DYNALINER INSTALLATION GUIDELINES

These guidelines are intended to give an overview of the procedures and techniques used to install the DYNALINER PVC pipeline rehabilitation system. Actual field conditions may affect installation procedure.

SEQUENCE OF EVENTS

- Pre-Installation TV Inspection
- Pre-Installation Pipeline Preparation
- Liner Installation
- Post-Installation TV Inspection
- Reinstatement of Service Connections

1. PRE-INSTALLATION TV INSPECTION

- Prior to inspection, the pipeline is cleaned using a high pressure water jet to remove any debris in the pipeline.
- Identify any conditions in the pipeline that could impede or prevent the proper installation of the liner.
- Provide a record of the pre-lined condition of the pipe.
- Accurately record the position of all service connections.

2. PRE-INSTALLATION PIPELINE PREPARATION

Typical pipeline conditions that must be remediated prior to lining:

- Roots: Roots must be removed from the pipeline prior to installing the liner. Roots may be removed by using a mechanical means such as chain flails.
- High Level of Groundwater Infiltration: Large quantities of cold ground water flowing into the pipeline can act as a heat sink and prevent the PVC liner material from reaching the temperature needed to form properly. Infiltration may be eliminated either by chemical grouting or installing a patch prior to lining.
- Collapsed Pipe: Collapsed pipe that reduces the inside circumference of the pipeline to less than the outside circumference of the pipe liner will not allow the liner to form properly. This condition is usually presented as a longitudinal rib after the liner is installed. To avoid ribs in the liner, sections of pipeline containing collapsed pipe should be point repaired prior to lining.
- Offset Joints: Offset or dropped joints of more than one inch of the inside pipe diameter can cause ribs to form in the liner, similar to a collapsed pipe. To avoid ribs in the liner, sections of pipeline containing offset or dropped joints should be point repaired prior to lining.
- Protruding taps: Service taps that protrude into the pipeline more than 12.5% or 1-inch should be cut off using a chain flail or remotely controlled grinder.

3. LINER INSTALLATION

- Equipment Setup

- Heat Coiled Liner
- Insert Liner into Host Pipe
- Process Liner

A. Equipment Setup

Stage a steam boiler apparatus, flow-through plug, and the coiled liner at the upstream structure (i.e., headwall, manhole, drop inlet, etc.). Stage a winch, flow-through plug and exhaust manifold at the downstream structure. Use a jet apparatus to run the winch cable from the downstream structure to the upstream structure.

B. Heat Coiled Liner

Drill holes through the end of the liner pipe and connect the winch cable. Enclose or cover the coiled liner and heat with steam at approximately 190°F. Heating time will vary depending on ambient temperature, altitude and steam quality.

C. Insert Liner into Host Pipe

When the liner is pliable, make a pulling nose by drilling holes perpendicularly through the free end of the folded liner, then weaving a cable or chain through the holes. Insert the liner into the host pipe by uncoiling the pipe reel (either mechanically or manually) from the upstream side, with assistance from the winch cable at the downstream side. Liner should be inserted at a rate of 100 to 120 feet per minute. Maintain the upstream feed from the pipe reel to avoid stretching the pipe with the winch cable. Coordinate the speed at which the liner is inserted into the pipeline using two- way radio communication between the upstream and downstream stations. Pull enough liner so that sufficient material is available at the downstream station to allow for inserting the flow-through plug.

D. Process Liner

After the liner pipe has been inserted and plugged at the upstream station, allow the liner pipe relax for approximately five (5) minutes. The liner pipe relaxation is particularly important if the liner pipe has been stretched during the insertion process, and may require more than five (5) minutes in those cases.

