hydraulic resistance to the flow of sewage.

The systems can be renovated by relining method using GRP pipes with a circular cross-section or, in the case of non-circular sewers, specially designed Amiblu NC Line® pipe profiles with a non-circular cross-section, matching the shape of the sewer to be repaired. The annular space between the host channel and the new NC pipe profile is filled with grout, which additionally strengthens the entire system.
In addition, the renovation process itself does not require extensive construction work, being limited to an exceedingly small area of urban infrastructure and only minimally affecting its functioning.

The above technology enables the continued effective operation of the existing sewerage network, eliminating the need to replace it in whole or in part.

The Amiblu NC Line® system is manufactured according to filament winding technology in the form of GRP pipe profiles of various geometries and with cross-sectional dimensions ranging from 300 to 4000 mm.

1.2. Introduction

This manual is a part of the Amiblu documentation for users of Amiblu NC Line® non-pressure products. The manual is intended to help installers understand the requirements and procedures concerning the proper transport, handling and installation of non-circular Amiblu NC Line® pipe profiles for rehabilitation and open-cut installation. The intent is that this document will be a helpful source of data for the contractor's engineers.

The manual discusses the conditions that usually occur on the construction site but does not present unusual situations that require special consideration, and which should be solved in cooperation with the supplier. Most important in this installation manual is not intended to replace common sense, appropriate technical qualifications, applicable legal and safety regulations, environmental protection legislation or other local regulations and ordinances, and likewise the owner's specifications, instructions and those of the owner's supervision inspector, who is the final authority on every subject. Should information contained in this manual create doubts as to the proper course of action, one should consult the supplier and the supervision inspector.

Appropriate action, following the installation procedures as outlined in this manual and the recommendations of the construction engineer, will ensure the correct execution and long-term reliability of the facility. In the event of any questions or where any installation methods other than those included in this manual are considered, the supplier should be consulted.

1.3. The engineer – on-site technical advisor

At the request of the investor and on terms agreed between the purchaser and the manufacturer, the manufacturer can provide technical assistance on site. A technical consultant at the construction site can advise the purchaser and/or contractor, thus helping them achieve satisfactory pipe assembly results.

1.4. Safety recommendations

Operations during rehabilitations of sewers as well as in open trenches are conducted in potentially hazardous conditions. Where appropriate, shore, sheet, brace, slope or otherwise support the trench walls to protect any person in the trench.

Take precautions to prevent objects falling into the trench, or its collapse caused by the position or movements of adjacent machinery or equipment, while the trench is occupied.

Excavated material should be deposited at a safe distance from the edge of the trench, and the proximity and height of the soil bank should not be allowed to endanger the stability of the excavation. Local health and safety instructions, as well as environmental regulations for construction work should be always taken into consideration. Glass-reinforced polyester (GRP) is not recommended for use in applications that are exposed to intense heat or flames. During installation, care must be taken to avoid exposure of the pipe to welder's sparks, cutting torch flames or other heat/flame/electrical sources, which could ignite the pipe material. This precaution is particularly important when working with volatile chemicals in making layup joints, repairing or modifying the pipe in the field.

The installation of Amiblu NC pipe profiles is subject to applicable standards and guidelines such as EN 1610.

2. Transportation, handling and storage

2.1. Transport

Amiblu NC Line pipe profiles can be transported by road, rail and sea.

Small diameter pipes with nominal breadth - BN or nominal height - HN < 900 mm of a maximum cross-sectional size can be packed and transported in bundles, the total height of which should not exceed 2.5 meters (Fig. 1).

Larger diameter pipes (BN or HN ≥ 900 mm) are packed individually on the load platform, on pallets or in wooden crates, possibly stacked as long the total height doesn't exceed 2.5 meters (Fig. 2).

The load should be carefully secured transversely and longitudinally using plastic straps or hemp ropes.
The pipes must not rest on protruding edges causing point pressure (Fig. 3, Fig. 4).

Pipe profiles must be tightly wedged before moving.
To use the maximum carrying capacity, depending on the size of the cross-section, Amiblu NC Line pipe profiles can be loaded along (Fig. 1 and Fig. 2) or across the load platform (Fig. 3, Fig. 4 and Fig. 5).

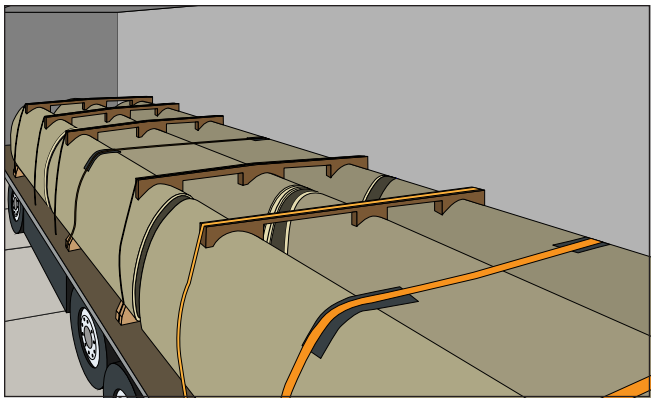

Fig. 1: Example of packs of pipe profiles packaging for transportation

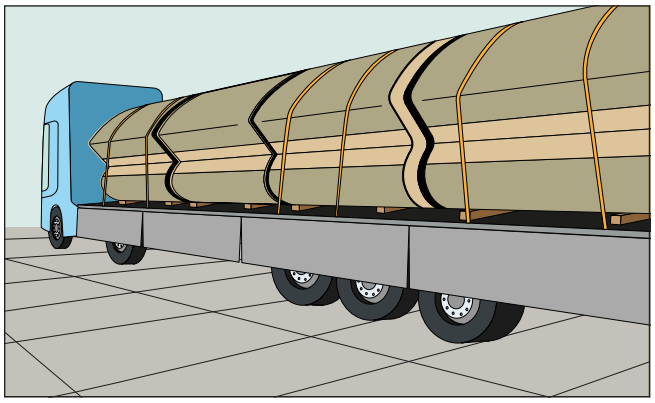

Fig. 2: Example of individual pipe profiles packaging for transportation

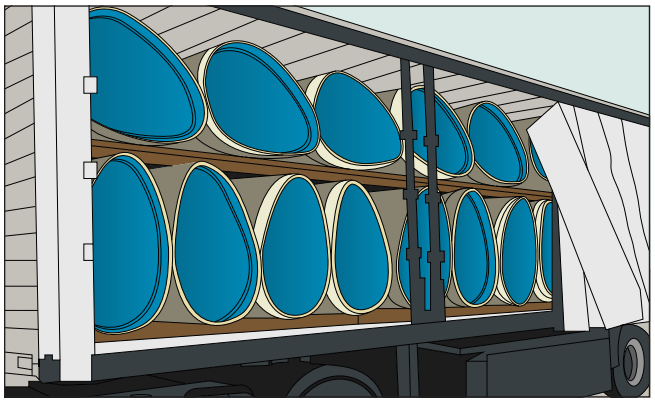

Fig. 3: Example of pipe profiles packaging for transportation (1)

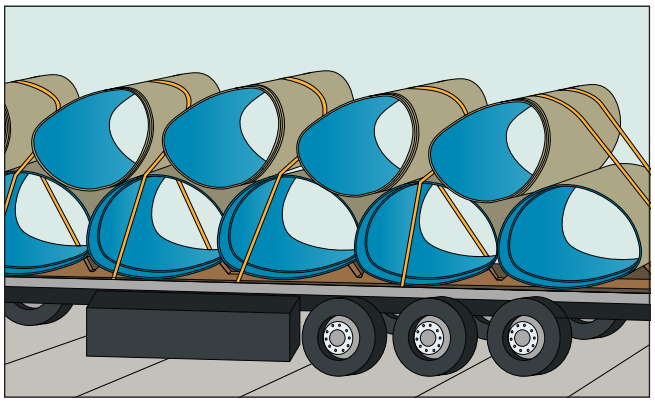

Fig. 4: Example of pipe profiles packaging for transportation (2)

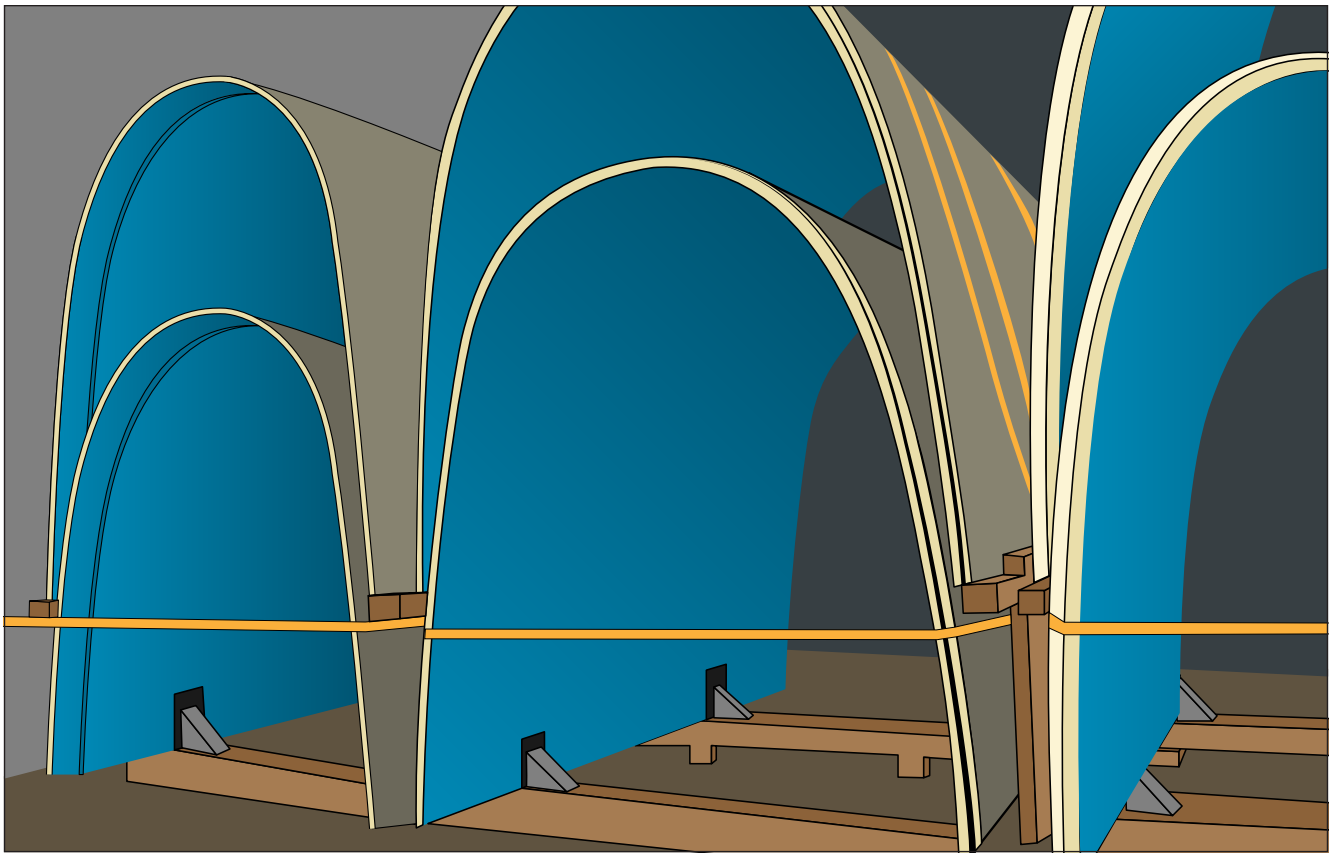

Fig. 5: Example of half pipe profiles packaging for transportation

2.2. Inspection of pipe profiles

All pipe profiles should be inspected upon receipt at the job site to ensure, that no damage has occurred during transportation.

Inspect the shipment upon delivery, as follows:

1. Make an overall inspection of the load. If the load is intact, ordinary inspection while unloading will normally be sufficient to make sure the pipe profiles have arrived without damage.
2. If the load has shifted or indicates rough treatment, carefully inspect each pipe profile section for damage. Generally, an exterior inspection will be sufficient to detect any damages. When pipe profiles size permits, an interior inspection of the profile surface at the location of an exterior scrape may be helpful to determine if the pipe is damaged.
3. Check the quantity of each item against the bill of loading.
4. Note on the bill of loading any transit damage or loss and have the carrier representative sign your copy of the receipt. Claims against the carrier should be per their instructions.
5. If any product flaw or damage is found, segregate the affected pipe profiles and contact the supplier.

Do not use products, that appear damaged or defective. Both, internal and external surfaces, will be free from any damages that might impair the ability of the component to conform to the requirements.

Depending on the length of the storage period, the amount of movement of pipes conducted on the construction site (e.g., additional transports), and the impact of other factors that may affect the condition of the pipes, it is recommended they be re-inspected before installation.

2.3. Unloading and handling of pipes

Unloading pipe profiles is the responsibility of the customer. Be sure to maintain control of the product during unloading. Guide ropes attached to pipe profiles or packages will enable easy manual control when lifting and handling. Spreader bars may be used when multiple support locations are necessary.
Do not drop or bump pipe profiles, particularly at their ends. Moving pipe profiles must not involve their being rolled or dragged along the ground.

2.3.1. Single pipe profiles.

When handling a single profile, use straps, slings or rope to lift. Do not use steel cables or chains to lift or transport the pipe. Pipe sections can be lifted with only one support point (Fig. 6). Two support points (Fig. 7, Fig. 8) are the preferred method for safety reasons, as it makes the pipe easier to control. Do not lift pipes using hooks at pipe ends.

2.3.2. Unitized Loads

Unitized loads may be handled using a pair of slings or a forklift (Fig. 11). Do not lift a non-unitized stack of pipes as a single bundle. Non-unitized pipes must be unloaded and handled separately (one at a time). If at any time during handling or installation of the pipe, any damage such as a gouge, crack or fracture occurs, the pipe should be repaired before the section is installed. Contact the supplier for inspection of damages and recommendation of repair method or disposal.

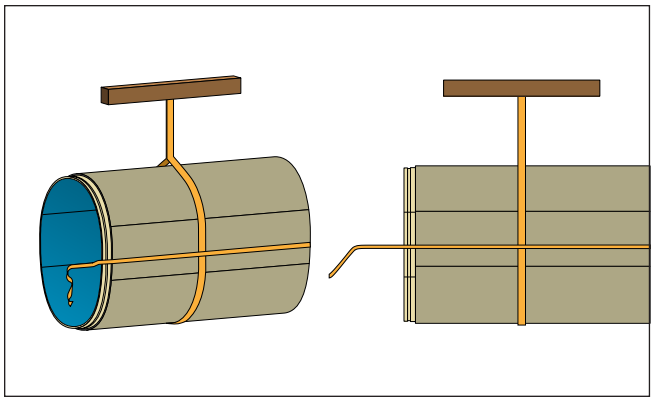

Fig. 6: Lifting a pipe profile with one support point.

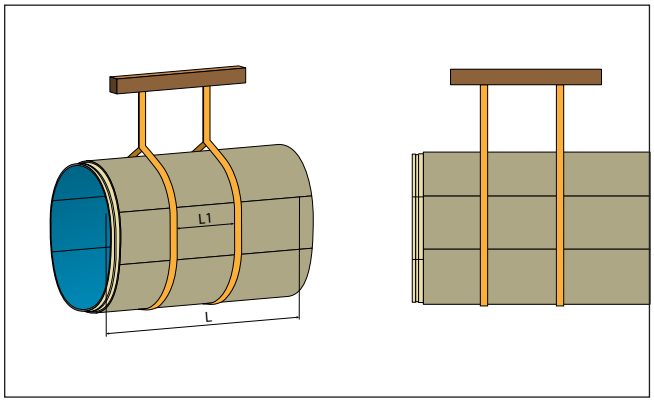

Fig. 7: Lifting a pipe with two support points, (L1 = 0.6 x L)

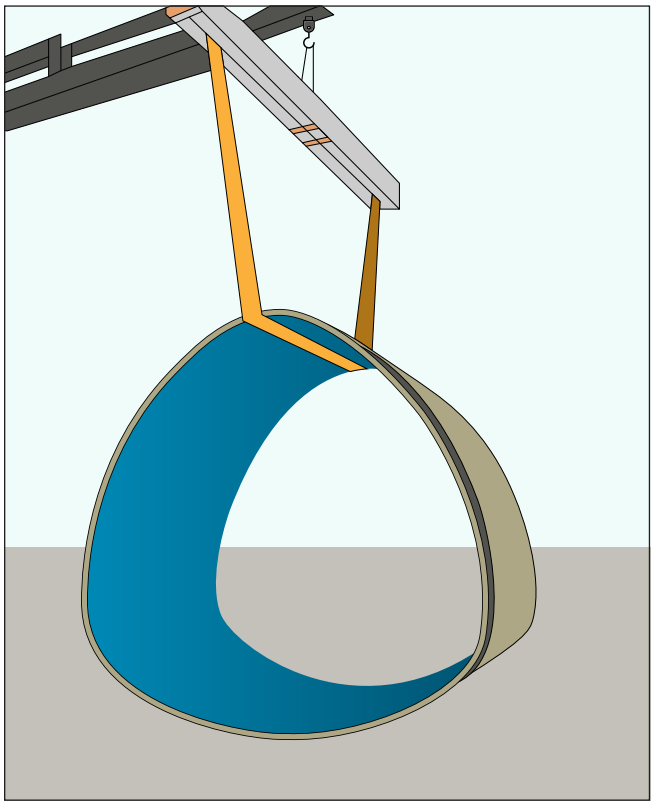

Fig. 8: Lifting a pipe with beam, (beam length = 1.25 x Lprofile)

It is forbidden to unload pipe profiles using straps passed inside of it without using a beam, as this could lead to damage to the sockets and spigot.

The goods should be unloaded in a strictly defined way depending on the type of transport trailer:

- From the side of the truck with a forklift. The forks should be covered with a flexible material if intended to be in direct contact with the pipe profile to avoid any damage.
- From the upper part of the truck using a crane or an excavator (Fig. 9).
- From the rear part of the truck using a forklift equipped with a special pin passing through the interior of the pipe (Fig. 10).

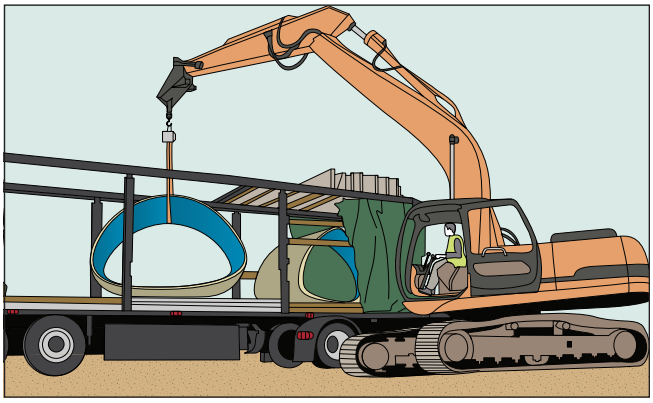

Fig. 9: Unloading from the upper part of the truck

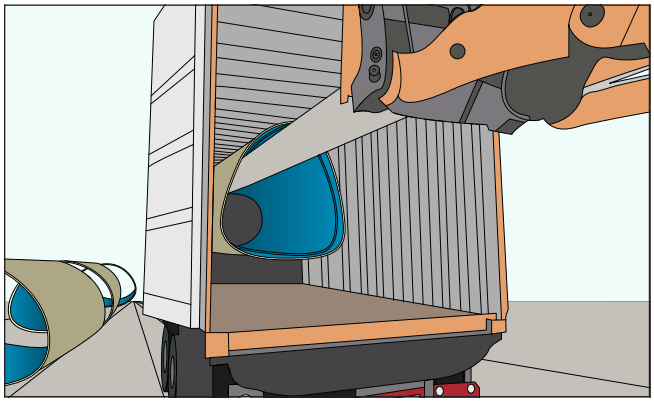

Fig. 10: Unloading from the rear of the truck or container

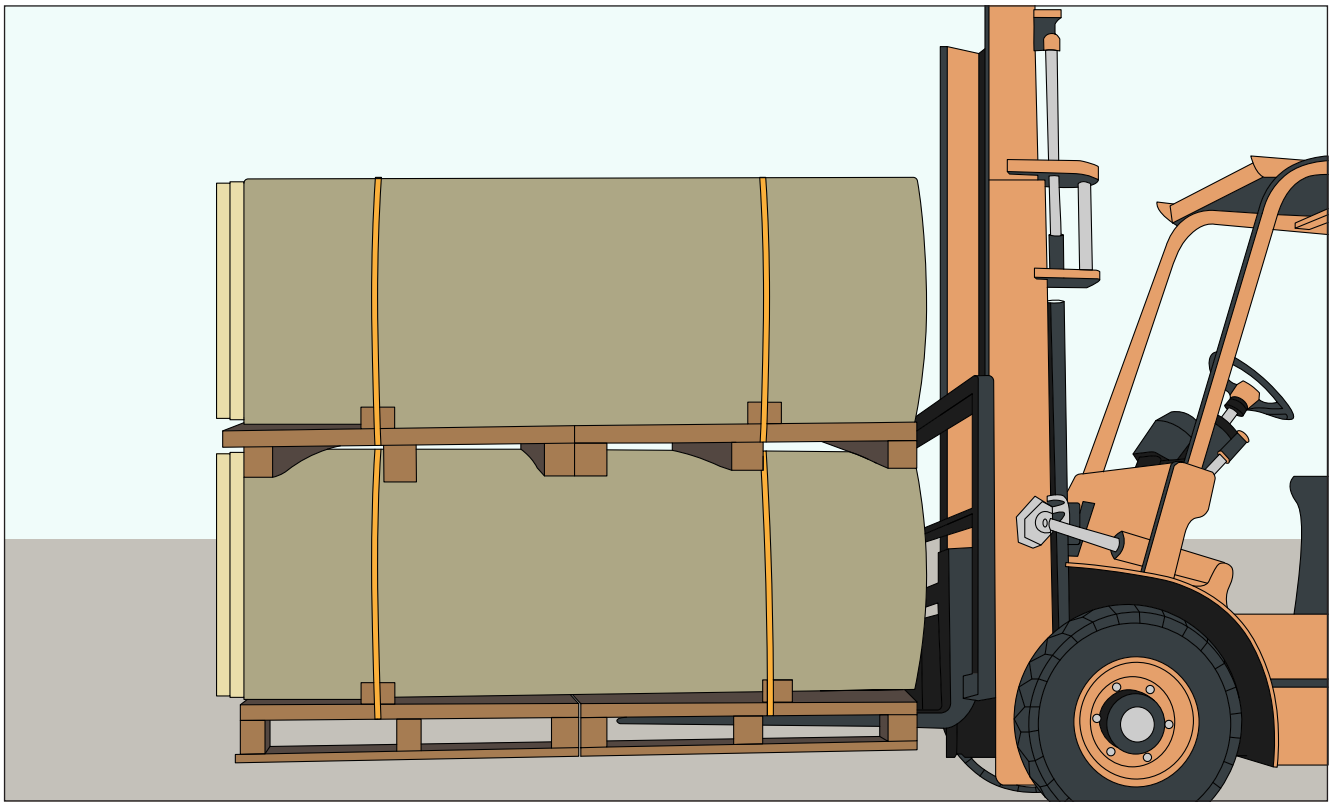

Fig. 11: Transportation of pipe profiles using a forklift

2.4. Storage of pipe profiles on the construction site

It is recommended to use the original shipping packaging and to store pipes on flat timber to facilitate placement and removal of lifting slings around the pipe. All pipes should be choked to prevent rolling. If it is necessary to stack pipes, ensure the stack will be stable, including conditions such as high winds, uneven storage surface or other horizontal loads. For example, if intensive winds are anticipated consider using ropes or slings to tie pipes down. The maximum stack height is approximately 3 meters with max. 2 layers (Fig. 12). Prevent deformation and damages of pipe profile during storage. Storing pipes outside of these limitations may result in damage to the pipes.

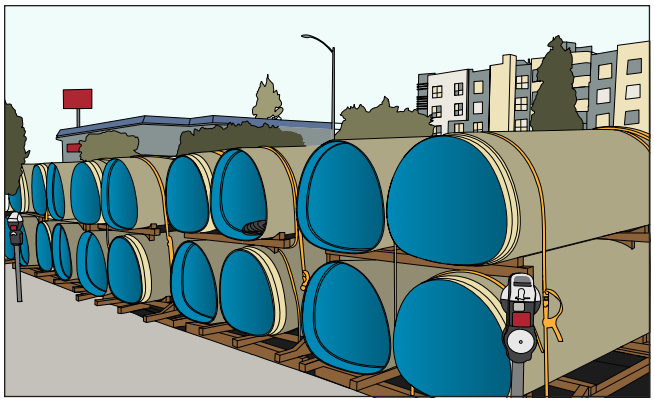

Fig. 12: Storage of pipes on the construction site

2.5. Storage of seals and lubricants

Rubber ring gaskets, when shipped separately from pipe profiles, should be stored in the shade in their original packing and should not be exposed to sunlight except during the pipe joining. Also, the gaskets must be protected from exposure to petroleum-derivative greases and oils, as well as solvents and other harmful substances. Gasket lubricant should be carefully stored to prevent damage. Partially used buckets should be resealed to prevent contamination of the lubricant. If temperatures during installation are below 5 °C, gaskets and lubricant should be sheltered until used. A special lubricant for lower temperatures than 5 °C is available on request.

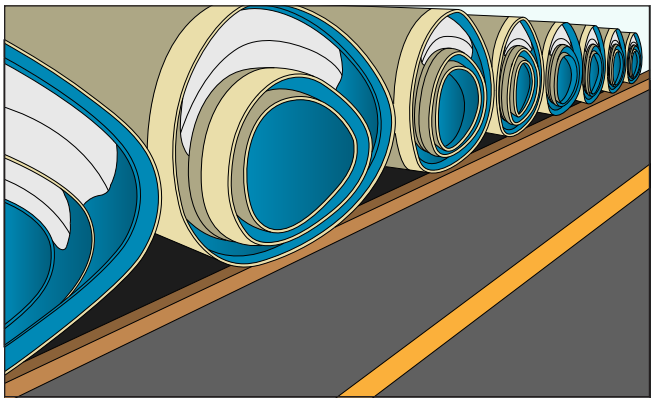

Fig. 13: Storage of nested pipes

2.6. Transportation of nested pipes

Nesting of Amiblu NC Line pipes is a way of packing and transporting pipes one inside another (Fig. 13). This is possible when the delivery involves transporting non-circular pipes of the same shape in several sizes. For further information please contact your local supplier.

- Always lift the nested set of pipes using at least two flexible transport straps. The spacing of straps and their load capacity should be chosen each time for the given set of pipe profiles (Fig. 14).
- Nested pipes should not be stacked.
- Unpacking of nested pipes is best conducted at a suitable work stand and with the use of a forklift equipped with a "pin" device covered with rubber to avoid damages (Fig. 15). Removing smaller pipe profiles should be done by slightly lifting the padded pin of the forklift, placed inside the pipe, so that it supports the section of the removed pipe and it can be carefully removed from the set along with the pipe, without damaging other pipe profiles.

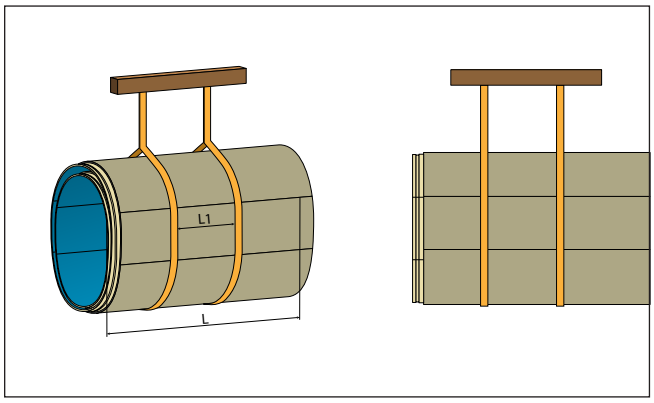

Fig. 14: Lifting of nested pipes, (L1 = 0.6 x L)

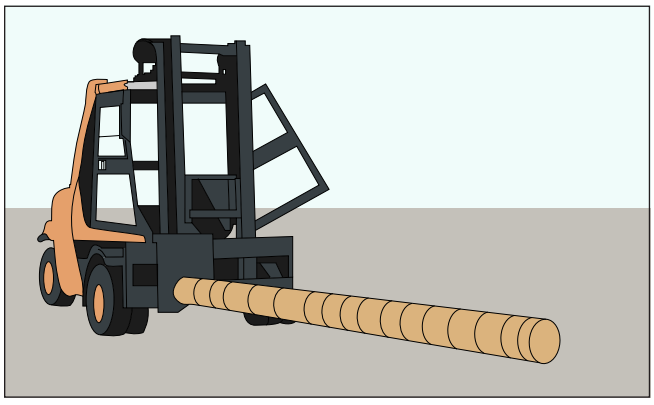

Fig. 15: De-nesting using a 'pin' inserted into the pipe profile

3. Amiblu NC Line pipe installation

The purpose of this chapter is to present trenchless rehabilitation of existing sewer by slip lining method (one discrete pipe inserted after another into the host pipe) using Amiblu NC pipe profile. Pipe profiles can be introduced into the sewer using various methods, which are adapted to local conditions. After installation of pipe profiles into the host pipe, the annular space between them should be filled with a grout, cement-based injection or other filler compliant with the design documentation. All the installation works are preceded by preparatory activities.

3.1. Preparation steps

The following preparatory works are usually conducted before starting the assembly of pipes:

- Restrict or completely close the inflow of sewage to the repaired section by using by-passes.
- Wash away any residual deposits mechanically and hydro-dynamically from the sewage collector.
- If groundwater infiltrates the sewer, it should be sealed temporarily.
- Remove all obstacles from the sewer; i.e., loose bricks, protruding bars, etc.
- Soil and void treatment are done at that stage if needed. (Fig. 16)
- Determine the internal dimensions of the repaired sewer in the most deformed sections through direct measurement or scanning.
- If necessary, re-profile the host pipe invert surface (Fig. 17).
- Determine the outer dimensions of the pipe profiles used; i.e., the maximum dimensions of the socket and the length of the pipe to be assembled. According to the WRc[1] method, it is recommended to take into consideration a minimal grout thickness of 25 mm. This can be done also by a 3D-scan (Fig. 19) or passing along the sewer a template made of wood (Fig. 18 and Fig. 20) or steel (Fig. 21) with the extreme outer dimensions of the pipe to be assembled. Checking with the template is always highly recommended.
- Make a final inspection of the sewer before pipe installation, determining the position of all branch inflow pipes.