Insert a flow-through plug into the upstream end of the liner (the upstream end may be reheated in order to soften the material enough to insert the plug). Leave a “window” of pipe liner between the opening of the host pipe and the end of the plug to allow for observation of the liner as it is processed. Attach the steam hose to the upstream plug, and apply steam at approximately 215°F through the liner. Heat and relax the liner until movement at the downstream station has stopped. Cover the downstream end of the liner with a tarp or similar cover to allow the steam flow to soften the material enough to insert the downstream flow-through plug. Connect the downstream flow-through plug to an exhaust manifold, and apply a small amount of backpressure (approximately ½ PSI) to the liner system. Do NOT close the exhaust plug valve. The steam temperature and pressure are monitored and controlled at the upstream and downstream process stations.

Heating time is determined by the length and wall thickness of the liner. Additional heating time may be added by the installer if warranted by conditions within the host pipe. As the liner is thoroughly heated, internal pressure is slightly increased to cause the liner to conform tightly to the

interior of the host pipe. Two (2) to five (5) PSI of backpressure should be sufficient to form the liner in the host pipe. At the end of the heating time, switch from steam to compressed air. Maintain internal pressure until the exhaust air temperature has reached a predetermined temperature (usually 100° F). Water may be induced into the compressed air during the cooling process to reduce the cooling time.

4. POST INSTALLATION TV INSPECTION

- After the liner has been cooled, remove the flow-through plugs and inspect the liner using CCTV. Ensure that the liner has formed properly and that there are no defects in the liner.

5. REINSTATEMENT OF SERVICE CONNECTIONS

Reconnect services using a remotely controlled robotic cutter.

- In most cases the service connection is located by means of a pronounced dimple in the liner.
- When the dimple is not clearly visible, refer to the pre-installation inspection tape and the previously recorded position of all the service connections.
- Use a brush- or rasp-type bit to make service connection holes. Do not use a fluted-type or router bit.
- When reinstated the hole for the connection must be smooth and conform to the inside shape of the old opening.
- The hole must be a maximum of 105% and a minimum of 90% of the service pipe diameter.
- The ends of the liner are neatly trimmed leaving one to one and one half inches of liner extending into the manhole.

GENERAL SPECIFICATION FOR THE REHABILITATION OF SEWERS USING THE DYNALINER (PVC) PIPE LINING SYSTEM

1. GENERAL

1.01 DESCRIPTION

A. The Contractor shall furnish all labor, equipment and materials necessary to complete the lining of sanitary and storm sewers as stipulated herein and as shown on the Contract Documents. As applicable to a specific contract, the work shall include the preparation of the construction site, including cleaning and flushing of existing piping; flow control bypass pumping; protection of existing conditions during installation work; unloading; hauling; distribution and installation; testing of all pipe, fittings, scaffolding, piping, valves, boilers, etc. and other accessories as required for proper installation; protection of the site during the work, including protection of necessary watchmen, warning lights, barricades, traffic control, dust control and maintenance of detours, as needed; and the cleanup of the work site.

B. It is the intent of this Specification to provide for the reconstruction of sanitary and storm sewers by the installation of a polyvinyl chloride (PVC) pipe liner into the existing sewer line. When installed, the pipe liner shall extend over the length of the pipe between manholes in a continuous, tight fitting, watertight pipe-within-a-pipe. The lining system shall be installed using trenchless technology, with no excavation or surface restoration required.

C. Pipe relining is one method of pipeline rehabilitation. Depending on site conditions, other or additional pipeline rehabilitation methods, e.g., point repairs, may be required.

1.02 SUBMITTALS

A. Submit product data, video records, and installation instructions for approval.

B. After award of the Contract and before any materials are delivered to the job site, the Contractor shall submit to the Engineer a complete list of all materials proposed to be furnished and installed for the work.

1. The materials list shall include the manufacturer's name and catalog number for each item, furnish catalog cuts and technical data, and the manufacturer's recommendations as to method of installation.

2. Upon approval of the Engineer, the manufacturer's recommendations shall become the basis for acceptance or rejection of actual methods of installation used in the work.