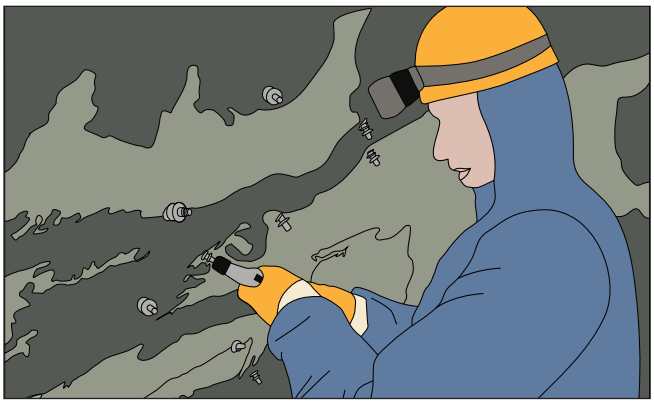

Fig. 16: Soil and void treatment

Fig. 17: Existing sewer bottom treatment for proper installation

1 WRc - Sewerage Rehabilitation Manual (SRM) volume 4, 4th edition 2001

Fig. 18: Wood 3D template example

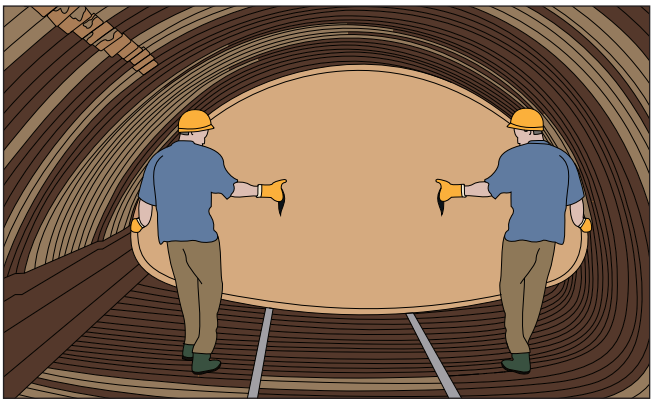

Fig. 20: Verifying the sewer's dimensions using a 3D wooden template

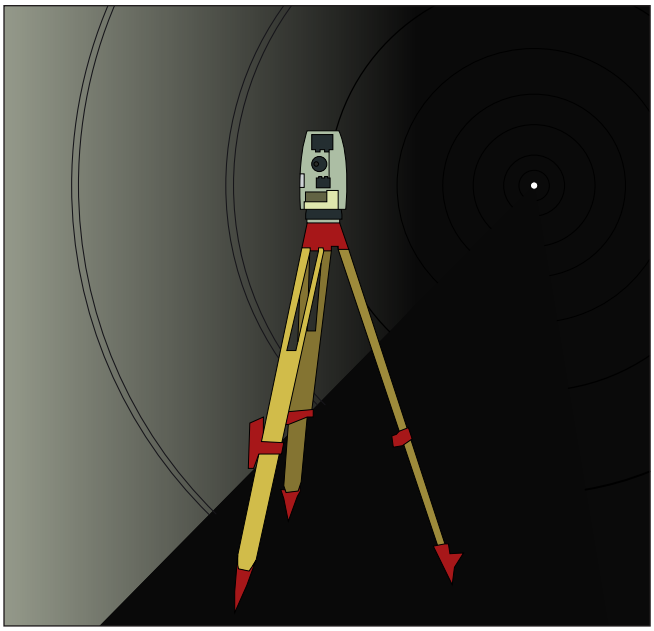

Fig. 19: 3D laser scan

Fig. 21: Steel 3D template example

3.2. Transporting pipes into the sewer

Amiblu NC Line pipes are introduced into the host pipe through existing manholes or working chambers; i.e., pit. It is advisable that these chambers are spaced so that correct handling is possible, depending on the installation method. The rules for handling pipes are in section 2.3.

After inserting pipes into the sewer, they can be transported to the place of assembly using specially designed trolleys which can be self-driving (Fig. 23, Fig. 24 and Fig. 25) or pulled by a cable system (Fig. 22). The level of the spigot must be at a proper height, allowing for a smooth connection with the bell of the preceding pipe profile (Fig. 26). Trolleys must enable horizontal and vertical adjustment of pipe profile positions against each other before joining them together. During installation it is necessary to use rubber between steel elements and GRP pipe profiles.

It is also possible to install pipe profiles by pushing or pulling the complete set of connected profiles by using a cable passing through the inside of subsequent pipe profiles from the starting chamber. These methods are not described in this manual. This method is workable for sewers in operation (Fig. 27 and Fig. 28) but also requires contractors and designers to consider their safety.

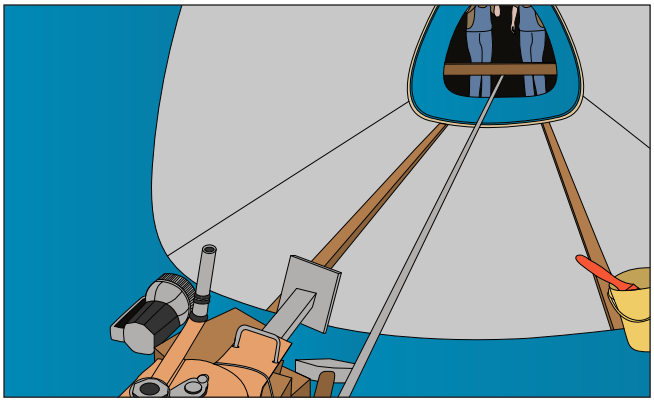

Fig. 22: Cable system for pipe profiles transport inside the host pipe

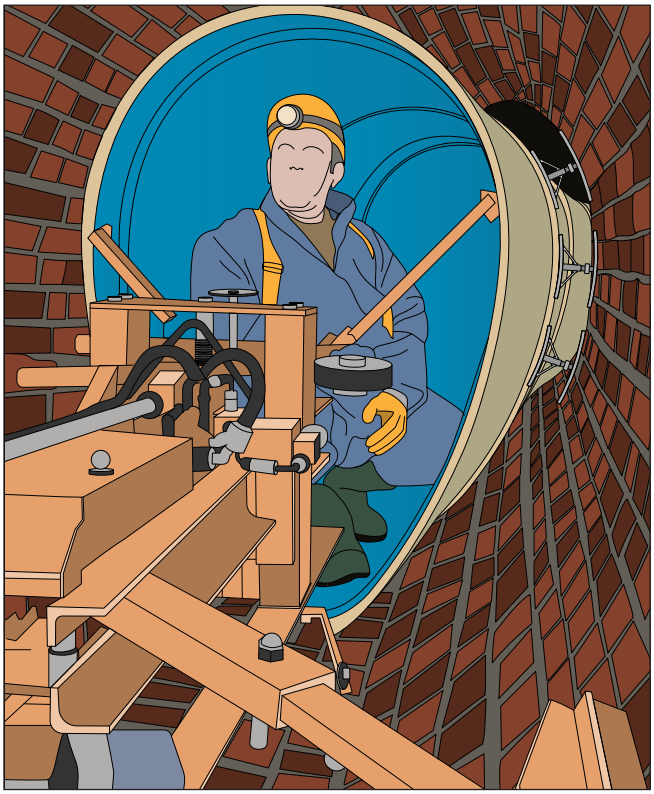

Fig. 23: Trolley system for pipe profiles transport inside the host pipe (1)

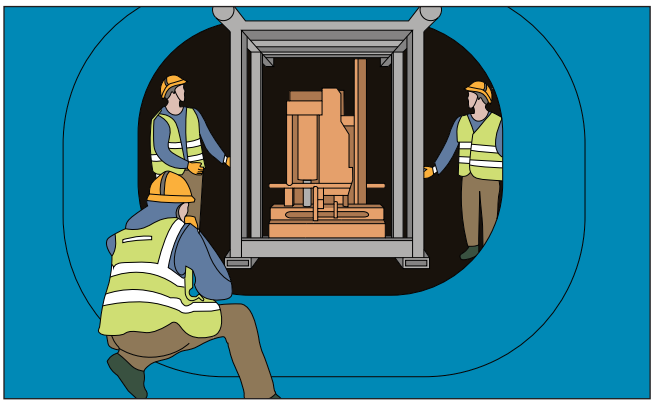

Fig. 24: Trolley system for pipe profiles transport inside the host pipe (2)

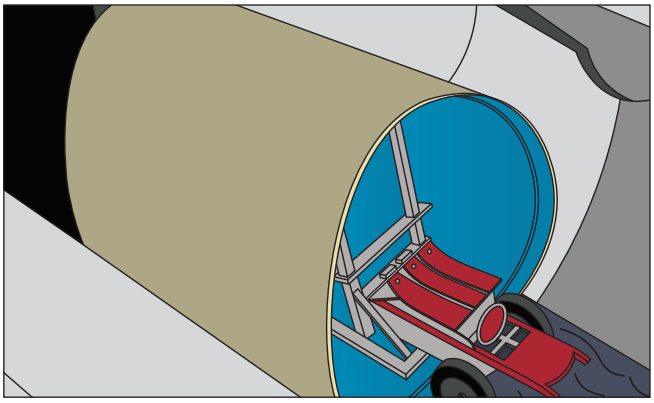

Fig. 25: Trolley system for pipe profiles transport inside the host pipe (3)

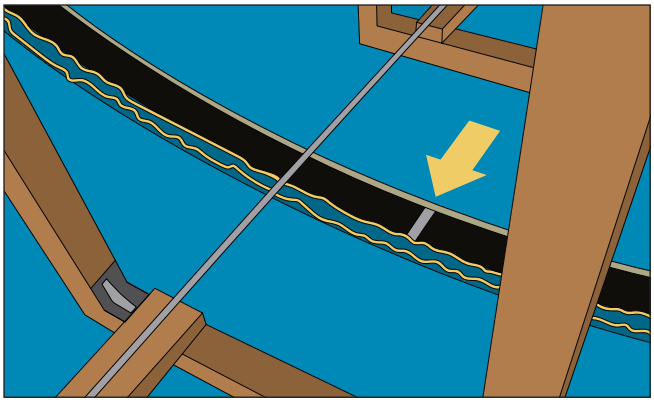

Fig. 26: Installing spigot inside preceding pipe profile bell

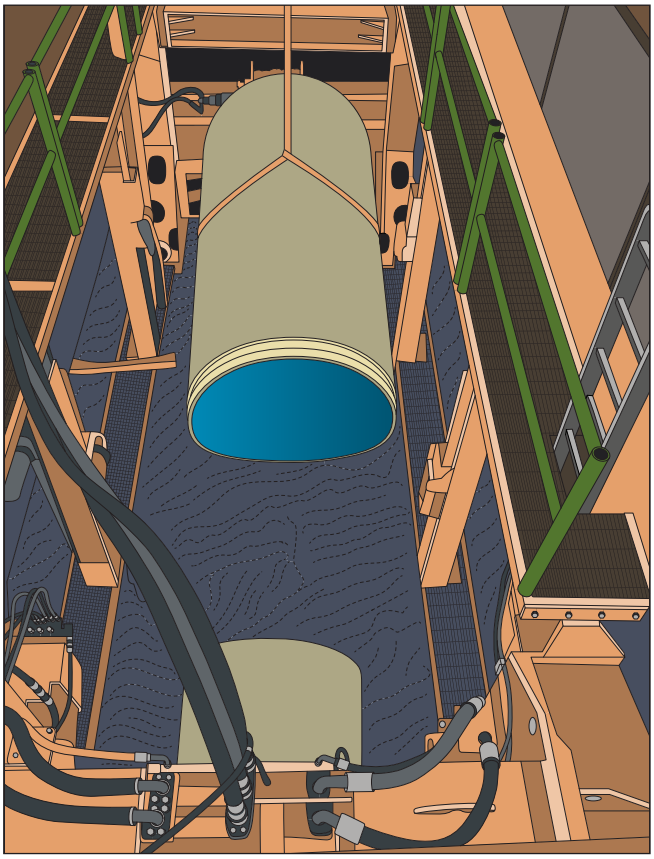

Fig. 27: Transport of pipe profiles in the live flow installation pit with stripes

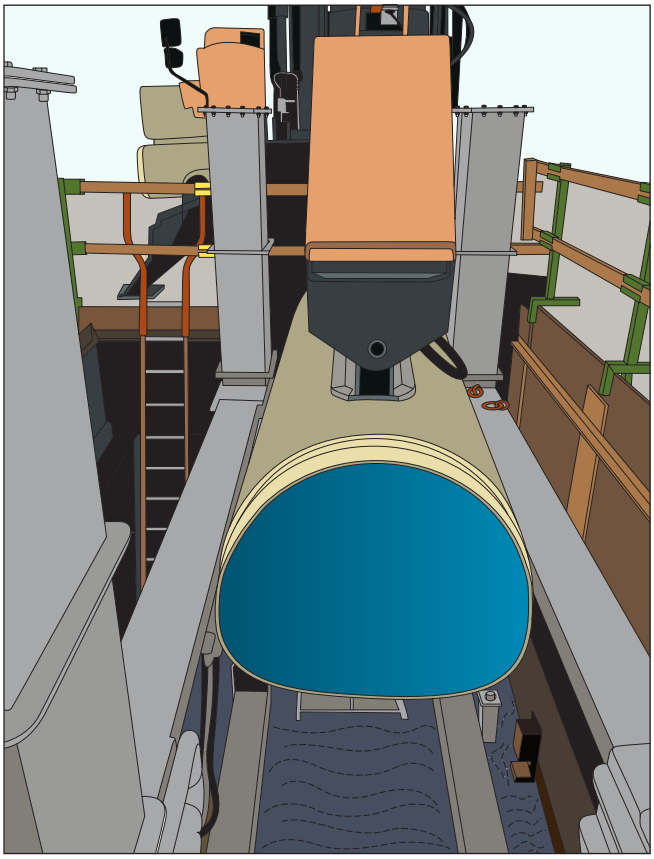

Fig. 28: Transport of pipe profiles in the live flow installation pit with vacuum lifting system

3.3. Connecting the pipes

The Amiblu NC Line pipe system used in non-pressure systems has a typical socket to spigot connections with elastomeric seals. These connections ensure the proper functioning of the system throughout its lifetime. For typical sewage applications, a connection with a seal is used. For special shapes and agreed applications where elastomer seals cannot be used or are not required, a glued connection can be used and optionally can be laminated from the inside if tightness is required. The laminate specification should in any case be determined with the supplier's representative in consultation with the pipe's manufacturer.

The first installed panel must be longitudinally blocked to avoid movement during jointing (Fig. 29 and Fig. 30).

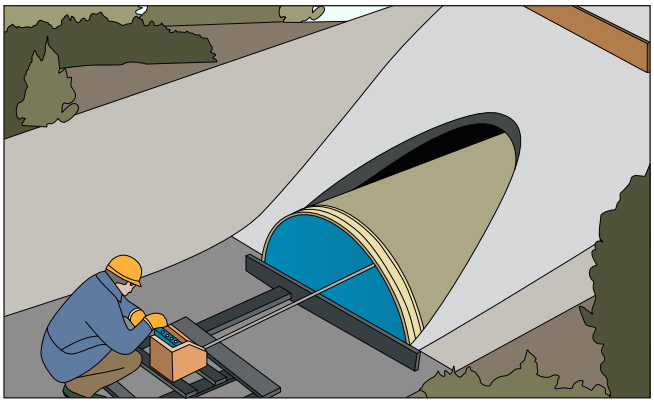

Fig. 29: The fixed point at the beginning of installation (1)

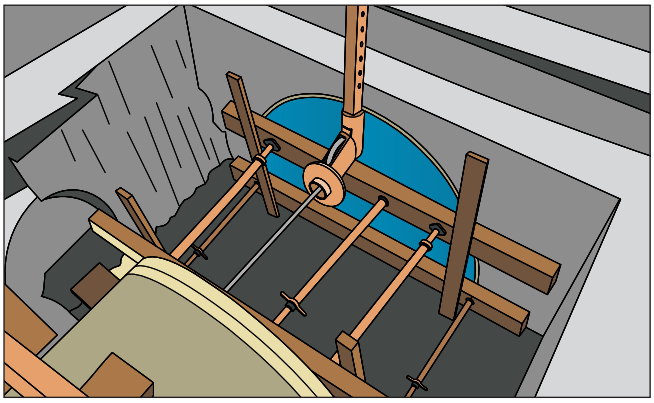

Fig. 30: The fixed point at the beginning of installation (2)

3.3.1. Amiblu NC Line bell/spigot with gasket – flexible joint

This connection is made of a bell/spigot system, where the spigot is grooved to host elastomeric gasket and follows tightness requirements specified by ISO 16611 standard.

- **The following drawings describe available flexible joint types: A, B, B1 and C.**

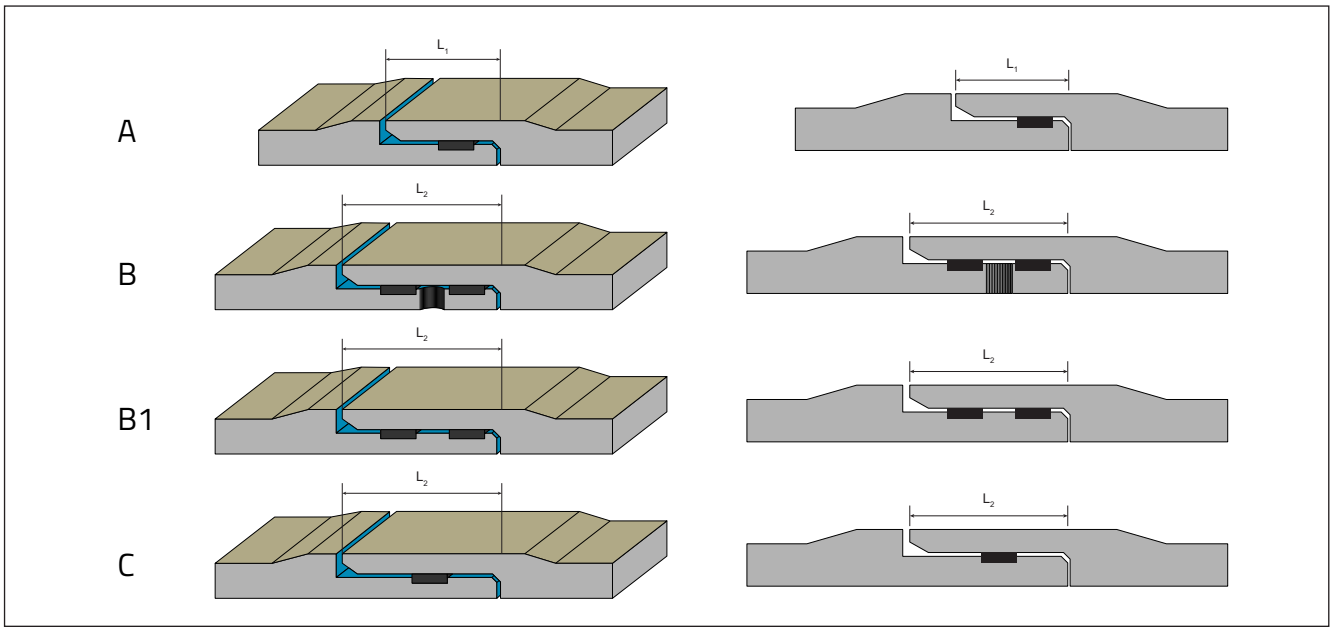

Fig. 31: Bell and spigot flexible joints – type A, B, B1, and C (L1 = 100 m, L2 = 140 mm)

Maximum admissible draw (Fig. 32) in-service at each connection, must not exceed the values given in Table 1. This can be used to accommodate gradual changes in line direction (curved installation). The pipes should be joined in straight alignment and thereafter deflected angularly as required.

The maximum total draws, T are shown in Table 1. The calculation of the draw D according to ISO 16611 to consider the Poisson contraction and the longitudinal thermal effects are equal to 0.2% of the Laying length. The maximum admissible angular deflection is equal to Asin ((T-D) / (MLW)) with MLW: pipe profile maximum internal dimension in the angular deflection plane.

Calculation example:

Unit laying length of NC profile: 2250 mm
MLW: 1200 mm
Joint type: Type C with CK-89 gasket

a = arcsin ((T-D) / (MLW)) = arcsin ((43.7-0.002x2250) / (1200))
a = 0.0326 radian or 0.0326x180 / π = 1.8 °

For the installation requiring greater angles, a special deflected socket-pipe system can be considered. For availability, please contact your local supplier (Fig. 33).

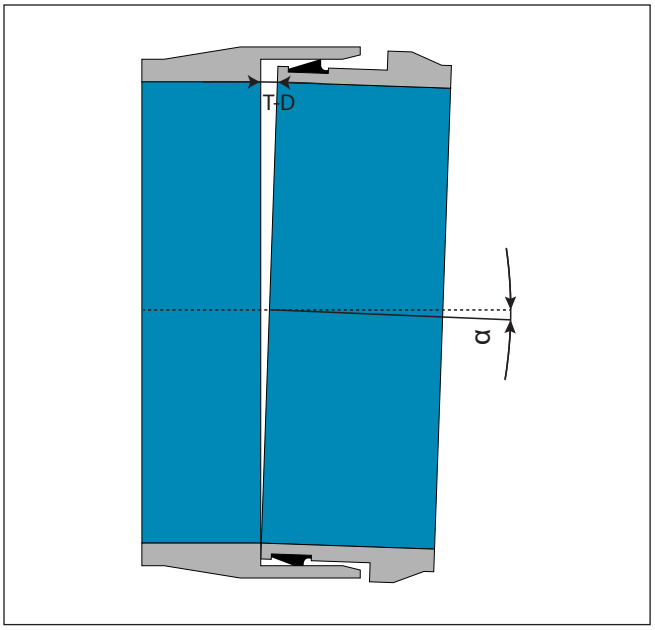

Fig. 32: Admissible angular deflection for standard bell/spigot connection

Flexible joint type	Maximum admissible draw T, according ISO 16611
(x)	(mm)
Type A with gasket CK-89	23.4
Type B with gasket CK-89	21.0
Type C with gasket CK-89	43.7
Type C with gasket DS-GS	36.0

Table 1: Maximum admissible draw T, according to ISO 16611

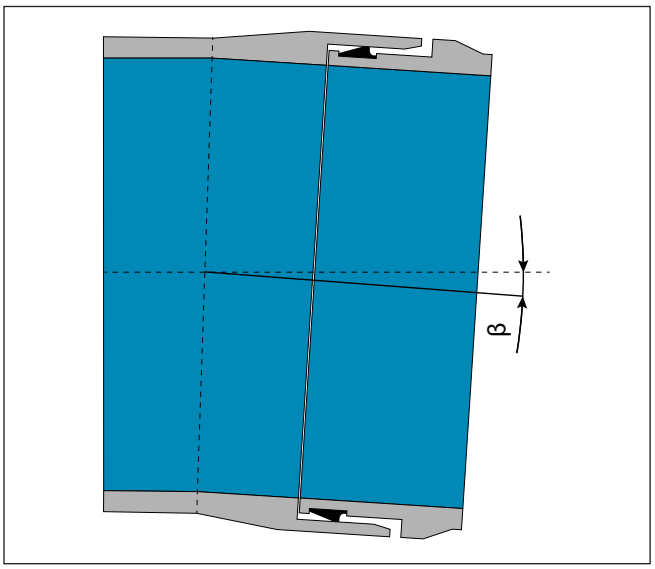

Fig. 33: Spigot/socket connection with enlarged additional deflection of the socket-pipe

The following steps (1-5) concerns the assembly of a flexible joint system.

Step 1 - Spigot cleaning

Thoroughly clean the spigot and rubber gasket ring to make sure no dirt or oil is present.

Step 2 - Gasket installation

Gaskets are usually delivered separately from the NC profile in a dedicated box.

Inspect the gaskets carefully before installation and in case of any visible damages do not use them and contact the supplier. Insert the gasket into the groove. Do not use any lubricant in the groove or on the gasket at this stage of assembly. Water may be used to moisten the gasket and groove to ease positioning and insertion of the gasket.

Make sure that the gasket is installed properly (with labeling on top, Fig. 35) – lip direction, gasket bottom in contact with the bottom of the groove.

Step 3 - Bell and spigot cleaning and lubrication

Thoroughly clean profile bell/spigot to remove any dirt, grit, grease, etc. Inspect sealing surfaces for possible damage. Apply a layer of lubricant to the bell and spigot (Table 2). After lubricating, take care to keep the bells and spigots clean. It is recommended to continue with this step just before joining the NC profiles. Lubricants suitable for low temperatures are available on request. **!Caution: It is especially important to use lubricant approved by the supplier. Never use a petroleum-based lubricant.**

Step 4 - Pipe Placement

Ensure that the profiles are aligned. As the bell waits for the spigot, slightly lift the spigot profile before its introduction into the bell (see also chapter 3.2).

Step 5 - Joining the pipe

The joining force is described in the formula below. This is an estimation that does not consider: friction due to the own weight of the profiles and specific site conditions (extreme temperatures, misalignments, etc.).
The approximate joining force can be calculated as follows:
Mounting forces in tons = (Max. NC profile dimension in mm / 1000) x 2.

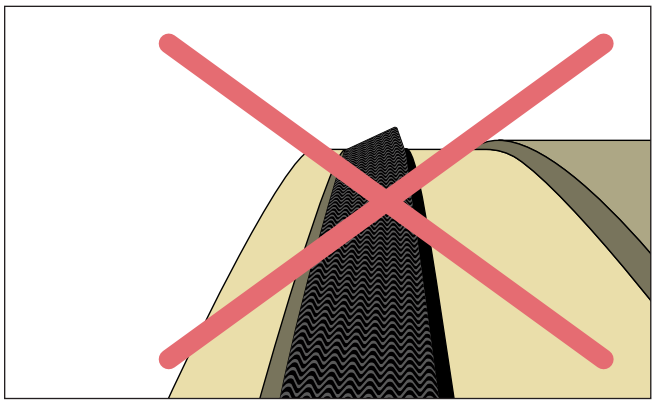

Fig. 34: Wrong positioning of the gasket inside the groove (gasket upside down)

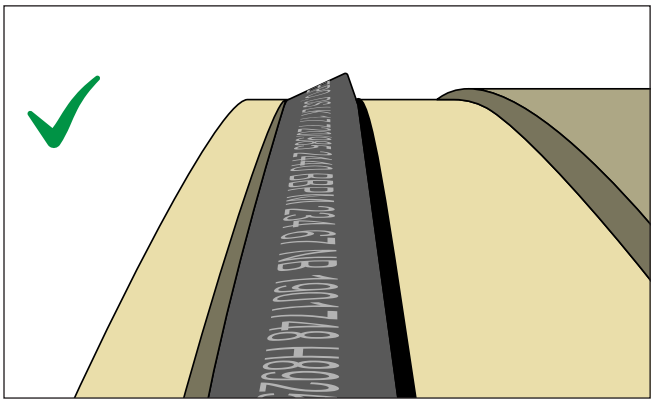

Fig. 35: Correct positioning of the gasket inside the groove

BN/HN nominal dimensions	Estimated amount of lubricant per connection [kg]
up to 600/900	0.10
700/1050-800/1200	0.20
900/1350-1000/1500	0.25
1200/1800-1400/2100	0.35
1600/2400	0.45
3000/2400	0.55
3400/2150	0.60
3800/2250	0.65

Table 2: Estimated amount of lubricant

Note: The amount of lubricant quoted in the table is approximate and applies to a single spigot/socket connection.

The most common way to apply the joining force is to use a "cross" device installed within the bell (Fig. 37). Forces will not be directly applied to the bell (Fig. 38).

If the "cross" is made of steel, use wood (Fig. 39) or an EPDM band at the interface between steel and GRP for protection (Fig. 40).
The "cross" device combined with the use of two or three come-along jacks enable distribution of joining forces, allowing optimal control during this operation.

Fig. 36: Example of "Cross" Device

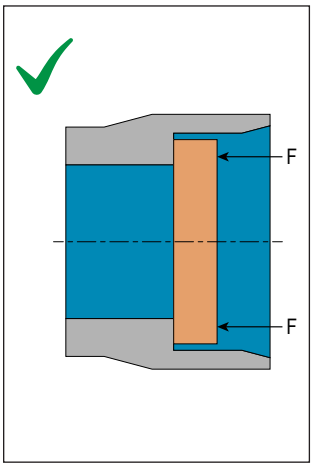

Fig. 37: Joining Force application within the Bell

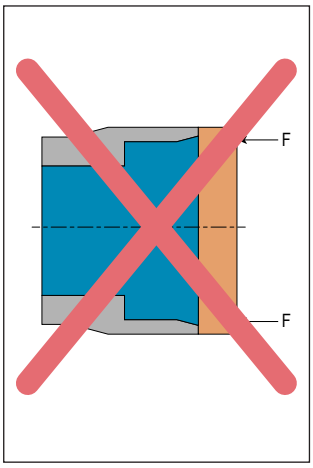

Fig. 38: Improper joining force application on the bell

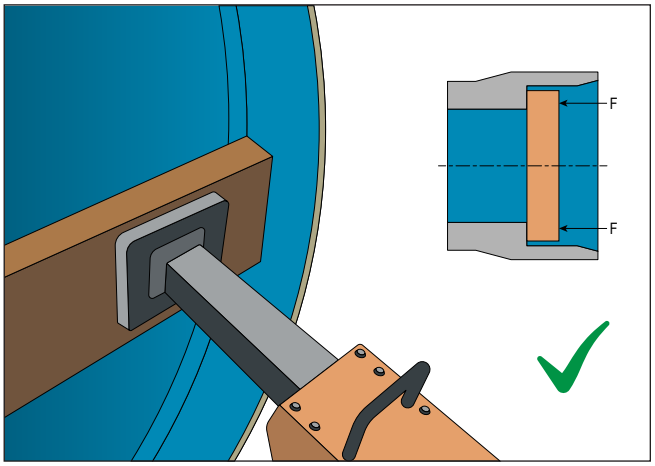

Fig. 39: Steel cross with wood for protection

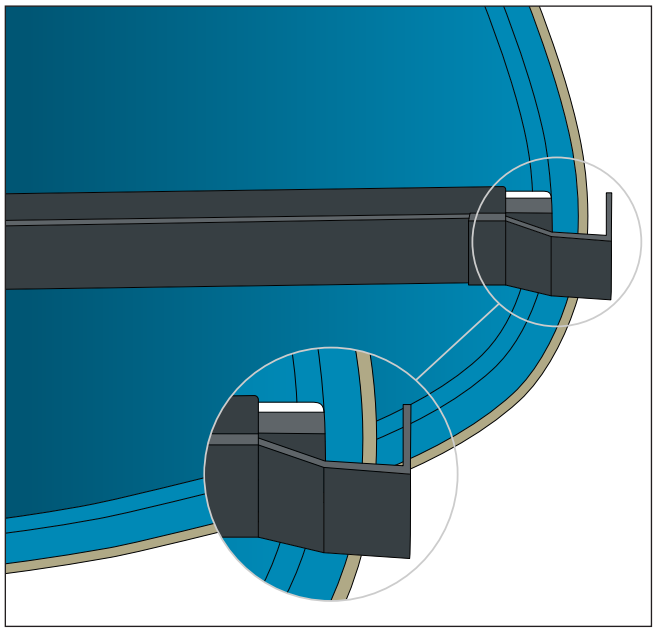

Fig. 40: Steel cross with EPDM band for protection

3.3.2. Amiblu NC Line bell/spigot without gasket – To be glued

This connection is made of a bell/spigot system to be glued on-site with for example polyurethan or epoxy glue. This glued system is only made to enable grouting during the installation phase.

For adhesives, please contact your local supplier.

If tightness is needed, an inside laminate must be done after installation on site. For additional information please contact your local supplier.

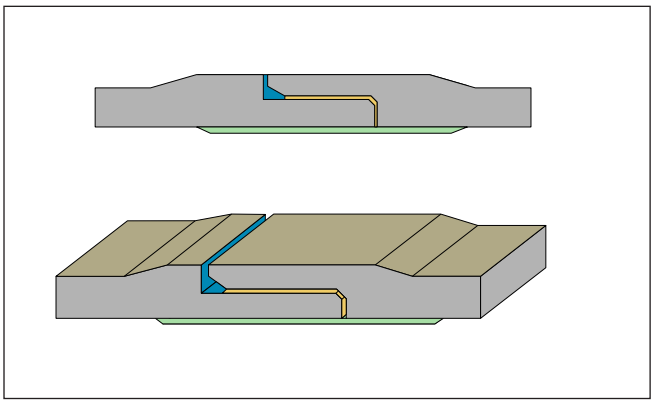

Fig. 41: Rigid Type D connection with glue and internal laminate

The following steps (1-5) concerns assembly of Type D rigid joint system:

Step 1 - Bell and spigot cleaning

Thoroughly clean the spigot of the pipe and clean the inner side of the bell to ensure that they are free of dirt or other impurities.

Step 2 – Adhesive application

Apply the adhesive on the inner surface of the bell around the whole perimeter, following the instructions of the glue supplier.