3. The Contractor shall not permit any sewer-lining component to be brought onto the job site until it has been approved by the Engineer.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Protection: The Contractor shall use reasonable means to protect sewer lining materials before, during, and after installation and to protect the installed work and materials of other trades.

B. Replacement: In the event of damage to the sewer lining materials, the Contractor shall make timely repairs and replacements necessary to the approval of the Engineer at no additional cost to the Owner.

1.04 WARRANTY

The Contractor shall warrant all work to be free from defects in workmanship and materials for a period of one year from the date of final completion of the project.

1.05 EXISTING SEWER SYSTEM

A. Active Sewers: The Contractor shall maintain in operating condition all active sanitary and storm sewers encountered in the sewer lining installation.

B. Connections to Existing Sewers and Structures: The Contractor shall make all required connections to existing sewers and structures (i.e., manholes, drop inlets, headwalls) and carry out such work in accordance with local standards and requirements and as directed by the Engineer. The Contractor shall exercise reasonable care to prevent debris from entering existing sewers to be lined.

C. The DynaLiner system is not recommended for above-ground, geothermal, or other piping systems with service temperatures over 120°F.

2. MATERIAL AND EQUIPMENT

2.01 MANUFACTURER

The pipe liner pipe rehabilitation system shall be the DYNALINER pipeline rehabilitation system as produced by DYNALINER LLC, or approved equal. Alternative materials must be approved not less than 30 days prior to bid date.

2.02 PIPE LINING MATERIALS

A. Polyvinyl Chloride Liner

1. The liner shall be fabricated to a size which, when installed, will fit the internal circumference of the pipe as specified by the Engineer. Allowance for circumferential expansion during installation shall be made. The liner material shall be made only from a polyvinyl chloride (PVC) compound.

2. The minimum liner length shall span the distance from the inlet to the outlet of the pipe to be lined. The Contractor shall verify the lengths in the field before insertion of the liner. Unless otherwise agreed, 4 inch to 15 inch diameter liner shall have a dimension ratio of SDR 35, or as determined by the design calculations of a professional engineer. Unless otherwise agreed, 18 inch to 36 inch diameter liner shall have a minimum wall thickness of 0.300 inch, or as determined by the design calculations of a professional engineer.

3. Unless otherwise specified, the Contractor shall furnish a polyvinyl chloride compound liner pipe meeting all the requirements for cell classification and minimum physical properties as defined in specification ASTM F1504-14, listed below:

Physical Characteristics	Test Procedures	Pipe Material PVC
Tensile Strength	ASTM D-638	5,000 psi
Tensile Modulus	ASTM D-638	>280,000 psi
Flexural Modulus	ASTM D-790	>280,000 psi

4. The liner shall be able to accommodate reasonable changes in host pipe diameter, with design approval

by Owner's representative, with the understanding by all parties that when the DynaLiner pipe expands beyond its nominal diameter that it will have a higher dimension ratio (SDR).

3. EXECUTION

3.01 EXISTING CONDITIONS

A. Inspection:

1. Prior to installation the Contractor shall: Inspect the host pipe for any pre-existing conditions that could inhibit the installation of the liner.

2. Verify that the liner is to be installed in accordance with all applicable codes, regulations, referenced standards and the manufacturer's recommendations.

B. Discrepancies:

1. In the event of a discrepancy, immediately notify the Engineer.

2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.02 FIELD MEASUREMENTS

Make all necessary measurements in the field to ensure precise fit of items in accordance with the Contract Documents.

3.03 INSPECTION OF PIPE LINER

No pipe shall be lined without prior notification to the Engineer. Each liner shall be subject to inspection by the Engineer immediately before installation, and defective liner will be rejected.

3.04 INSTALLATION OF PIPE LINER

Installation of PVC pipe liner shall be performed by personnel who are recognized by the manufacturer as an authorized installer of its PVC pipe liner product.

A. Installation Procedures: The following installation procedures shall be adhered to unless otherwise approved by Owner's representative.