Step 3 – Pipe placement and Jointing

Ensure that the profiles are aligned. If the bell and spigot are properly aligned the joining force is low compared to other forces (e.g., friction forces due to handling).

Step 4 – Cleaning of the connection

Wipe off adhesive excess.

Step 5 – Inside lamination

If tightness is needed, continue to internal lamination of the connection (Fig. 41).

3.4. Wedging and Shoring of pipe profiles

3.4.1. Wedging

After pipe profiles jointing and positioning, the pipe area at the bell location should be wedged to prevent displacement due to buoyancy induced by the liquid grout and to maintain its planned position. The wedges enable as well to limit the profile deformation during grouting.

The wedges are installed around the bell area.

Wedging can be done using watered wooden blocks, steel struts, bricks, plastic, etc.

For recommendations concerning the position and number of wedges, contact your local supplier if needed.

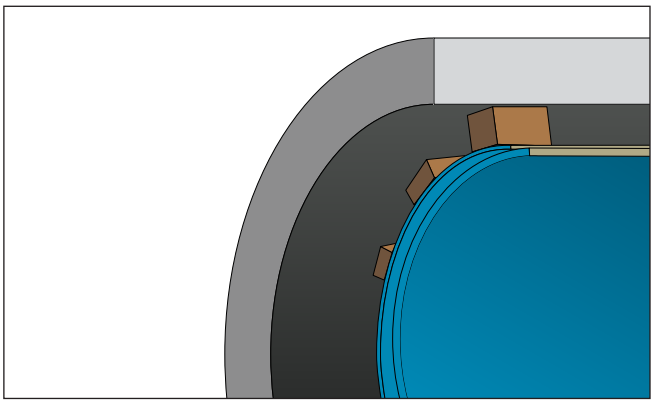

Fig. 42: Wedges location - Example (1)

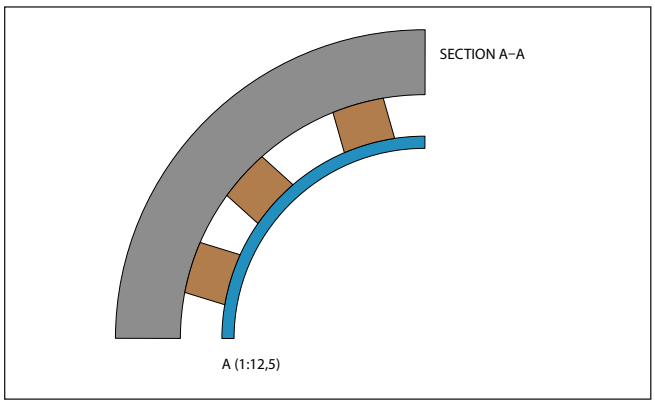

Fig. 43: Wedges location - Example (2)

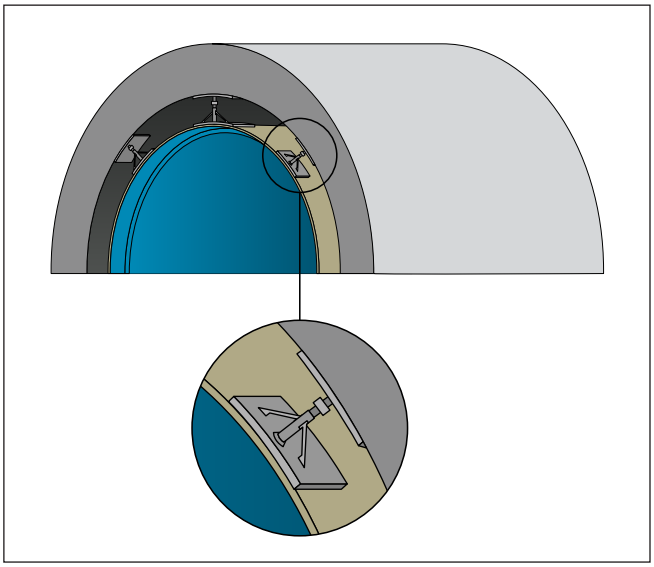

Fig. 44: Wedges location - Example (3)

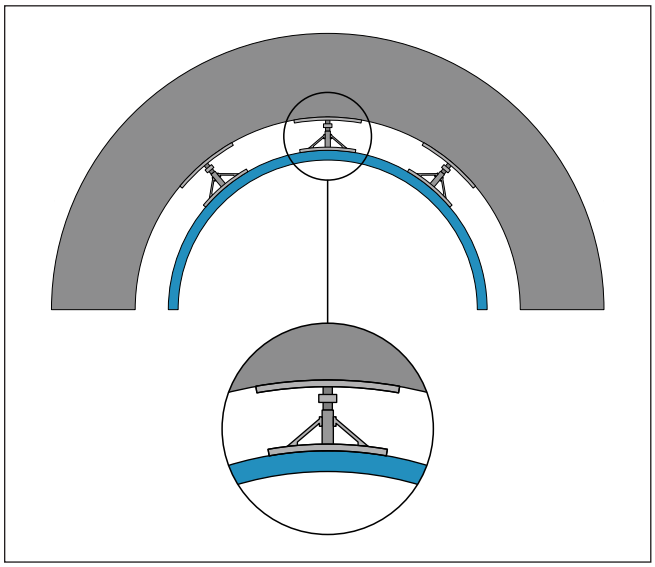

Fig. 45: Wedges location - Example (4)

Steel struts with distribution plates should be designed in a way to avoid excessive point stress concentration on pipe profile.

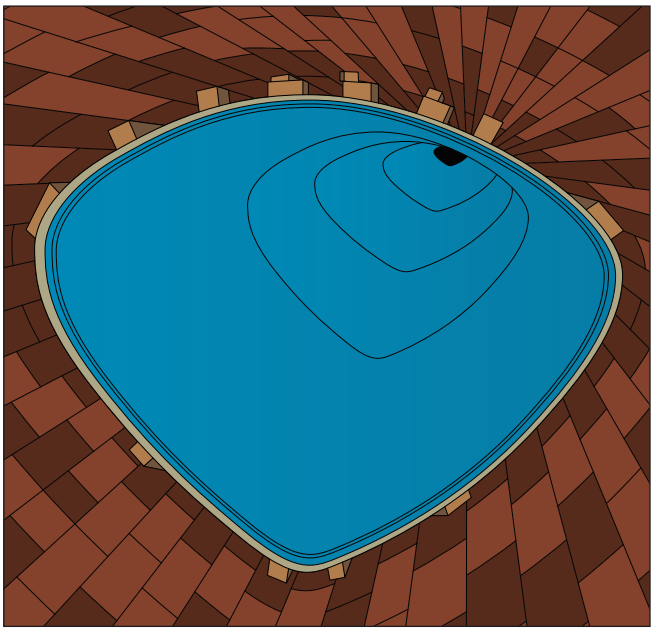

Fig. 46: Wedging example (1)

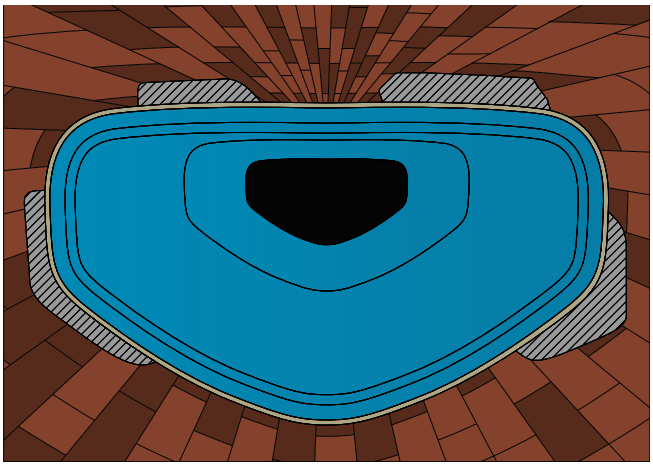

Fig. 47: Wedging example (2)

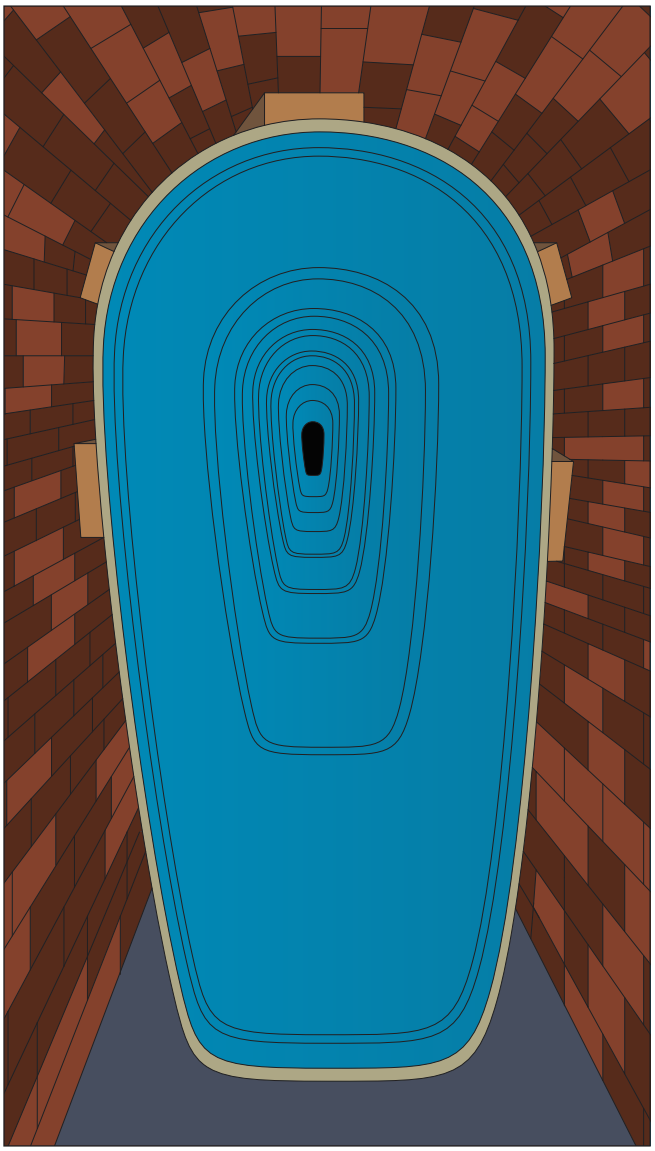

Fig. 48: Wedging example (3)

3.4.2. Shoring

Depending on grouting procedure, site conditions, pipe profile dimensions, shape and wall thickness, shoring might be recommended during grout injection.

In this case, struts will be installed inside the pipe profiles at the wedging location to prevent deformation due to excessive resulting buoyancy force induced by the liquid grout. Groundwater accumulation between the GRP profile and the existing sewer will be prevented before the complete grouting of the annual gap.

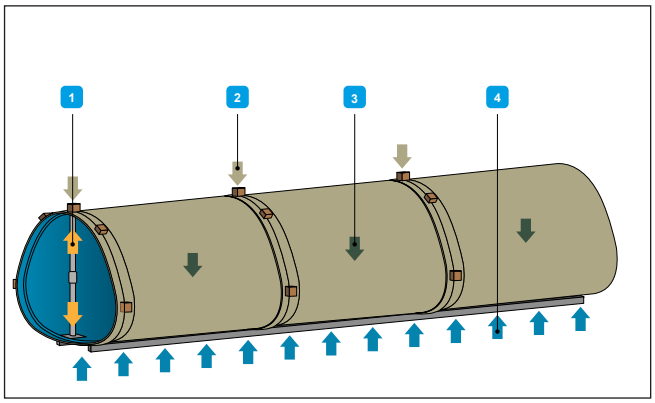

Fig. 49: External loads and reactions (1) | See Legend 1

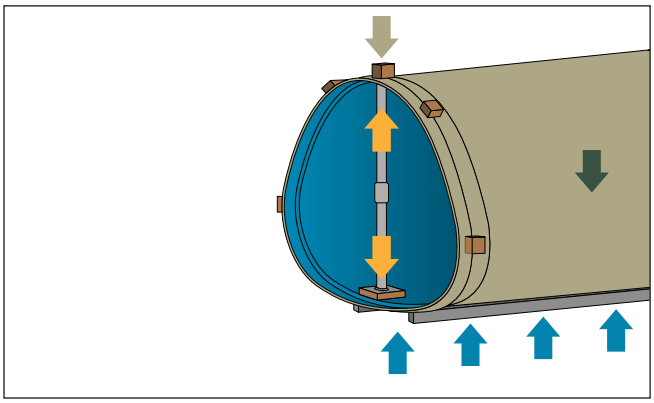

Fig. 50: External loads and reactions (2)

1 - Shoring reaction (preventing deformation)
2 - Wedging reaction (preventing profile movement)
3 - Pipe profile weight
4 - Buoyancy due to liquid grout

Legend 1: Fig.49

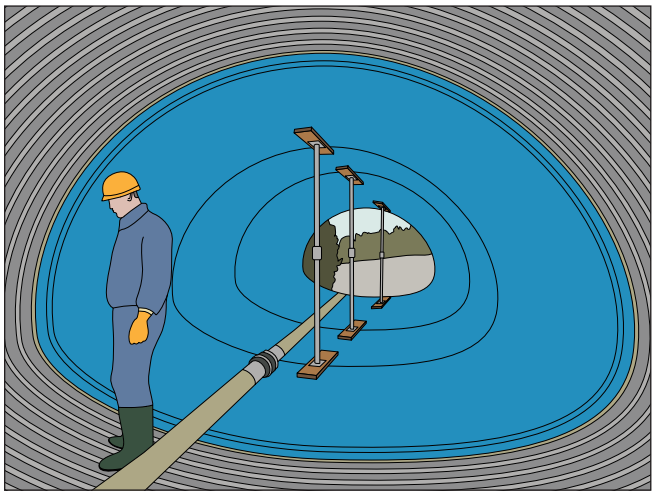

Fig. 51: Shoring example

3.5. Connection of branch inflow pipes

To connect the lateral branches, the pipe profile must be prepared with a marked position of the connection to be done and be drilled on-site. The connection of the lateral branch with the Amiblu NC Profile can be done following typical practices listed below:

3.5.1. Branches in good structural condition

The connection of the branch is conducted in clean and dry conditions as follows:

- Determine the existing branch position.
- Prepare transition pipe (material, diameter, length).
- Drill the hole in the GRP pipe profile.
- Clean and roughen the contact surfaces for adhesive/ sealant.
- Place the adhesive and sealant between an existing branch and transition pipe.
- Insert the transition pipe into the existing branch
- Superficially grind NC pipe profile and transition pipe inner surface at the lamination area.
- Laminate the transition pipe with the GRP profile.

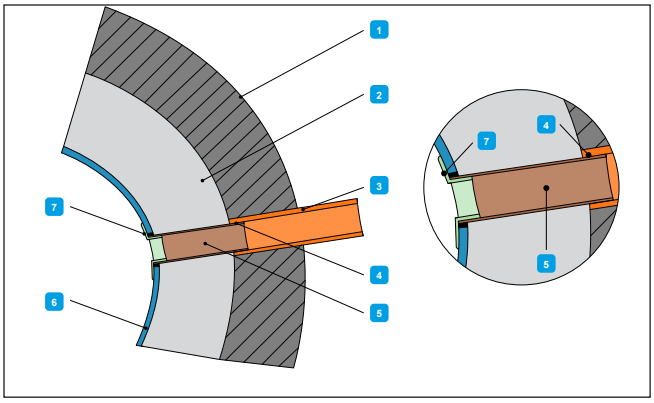

Fig. 52: The connecting principle of a lateral branch being in good structural condition | see Legend 2

1 - Host pipe
2 - Grout
3 - Existing branch
4 - Adhesive/Sealant
5 - Transition pipe
6 - Amiblu NC Line profile
7 - Laminate on site

Legend 2: Fig. 52

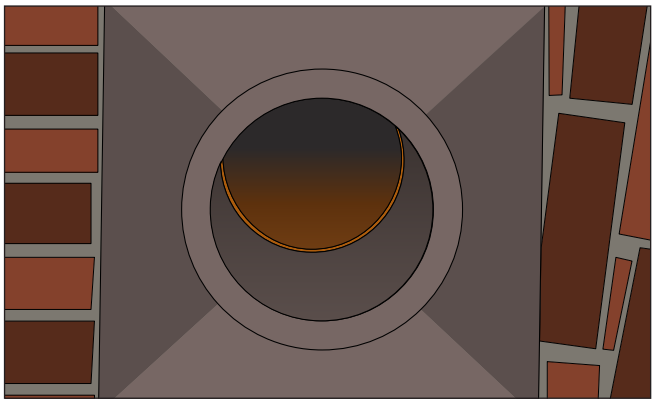

Fig. 53: Connection of branches in good structural condition illustrations (1)

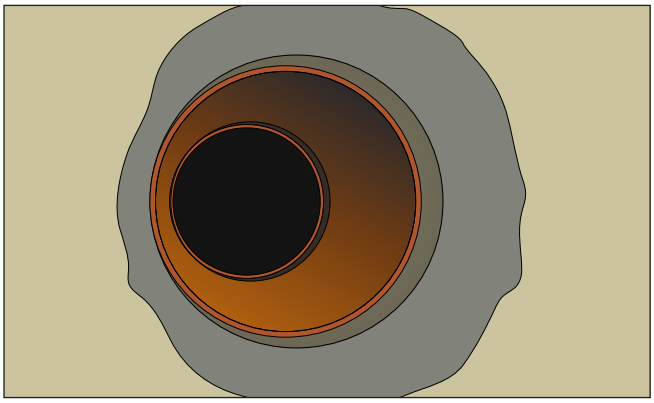

Fig. 54: Connection of branches in good structural condition illustrations (2)

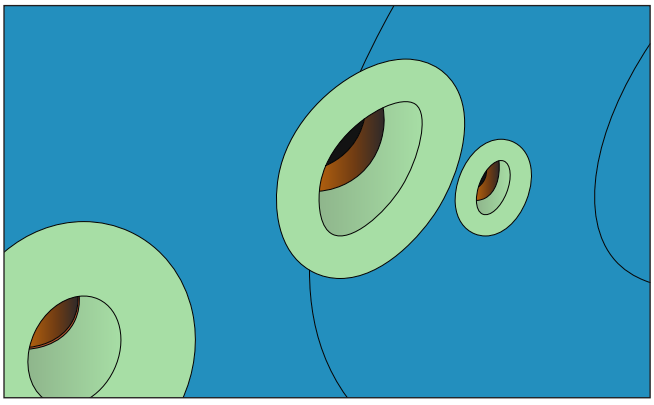

Fig. 55: Connection of branches after rehabilitation

3.5.2. Branches in poor structural condition

The connection of the branch is carried in clean and dry conditions as follows:

- Uncover and remove the damaged part of the branch from inside.
- Determine the existing branch position.
- Prepare transition pipe with bell (diameter, length).
- Clean and roughen the contact surfaces for adhesive/ sealant.
- Place the adhesive/sealant between an existing branch and transition pipe.
- Insert transition pipe with bell and fix it in repair mortar.
- Drill the hole in the GRP pipe profile.
- Insert the pipe sleeve into the transition pipe bell.
- Superficially grind NC pipe profile and pipe sleeve inner surface at the lamination area.
- Laminate the pipe sleeve with the GRP profile.

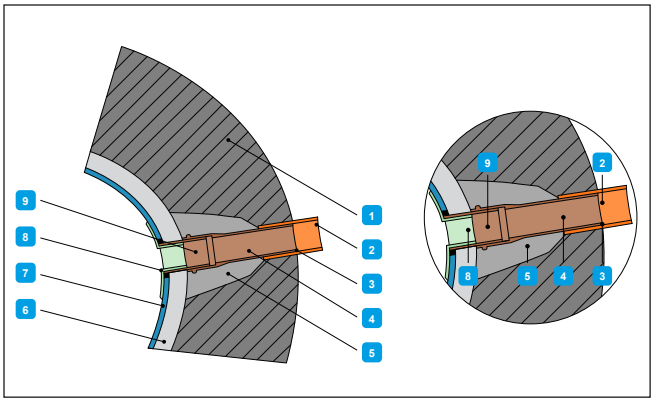

Fig. 56: The connecting principle of a lateral branch being in poor structural condition | see Legend 3

1 - Host pipe
2 - Existing branch
3 - Adhesive/Sealant
4 - Transition pipe with bell
5 - Repair mortar
6 - Grout
7 - Amiblu NC Line profile
8 - Laminate on site
9 - Pipe sleeve

Legend 3: Fig. 56

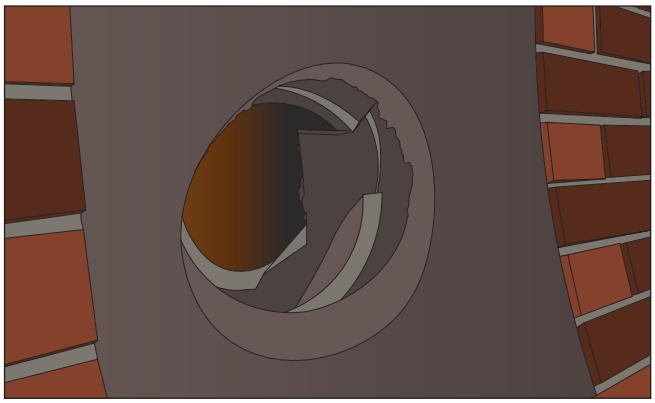

Fig. 57: Connection of branches in poor structural condition illustrations (1)

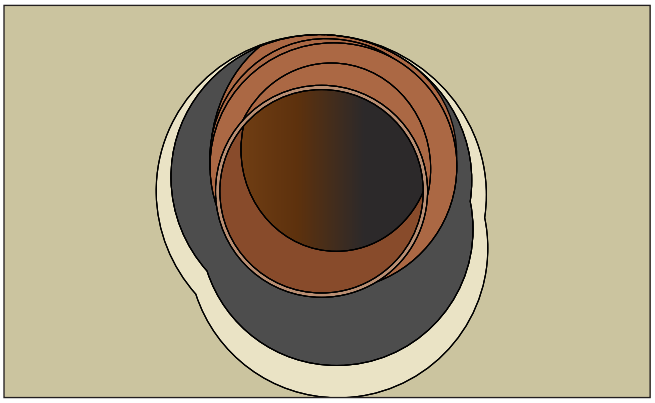

Fig. 58: Connection of branches in poor structural condition illustrations (2)

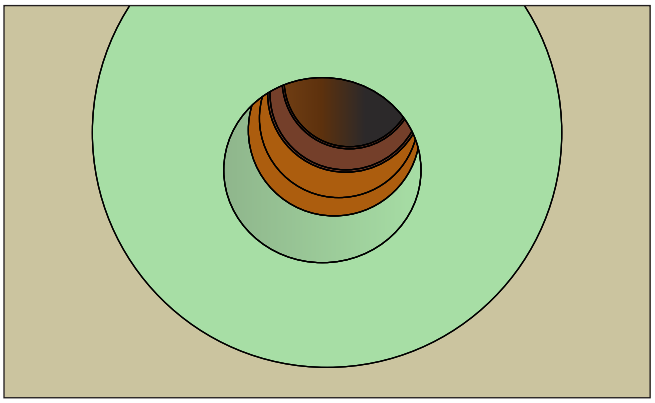

Fig. 59: Connection of branches after rehabilitation

3.5.3. Lateral Connection Repair LCR with "Hat Profile"

The connection of the branch using a “hat shape” solution is conducted in clean and dry conditions as follows*:

- Determine the existing branch position.
- Prepare the hat shape.
- Drill the hole in the GRP pipe profile.
- Clean and superficially grind the surfaces to be covered with a hat shape.
- Insert the hat profile soaked in resin into the existing branch.
- Introduce an inflatable plug into the hat shape.
- Wait until curing is achieved and then remove the inflatable plug.
- Superficially grind NC pipe profile around the hat profile brim and laminate for tightness and finishing.

*For more information regarding this solution contact LCR "Hat Profile" supplier.

Fig. 60: Lateral connection repair LCR with "Hat Profile"

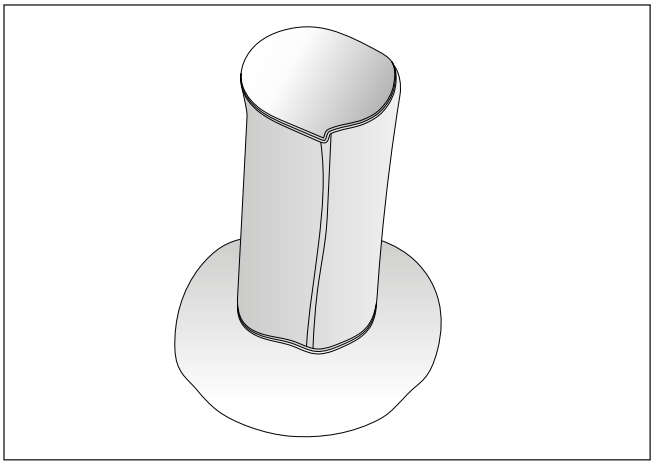

Fig. 61: LCR Hat Profile

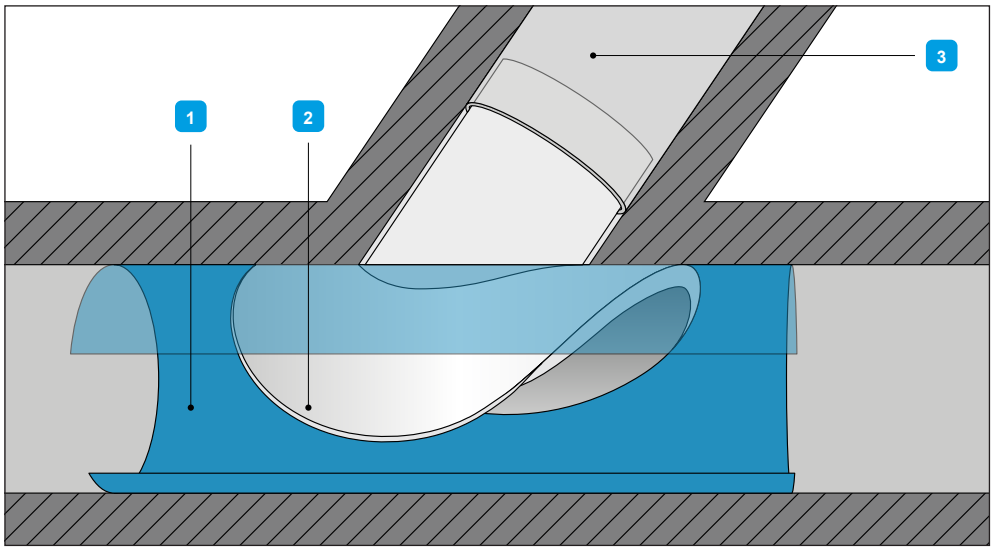

Fig. 62: Connecting a lateral branch using LCR with Hat Profile | Legend: 1 - Amiblu NC Line Profile; 2 - LCR Hat Profile; 3 - Existing Branch;

3.6. Cutting pipe to size

Amiblu NC Line non-circular pipes delivered to the construction site have unit lengths according to the customer's order. However, during installation, shortening a pipe might be necessary. Cut the pipe in the appropriate place using a circular saw with a diamond blade. After pipe cutting, connection to the rest of the pipeline is possible by lamination or through internal repair coupling (Amex type, Fig. 63). For laminate recommendations, consult the pipe supplier. In any case, the lamination area must be clean, dry and accessible.

*For more information about Amex repair coupling, contact the coupling supplier.

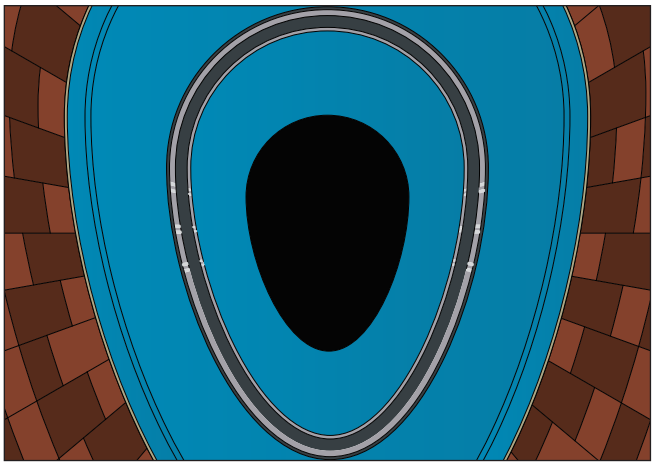

Fig. 63: Installation of AMEX-10 MONO seal in an egg-shaped sewer

3.7. Grout Injection

The annular gap between the assembled new pipe profiles and the host pipe should be filled with grout:

- By injection through nozzles distributed along the Amiblu NC Line pipeline.
- By non-pressure filling from ground level through an opening in the host pipe.
- Or by injection at the intermediate annular gap closures along the pipeline.

Before grouting, a visual inspection will be conducted. All wedging and, if needed, shoring will be in place. Upstream and downstream, the pipeline section to be grouted, the annular gap between the liner pipe and the host pipe must be closed to confine the liquid grout. At the top of those closures, an air evacuation hole will be made to let out the air that will be replaced by the incoming grout (Fig. 64).

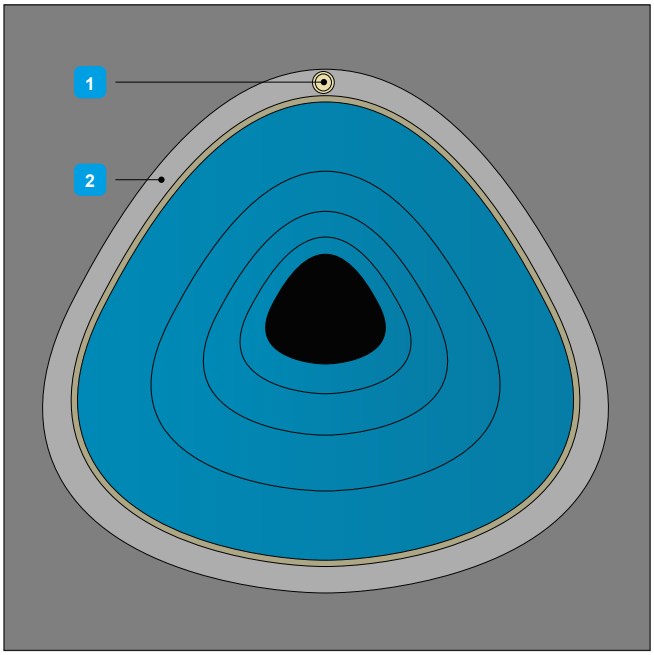

Fig. 64: Pipeline section enclosure with air evacuation hole | Legend: 1 - Air vent; 2 - Grout

The grouting procedure defined by the design office according to the local conditions and the GRP pipe profile will be followed. It is recommended by Amiblu to perform grout injection in several phases (Fig. 65) to avoid high buoyancy forces that could induce displacements and pipe deformation. The number and height of needed grout phases are highly dependent on the shape of the pipe profile. The following points will be considered:

- A new grouting liquid phase cannot be done until the previous one has bound.
- Grouting must be symmetrical (Left/Right Equilibrium).
- Grouting monitoring procedure must be followed (grout level, grout volume measurement, grout quality sampling, pipe measurement monitoring etc.).
- In case of a significant slope and long pipeline section to be grouted, intermediate sections must be determined to keep the height of the grout as initially designed (see drawing principle below).
- Pipe deformation will be monitored during grout injection phases.