1. Safety: The Contractor shall carry out its operations in accordance with all OSHA and manufacturer's safety requirements including, but not limited to working with boilers, steam, mechanical equipment, and confined space entry.

2. Cleaning of sewer line: It shall be the responsibility of the Contractor to remove all internal debris from the sewer line prior to installation.

3. Inspection of pipelines: Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television. The interior of the pipeline shall be carefully inspected to determine the location of any condition that may prevent the proper installation of the liner into the pipeline, and it shall be noted so that these conditions can be corrected. The Owner shall keep a videotape and suitable log for later reference.

4. Bypassing flow: The Contractor, when required, shall provide for the flow around the section of pipe

designated for the liner. The bypass shall be made by plugging the line at an existing upstream manhole and pumping the flow into a downstream manhole or adjacent system. The pump and bypass lines shall be of adequate capacity and size to handle the flow.

5. Line obstructions: The Contractor shall clear the line of obstructions or collapsed pipe that will prevent the insertion of the liner. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then the Contractor shall make a point repair excavation to uncover and remove or repair the obstruction. Such excavation shall be approved in writing by the Owner's representative prior to the commencement of the repair work and shall be considered as a separate pay item.

B. Installation of Pipe Liner: The method of installation shall be compatible with the manufacturer's recommended practices. For the pipe liner, the installation shall be as follows:

1. The liner shall be inserted into the sewer through existing structures, without modification of the structures.

2. The liner shall have been wrapped on a coil, in a reduced cross section of either a "C" or an "H" at the time of manufacture, to facilitate insertion into the host pipe.

3. The liner shall be brought to the work site in an apparatus suitable for applying heat to the PVC liner. The coil of liner shall be heated to a temperature (as determined by the manufacturer) to make the liner pliable enough to be easily removed from the coil and to remove any "reel set".

4. The heated liner shall be pulled into the host pipe using a cable from a winch located at a downstream manhole connected through the lumen of the host pipe and attached to the end of the liner. The coiled liner shall be unreeled from the upstream manhole to reduce the amount of tension placed on the liner by the winch cable. The Contractor shall insert enough liner material so that sufficient material is available to allow for insertion of flow-through plugs at both upstream and downstream stations.

5. After the liner pipe has been inserted, allow the material to relax for several minutes in order to recover from any stretching that may have occurred during the insertion process. Continue to heat and relax the liner until movement has stopped.

6. After insertion is completed, the Contractor shall supply suitable heat source equipment and flow-through plugs. The equipment shall be capable of delivering steam through the lining section to uniformly raise the temperature and pressure to effect forming of the PVC liner pipe. This temperature and pressure shall be determined by the system employed.

7. The heat source shall be fitted with suitable monitors to gauge the steam temperature and pressure at the input and exhaust ends of the liner. Steam monitoring methods and forming period shall be recommended by the liner manufacturer.

8. The liner pipe shall be plugged with flow-through plugs, and expanded until it is pressed tightly against the existing host pipe walls.

9. If the liner fails to install properly, the Contractor shall remove the failed liner and replace it with a new liner. This work shall be performed without additional cost to the Owner.

10. After the liner has been formed, the ends of the liner shall be cut away at both structures.

11. When the installation is complete, the liner pipe shall be continuous over the entire length of run between two structures and be as free as commercially practical from visual defects such as foreign inclusions and pin holes.

12. Any defects which affect the integrity or strength of the liner pipe during the warranty period shall be repaired at the Contractor's expense. Allowance shall be given for excess pipe (rib) when the cross-sectional area has been reduced due to offset joints, partial collapse, out-of-round sections, etc.

C. Sealing at Structures: If, due to broken or offset pipe at the structure wall, the pipe liner fails to make a tight seal, the Contractor shall apply a seal at that point. The seal shall be of a material compatible with the liner pipe material.