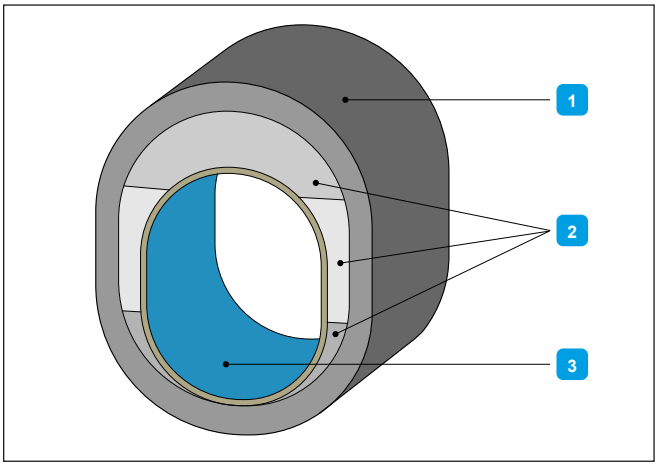

Fig. 65: Stepped grouting | Legend: 1 - Host pipe; 2 - Grouting phases; 3 - Amiblu NC Line profile

For pipe with a wall thickness bigger than 25 mm, Amiblu offers pre-installed stainless-steel injection nozzles sealed in the NC pipe profile wall. Those injection nozzles are internal threads equipped with a non-return valve. The provided threaded stainless steel cap is plugged after grouting.

Another common approach, in particular for smaller wall thickness, is to drill the holes in the profile on site. After drilling, store the GRP coupons and place them back in the hole after the grouting with glue and laminate afterwards. The hole size range is usually from 1 to 2 inches.

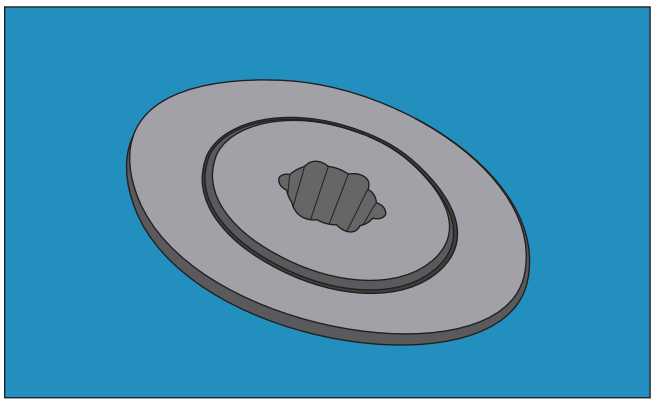

Fig. 66: 1" injection nozzle (1)

4. Pipeline inspection after installation and leak tightness test

Usually, visual inspection of a complete pipeline is conducted and consists of internal dimensions check, connection gaps measurements, liner damage inspection, etc.

Some work specifications include the requirement to perform a leak-tightness test of the finished installation before its approval and commissioning. Since Amiblu NC Line profiles are for non-pressure applications leak tightness test acc. EN1610 can be followed.

For man entry profiles, portable hydraulic equipment for individual joint tests can be used. This equipment can be used to test pipe connections from the inside after complete installation (see Fig. 68, follow EN1610 for pressure value and duration of the test).

Note: The tightness test of the entire renovated pipeline may be required prior rehabilitation of the branch connections and other ancillary structures.

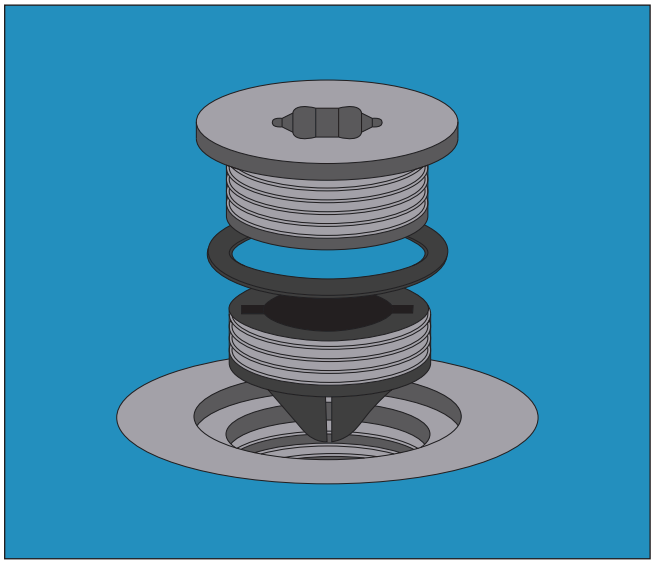

Fig. 67: 1" injection nozzle (2)

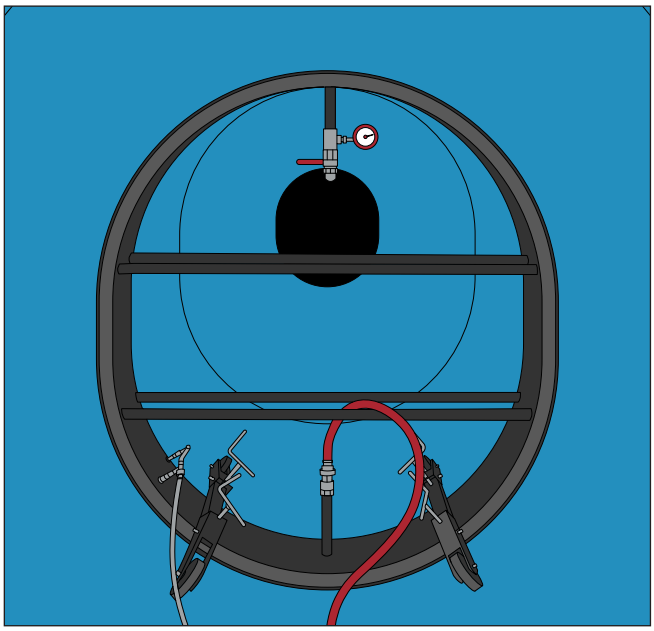

Fig. 68: Individual joint leak-tightness tester

5. Cleaning of pipes

5.1. General

NC Line pipes may need to be cleaned occasionally. The smooth inner surface of Amiblu pipes means less sand and sludge is deposited making cleaning easier.

5.2. Mechanical Cleaning

For cleaning simple brushes or such special devices as pigging systems, propelled through the pipes mechanically, with compressed air or water, are recommended. Special pigs for GRP pipes are available on the market, which should be used. The cleaning effect is usually achieved with the pig's size relative to the pipe inside diameter. Models range from brushes with plastic bristles to complex tools with integral spray nozzles for pipelines.
Chain spinners, metal bristles or other such devices are not allowed.

5.3. Cleaning by flushing at Normal Pressure

The most economical method of cleaning pipes is flushing, which increases the hydraulic shear stress, thus scouring and washing out deposited sediment.

5.4. Cleaning by High-Pressure Water Jetting

When pressure cleaning pipelines with water, take due care to prevent the inner surface of the pipes from being damaged. Always use methods that do not damage the pipe wall mechanically. Take care to choose the appropriate nozzle so that there will be no sudden impact of the nozzle touching the pipe wall. Amiblu can help in this regard.

- Maximum pressure at the nozzle up to 120 bar*. Due to the smooth interior surface of the GRP pipe, adequate cleaning and removal of blockages can normally be achieved below this pressure.
- Nozzles with jet holes around the circumference are to be preferred. Nozzles with cleaning chains or wires, as well as rotating, aggressive or other damaging nozzles are not allowed.
- The water discharge angle should not be greater than α= 30°. An angle smaller than α= 20° is usually sufficient for a GRP pipe, as the smooth surface of the material inhibits adhesion and only washing of the interior is needed.
- The number of jet holes should be 6 to 8 and the hole size must be at least 2.4 mm.
- The external surface of the nozzle will be smooth and the maximum weight is 4.5 kg. Nozzle length, corresponding to that weight, should be at least 170 mm. For small and medium-range diameters (DN 200 - 800) the lighter nozzles (approximately 2.5 kg) will be used.

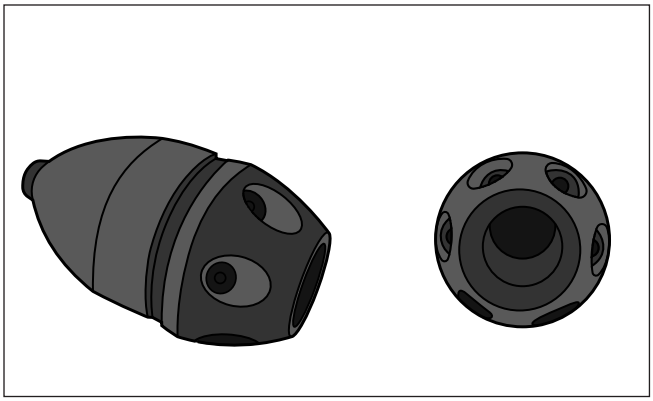

Fig. 69: Sewer cleaning and flushing nozzles (1)

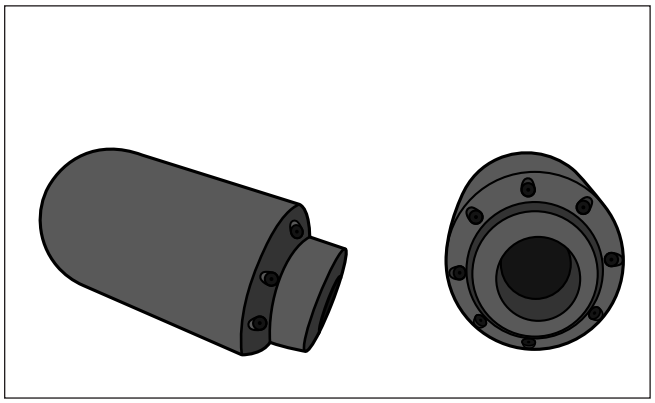

Fig. 70: Sewer cleaning and flushing nozzles (2)

*Cleaning takes place at a maximum water jet power of 330 W/mm^2. Experiments have shown that at this value, and when a recommended body and nozzle inserts are used at a flow of 300 liters/min, a pressure of 120 bars is created.

- The forward and backward moving speed of the nozzle will be limited to 30 m/min. Uncontrolled movement of the nozzle is not allowed. When inserting the nozzle into the pipe care should be taken to prevent it from hitting the pipe wall.
- Jetting/swabbing sleds with several runners give a greater distance between the nozzle and the pipe wall, resulting in a less aggressive cleaning.

Amiblu NC Line profiles generally meet the requirements of water jet cleaning according to DIN 19523. Recommendations are summarized below:

- Good cleaning results are achieved at a pressure of 60 – 100 bar at the nozzle.
- The size of the inserts in the nozzle should be 2.4 mm.
- The nozzle head should have six jet holes or more around the circumference.
- The nozzle weight should be less than 2.5 kg.
- The nozzle drag velocity will be 10 – 20 m/min. Avoid stopping the nozzle during the cleaning procedure.
- Ensure that the nozzle remains at least 30 mm away from the pipe wall. Use guides or spacers to maintain the minimum distance, if necessary.
- Keep the angle of the water jet to the pipe wall as small as possible. The angle for cleaning the pipe should be smaller than $\alpha = 25°$.

To improve cleaning results, increase the amount of water used and not the pressure applied. Hence it is recommended to increase the size and the number of inserts in the nozzles.

Annex A - Technical features

1. Overview

1.1. Definition

The Amiblu NC Line pipe profiles prefabricated by the Amiblu company are intended for use in the rehabilitation of gravity-flow sewer systems using GRP pipe and annular space grouting.

The prefabricated NC Line pipe profile system is used in trenchless rehabilitation of non-pressure sewers particularly those that are made of brick, steel; cement, stone, or reinforced or unreinforced concrete and that is intended to carry rainwater or domestic wastewater for other effluents, call your local technical support.

The host pipe may be prefabricated or not and may have standardized or non-standardized cross-sections.

The Amiblu NC Line pipe profiles comply with the specifications of the ISO 16611 standard, in particular, regarding dimensions, requirements, and tests for non-circular GRP pipe profiles intended for use in rehabilitations or in trench installations.

1.2. General description

The product consists of fiberglass strands incorporated into a thermo-setting resin matrix, with the addition of sand. The outer shape of the pipe profiles is designed for the best fit inside the collector to be rehabilitated. The inside extreme transverse dimensions of the manufactured products range from 300 to 4000 mm. The nominal wall thickness ranges from 7 mm to 60 mm.

Their laying length varies depending on the applications and the specific conditions of the project (e.g., transport, access, cross-section, installation method, gradient to be maintained, the weight of the components, etc.). The most commonly used unit lengths are between 1 and 3 meters (typically 2.25 meters).

In mechanical terms, the pipe profiles are characterized by their thickness, their wall structure and associated, flexural modulus, flexural strain, and flexural strength.
The products can be assembled using several types of joints depending on the conditions under which they are used and the customer's request.
The rehabilitation process includes a concluding step consisting of an annular grout injection between the pipe profile and the existing sewer.

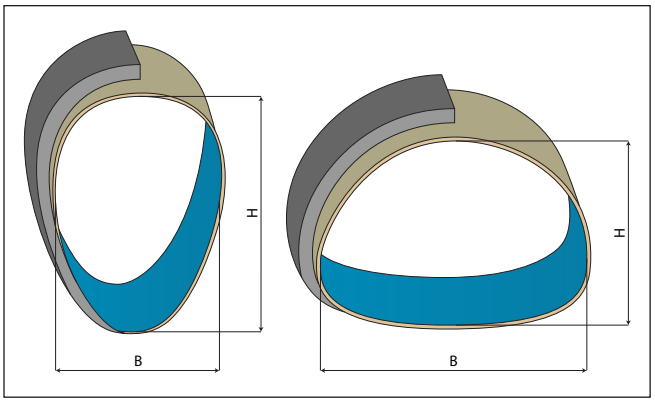

Fig. 71: Principle of rehabilitation with pipe profiles

1.3. References and standards

1.3.1. Product standards:

- ISO 16611, for non-circular pipe profiles; Plastics piping systems for drainage and sewerage without pressure —Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP)—Dimensions, requirements and tests.

1.3.2. Static Design examples:

- "New design recommendations for the rehabilitation of sewer systems using liners and pipes" (3R2014-ASTEE 2014).
- The WRc Sewerage Rehabilitation Manual (SRM), Volume 4 ("Manual for the rehabilitation of WRc sewer-system collectors") (4th edition, published in 2001).
- German Code DWA-A 143-2
- Finite Element Analysis

1.3.3. Installation recommendations:

- Amiblu NC Line Installation manual
- The RERAU 4 group's manual on the state of the art (pipelines using prefabricated elements with annular space), published in July of 2000 and the technical guide titled "Restructuring of accessible collectors", issued by the RERAU 4 group (volumes 1 and 2, published in 2002 and 2004).
- The WRc Sewerage Rehabilitation Manual (SRM), Volume 4 ("Manual for the rehabilitation of WRc sewer-system collectors") (4th edition, published in 2001).
- German Code DWA-M 143-12

2. Raw materials

The raw materials must follow the specifications outlined in the ISO 16611 standard. The following components are employed, in suitable proportions, in the manufacture of the Amiblu NC Line pipe profile:

2.1. Glass

The glass is type E-CR glass, as used in the form of roving, mats, veils, and/or chopped fibers, in compliance with the EN ISO 2078 standard.

2.2. Standard Resin

Structural layers: polyester resin type 1B or 2B in compliance with the EN 13121-1.
Liner: polyester resin type 4 as a base in compliance with the EN 13121-1 standard mixed with additives.
Other resin qualities are available on request.

2.3. Aggregates

As filler dried quartz sand is used.

3. Finished product description

3.1. Pipe Structure

The pipe profile wall consists of different layers. The principle of the Amiblu NC Line Pipe wall construction is shown in Fig. 72.

The resin-rich liner, which is the inside layer that provides protection mainly against abrasion, is around 1 mm thick.

Layers in the middle (inner skin, outer skin and core) compose the structural layer.

The outer layer, with a thickness of around 0.5 mm, particularly resistant to weathering and having protection against scratches, consists mainly of silica sand bonded with resin.

For static calculation, the structural layer is defined as the nominal thickness minus 2 mm.