D. Service Connections: After the pipe liner has been formed in place, the Contractor shall reconnect the existing active service connections as designated by the Engineer. This shall be done without excavation, and in the case of non-man entry pipe, from the interior of the pipeline by means of a television camera and a cutting device that re-establishes the service connection to not less than 90 percent capacity.

E. Clean-up:

1. The Contractor shall restore or replace removed or damaged paving, curbing, sidewalks, gutters, shrubbery, fences, sod or other surfaces or structures disturbed by the work to a condition equal to that before the work began, to the satisfaction of the Engineer, and shall furnish all labor and material incidental thereto.

2. Surplus liner material, tools and temporary structures shall be removed by the Contractor after completion of the work. All dirt and rubbish from the operation shall be legally disposed of by the Contractor, and the construction site shall be left clean to the satisfaction of the Engineer.

4. METHOD OF MEASUREMENT AND BASIS OF PAYMENT

4.01 DESCRIPTION

Description: The items listed below refer to and are the same pay items listed in the Proposal. They constitute all of the pay items for the completion of the work. No direct or separate payment will be made for providing miscellaneous, temporary or accessory works, plant services, Contractor's field office, layout surveys, job signs, sanitary requirements, testing, reparation of damages produced by Contractor, safety devices, water supplies, power, maintaining traffic, removal of waste, watchmen, bonds, insurance, and all other requirements of the Agreement, General Conditions, General Requirements and Special Construction. Compensation for all such services, things and materials shall be included in the lump sum price bid.

4.02 PIPE LINER MOBILIZATION

Mobilization for the Pipe Lining/Pipe Rehabilitation system equipment and crews shall be measured separately from the general Mobilization line item shown in the bid schedule. Pipe Liner Mobilization shall include: preparatory work and materials necessary for moving pipe lining personnel, equipment, supplies and incidentals to and from the Project Site; quality control; clean- up; preparatory work to include cleaning and inspecting the pipes prior to the pipe liner installation. Measurement for Pipe Liner Mobilization shall be as a "lump sum" as shown in the bid schedule and will only be paid one time regardless of the number of trips that are required to complete the work.

4.03 PIPE LINER INSTALLATION

Measurement shall be made for Pipe Liner Installation using a tape measure or other accurate measuring device to determine the total number of lineal feet of pipe liner in place and accepted. Measurement of the pipe liner shall be made from center of manhole to center of manhole.

4.04 RECONNECT SERVICE CONNECTIONS

Measurement for Reconnect Service Connections shall be made for each service connection that is reconnected following the installation of the pipe liner.

4.05 BASIS OF PAYMENT

The accepted quantity will be paid for at the contract unit price for:

PAY ITEM	UNIT
Pipe Lining Mobilization	Lump Sum
Pipe Liner Installation	Lineal Foot
Reconnect Service Connections	Each

SAFETY DATA SHEET
PVC PIPE LINER

1. PRODUCT AND COMPANY INFORMATION			
COMMON NAME:	DynaLiner Rigid PVC Fold-and-Form Pipe Liner		
CHEMICAL NAME:	Polyvinyl Chloride (PVC)		
RECOMMENDED USE:	Fold-and-Form Pipe Liner for Trenchless Sanitary Sewer, Storm Drain and Highway Culvert Rehabilitation.		
SUPPLIER:	DynaLiner, LLC		
ADDRESS:	3300 Pinson Valley Parkway Birmingham, AL 35217		
PHONE:	(205) 314-2498	EMERGENCY PHONE:	(205) 854-4330

2. HAZARDS IDENTIFICATION

As defined in the OSHA Hazard Communication Standard, 29 CFR 1910.1200, the products listed below are considered articles and do not require an SDS. In addition, articles are not included in the scope of the Global Harmonization System (GHS). As such, the GHS labeling elements are not included on this SDS. All components listed for this product are bound within the product. When handled as intended and under normal conditions of use, there is no evidence that any of the ingredients are released in amounts that pose a significant health risk. Although these products are not subject to the OSHA Standard or GHS labeling elements, DynaLiner, LLC would like to disclose as much health and safety information as possible to ensure that this product is handled and used properly. This SDS contains valuable information critical to the safe handling and proper use of the product. This SDS should be retained and be made available for employees and other users of this product. In addition, the recommendations for handling and use of these products should be included in worker training programs.