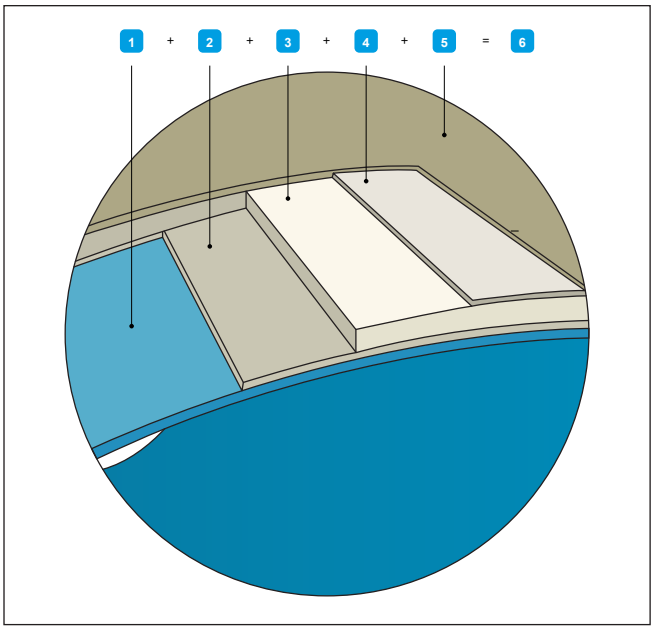

Fig. 72: Pipe profile wall | Legend: 1 - Inner Liner Layer; 2 - Inner Skin Layer; 3 - Core Layer; 4 - Outer Skin Layer; 5 - Outer Protective Layer; 6 - Total wall thickness (1+2+3+4+5)

3.2. Joining systems

The NC Line GRP pipe profiles are equipped with an integrated joining system. Two types are used:

3.2.1. Type A, B, B1 and C – Flexible Joint System:

A flexible assembly with an EPDM, SBR or NBR seal, consisting of a bell and a spigot with groove intended to receive the elastomeric seal. The elastomer used follows the EN 681-1 standard (equivalent to the ISO 4633 standard).

3.2.2. Type D – Rigid Joint System:

This assembly consists of a Bell and a spigot without a gasket. The connection is glued and possibly laminated on-site. This system is not associated with the Amiblu tightness warranty.

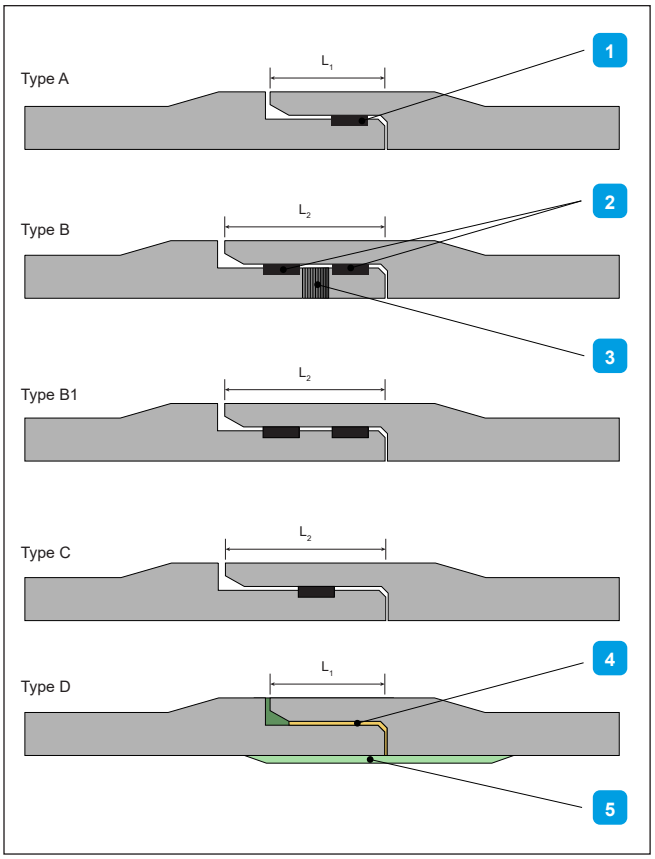

Fig. 73: Pipe Connection Types | 1 - Gasket groove; 2 - Sealing Gasket; 3 - Nozzle; 4 - Glue; 5 - Laminate

3.3. Options

A grout-injection nozzle (1-inch thread, if pipe wall is thick enough) or anti-slipping band may be provided at the client's request.

3.4. NC-Profile dimensions

The shape and dimensions of Amiblu NC Line profile depend on:

- Host pipe shape and dimensions.
- Loads and associated static calculations.
- Grout injection feasibility.
- Cost efficiency (existing mould etc.).

For non-circular pipe profiles, the nominal dimensions are indicated by BN(B) x HN(H), where "B" is the stated maximum inside Breadth and "H" is the stated maximum inside height, expressed in millimeters.

The nominal thickness of the pipe profile is defined as the minimum total thickness (Fig. 72). Over thickness of the pipe

profile wall is permissible. The laying lengths of the pipe profiles have tolerances of +20 / -10 mm.

3.5. Appearance

The outside surface has a granular appearance, and its color is that of the silica sand that is used.
The inside surface is smooth according to the filament winding process and has a glossy appearance. The wall is opaque. Its color depends on the dyes used for the liner (reference: RAL 5012).

3.6. Fittings

The GRP fittings for the Amiblu NC Line pipe profiles meet the requirements of the ISO 16611 standard (for non-circular pipe profiles). These fittings include, for example, elbows, tees, etc. Manholes are produced according to EN 15383.

4. Manufacturing

The Amiblu NC Line pipe profiles are manufactured through the filament winding process.

The NC Line pipe profiles are manufactured on computer-controlled machines.

The successive layers that constitute the wall are created around a mandrel (usually made of metal) that has the desired inside shape of the channel after renovation.

The spigot is ground on the pipe profile, with the aid of a milling machine specially designed for use with non-circular shapes. The bell is integrated as a part of the monolithic pipe profile. The elements are then stored in a yard before being loaded and shipped, after quality control confirmation of the dimensional and mechanical characteristics.

5. Mechanical, physical, and chemical properties

5.1. Specific mechanical properties of NC Line pipe profiles

In conformity, with the Standard ISO 16611, test requirements:

- The specimens that are tested for the evaluation of the short-term mechanical properties are samples that were cut from the parts of the pipe profile with a maximum radius of curvature.
- The specimens that are tested for the evaluation of the long-term mechanical properties are circular pipe profiles that were manufactured under the same conditions, and that have the same wall structure, as the non-circular pipe profiles.

The values of the mechanical properties described below refer to the structural layers.

5.1.1. Hoop Bending properties

The short-term bending modulus; the resistance in strain corrosion; and the bending strength are measured within the scope of the inspection tests, as prescribed in the EN ISO 178 standard.

The values of the long-term bending modulus are evaluated per the ISO 10468 standard. The values taken into consideration are the ones for a wet environment.

The minimum long-term resistance in strain corrosion (5% sulfuric acid, or 0.5 mole/liter) is evaluated based on type tests performed per the ISO 10952 standard. These values characterize the suitability of the material when subjected to stress in an acidic environment. The long-term bending strength is calculated per the ISO 16611 standard.

Properties in Hoop Direction		
Short-term bending modulus	Short term	9500 Mpa
Short-term bending strength		200 Mpa
Short-term bending strain		1.6 %
Long-term bending modulus	Long term	6000 Mpa
Long-term bending strength		80 Mpa
Long-term resistance in strain corrosion		0.8 %

Table 3: Short-term and long-term hoop bending properties

5.1.2. Initial longitudinal tensile strength

The minimum values according to the table associated with the ISO 16611 standard are met and measured within the scope of the routine inspection tests, per the ISO 8513 standard.

5.1.3. The Poisson coefficient

The value considered for the calculations is 0.30.

5.2. Abrasion resistance

The standard tests performed per the principles described in the EN 295-3 standard have shown that the average depth of abrasion of the tested products is less than the minimum thickness of the liner after 100,000 load cycles.

5.3. Temperature Application Range

The GRP NC Line pipe profiles are designed to withstand operating conditions of urban effluents; i.e., 0°C to 35°C. If a higher temperature is required, then a special design can be offered.

5.4. Coefficient of thermal expansion

The coefficient of linear expansion of the pipe profile is $30x10^{-6}$ mm/mm/deg C.

5.5. Flexible Joint Performance (A, B, B1 and C)

Thanks to the manufacturing process that is used, Amiblu NC Line pipe profiles are leak-tight when subject to internal and external hydrostatic pressure according to limits defined by the ISO16611.

Type A, B, B1 and C – Flexible Joining Systems are suitable for use in non-pressure pipeline systems. From a Tightness point of view, the maximum internal working pressure is 1 bar.

From a Tightness point of view, the maximum external pressure is 0.8 bar (that is, an 8-meter water column from pipe bottom), subject to verification of the mechanical stability of the pipe profile under these conditions. The maximum permissible angular deviations are described in Chapter 3.3.

5.6. Water jet cleaning

The Amiblu NC Line pipe profiles are tested for high-pressure jet cleaning per the DIN 19523 standard (material and practical test).

Maximum dimension of cross section (MDC) mm	Minimum initial specific longitudinal tensile strength N/mm of circumference
150	**75**
200	80
250	85
300	95
400	105
500	120
600	130
700	145
800	155
900	165
1000	180
1200	205
1400	230
1600	255
1800	280
2000	305
2200	330
2400	350
2600	375
2800	400
3000	425
3200	450
3400	475
3600	500
3800	525
4000	550

Table 4: Minimum initial specific longitudinal tensile strength

Test	Tests to be performed	Test pressure (Bar)	Duration
External pressure differential	Negative pressure[a]	0.8 (-0,08 MPa)	1 h
Deformation and draw[b]	Positive static pressure	1.5 bar	24 h
	Positive cyclic pressure	Atmospheric to 1.5 bar	10 cycles of 1.5 min to 3 min each
Angular deflection and draw	Initial pressure	1.5 bar	15 min
	Positive static pressure	1.5 bar	24 h

[a] Relative to atmospheric; i.e., approximately 0.2 bar (0.02 MPa) absolute.
[b] The force will be min. 20 N per millimeter of the internal height (H) in millimeters and it will be applied on the area of the lowest stiffness of the test piece

Table 5: Summary of ISO16611 test requirement for non-end-load bearing flexible joints

6. Labeling

The NC Line pipe profiles can be identified by label. The following information appears on each pipe profile:

- Manufacturer identification: Amiblu + manufacturing site;
- Trade name: Amiblu NC Line;
- Nominal wall thickness;
- Worksite or order reference;
- Date of manufacture, and production reference;
- Dimensions (working length, height, and width or diameter)

7. Quality control

7.1. Internal inspections

The quality control activities are performed per the quality control plan. The following routine inspections are performed:

1. On raw materials: resin, sand, glass fibers and gaskets per batch.
2. Production: Recording of the machine-operation parameters.
3. Finished products batch:
    - Inspection of the structure of the wall.
    - Visual inspection.
    - Pipe profile dimensions (length and thickness).
    - Assembly dimensions.
    - Perpendicularity of the ends.
    - Short-term bending strength and modulus.
    - Tensile strength.
    - Dimensional inspection of the joints.

All the inspections are performed at least once for each type of pipe profile corresponding to an order.

7.2. External inspections

7.2.1. Quality management system

The quality management system implemented for the manufacturing process holds an ISO 9001 certification. Additionally, the Amiblu NC Factories are certified acc. ISO 14001.

7.2.2. Product certification

The Amiblu NC Line pipe profiles are certified by accredited third-party inspection.

8. Mechanical design

8.1. Amiblu NC Line shape design

Preliminary studies will be performed. The company responsible for the rehabilitation conducts a visual inspection to check and confirm the host pipe condition and determine the internal dimensions according to the most deformed host pipe sections and the newly rehabilitated sewer slope to be achieved through direct measurement or scanning.

Amiblu proposes based on data provided from the existing sewer channel an Amiblu NC Line Pipe Profile. The contractor and/or Client Engineer must validate the proposed NC profile.

8.2. Amiblu NC Line thickness design

A specific structural calculation to define the pipe profile thickness is realized by engineering company in charge considering: life loads, soil mechanical features and the existing pipe condition, etc.

The structural design will follow the nationally approved method agreed by the contractor.

The installation procedure (number of grouting phases, wedging, etc.) will be defined acc. to the designed product (shape and thickness).

9. Hydraulic design

The following value might be used for hydraulic project engineering with Amiblu NC Line pipe profile:

Colebrook-White absolute roughness: k = 0.03 mm

Annex B

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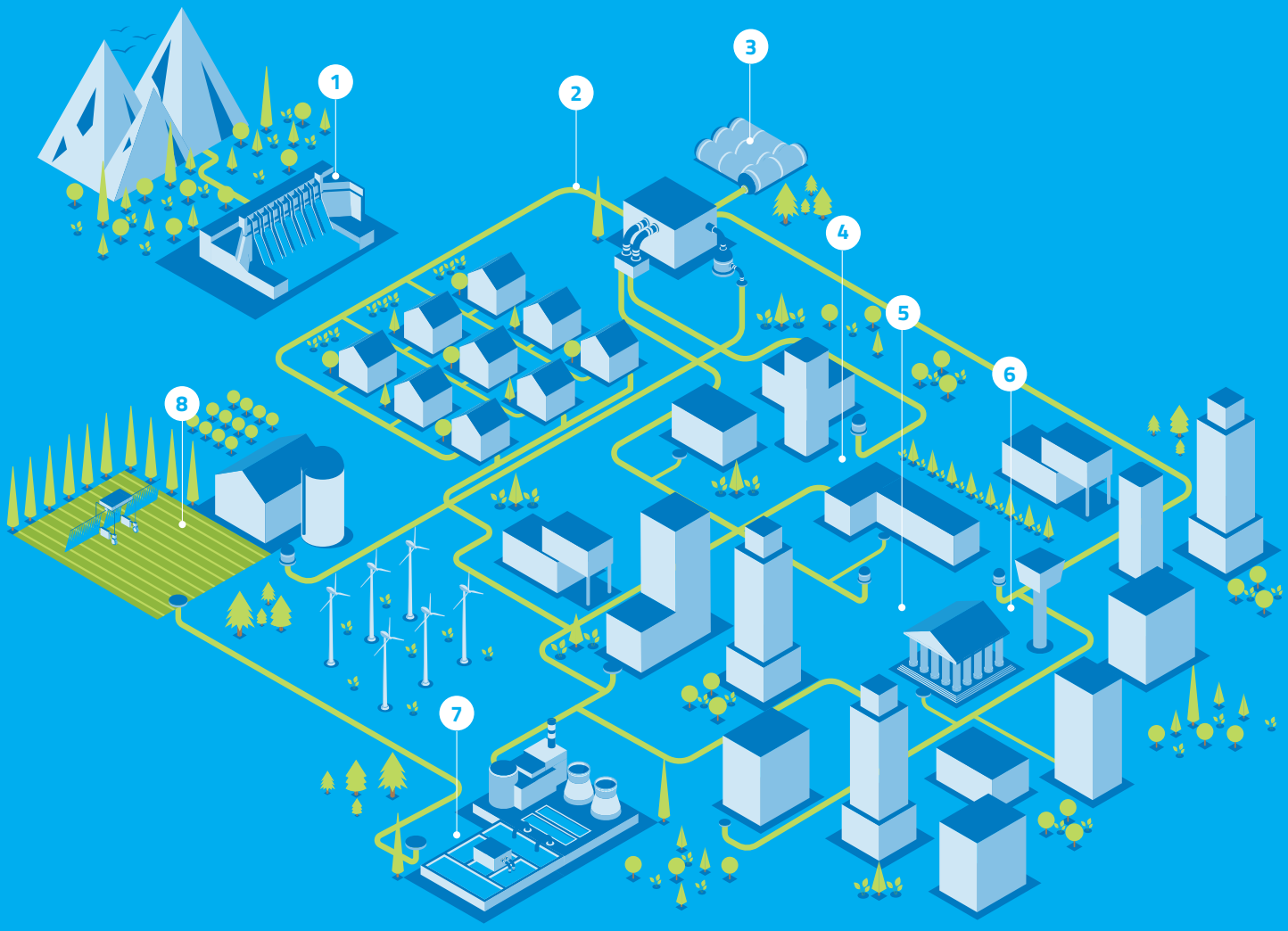
5. NC Pipes Rehabilitation
6. Jacking Pipes
7. Industry
8. Irrigation



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