Note: These products, as do most plastic products, contain chemicals which can be hazardous. These chemicals, however, are mixed and bound in the plastic and are not released except under extreme circumstances such as fire.

3. HAZARDOUS INGREDIENT IDENTIFICATION

INGREDIENT	% MAX WEIGHT	PEL-OSHA (mg/m^3)	TLV-ACGIH (mg/m^3)
Polyvinyl Chloride resin (CAS No. 9002-86-2)	≥ 80	15, 5 (respirable)	10
Proprietary ingredients	≤ 20	15, 5 (respirable)	10

4. FIRST AID MEASURES

Dust resulting from power or hand sawing this material is considered to be a low health risk by inhalation. Limits for total and respirable dust in Section 3 are applicable. Dust may be irritating to the skin, eyes, nose and upper respiratory tract. Toxic fumes and gases may be produced by combustion or high temperature decomposition. If this product is melted, this material may emit fumes and vapors that are irritating to the eyes, nose, skin and upper respiratory tract.

FIRST AID PROCEDURES (For exposure to products of decomposition)

EYES:	Immediately flush eyes with potable water for at least 15 minutes. SEEK MEDICAL ATTENTION.
SKIN:	Flush skin thoroughly with soap and cool water for at least five minutes. SEEK MEDICAL ATTENTION.
INHALATION:	Remove to fresh air. If breathing is difficult, administer oxygen. SEEK MEDICAL ATTENTION.

NOTE TO PHYSICIANS OR FIRST AID PROVIDERS:
Hazardous fumes and gases that result from incomplete combustion and decomposition are hydrogen chloride, benzene, water, carbon monoxide and carbon dioxide.

5. FIREFIGHTING MEASURES

PVC material is self-extinguishing. It will, however, burn in the presence of other materials that support combustion.

SUITABLE EXTINGUISHING MEDIA:	Dry chemical, foam, water spray or fog
HAZARDOUS COMBUSTION PRODUCTS:	Hazardous fumes and gases that result from incomplete combustion and decomposition are hydrogen chloride, benzene, water, carbon monoxide and carbon dioxide.
RECOMMENDED FIRE FIGHTING PROCEDURES:	Wear full protective equipment and NIOSH approved self-contained breathing apparatus.
UNUSUAL FIRE & EXPLOSION HAZARDS:	Static sparking can occur during handling. Flammable materials should be removed from the immediate vicinity or controlled. The use of static suppressants and grounding devices is recommended.

6. ACCIDENTAL RELEASE MEASURES

N/A

7. HANDLING AND STORAGE

N/A

8. EXPOSURE CONTROLS/PERSONAL PROTECTION
When cutting, wear safety glasses or goggles to prevent particles from being projected into eyes.
Use with adequate ventilation to meet exposure limits listed under Section 3. Where the exposure limits are or may be exceeded, use NIOSH approved respiratory protection. Select appropriate respirator (e.g., high efficiency dust mask, acid gas respirator) based on the actual or potential airborne contaminants and their concentrations present.

9. PHYSICAL AND CHEMICAL PROPERTIES			
Appearance:	Solid. White.	Vapor pressure:	N/A
Odor:	N/A	Vapor density:	N/A
Odor threshold:	N/A	pH:	N/A
Melting point/freezing point:	N/A	Relative density:	Approx. 1.4
Flash point:	N/A	Solubility:	Not soluble
Evaporation rate:	N/A	Self-ignition temperature:	849 deg. F
Flammability:	Product will burn in the presence of combustible material.	Decomposition temperature:	N/A
Upper/lower flammability or explosive limits:	N/A	Viscosity:	N/A

10. STABILITY AND REACTIVITY	
THERMAL STABILITY:	STABLE
CONDITIONS TO AVOID (STABILITY):	N/A
INCOMPATIBILITY (MATERIAL TO AVOID):	N/A
HAZARDOUS DECOMPOSITION OR BY-PRODUCTS:	Hydrogen chloride, carbon monoxide

11. TOXICOLOGICAL INFORMATION
No information available.

12. ECOLOGICAL INFORMATION:
No information available.

13. DISPOSAL CONSIDERATIONS	
WASTE DISPOSAL METHOD:	This product, as supplied, is not regulated as a hazardous waste by the U.S. Environmental Protection Agency (EPA) under Resource Conservation and Recovery Act (RCRA) regulations.
RCRA HAZARD CLASS:	None
Comply with state and local regulations for disposal.	

14. TRANSPORT INFORMATION	
U.S. DOT TRANSPORTATION	This product is not classified as a hazardous material for transport.
HAZARD CLASS:	N/A
ID NUMBER:	N/A
PACKING GROUP:	N/A
LABEL STATEMENT:	N/A
OTHER:	N/A

15. REGULATORY INFORMATION	
U.S. FEDERAL REGULATIONS	
TSCA:	N/A
CERCLA:	N/A
SARA	
311/312 HAZARD CATEGORIES:	N/A
313 REPORTABLE INGREDIENTS:	N/A
CALIFORNIA PROPOSITION 65:	N/A
Other state regulations may apply. Check individual state requirements.	

16. OTHER INFORMATION	
ADDITIONAL COMMENTS	N/A
DATE OF PREVIOUS (M)SDS:	March 15, 2015
CHANGES SINCE PREVIOUS (M)SDS:	N/A

This information relates to the specific material designated and may not be valid for such material used in combination with any other materials or in any process. Such information is to the best of our knowledge and belief accurate and reliable as of the date compiled. However, no representation, warranty or guarantee, expressed or implied, is made as to its accuracy, reliability, or completeness. It is the user's responsibility to satisfy himself as to the suitability and completeness of such information for his particular use. We do not accept liability for any loss or damage that may occur from the use of this information.

DYNALINER MANUFACTURER'S WARRANTY

DynaLiner LLC ("DynaLiner") hereby warrants its PVC pipe liner product for ten (10) years from the date of manufacture, against failure as a result of defects in materials or manufacturing, and that when properly installed the product will perform in accordance with the manufacturer's specifications.

Should there be any defects in the material requiring repair and/or replacement, the Owner must notify DynaLiner in writing immediately upon discovery, and allow DynaLiner a reasonable amount of time to assess the claimed material or manufacturing defect and to make any necessary product repair or replacement. Should any defect occur during the warranty period, DynaLiner will repair or replace, at its option, the defective product. In no event shall DynaLiner be liable or responsible for labor charges or other expenses arising from or pertaining to the removal or installation of either the original or replacement product. In lieu of repair or replacement, DynaLiner also reserves the right to refund the amount paid by the original purchaser for the DynaLiner product and such refund shall fully discharge all obligations and liabilities of DynaLiner under this warranty.

What is not covered in this warranty. This warranty does not apply to any product that has been subjected to an accident, misuse and abuse, nor to any product that has been modified, altered, defaced, and/or had repairs made/attempt by others. Warranty does not include normal wear and tear. Under no circumstances shall DynaLiner be liable by virtue of this warranty or otherwise for damage to any person or property whatsoever or for any special, indirect, secondary or consequential damages of any nature, however arising, out of the use or inability to use the product because of any manufacturing defect or any claimed manufacturing defect.

THE LIMITED WARRANTY AND EXCLUSIVE REMEDY DESCRIBED ABOVE ARE EXPRESSLY IN LIEU OF ALL OTHER REMEDIES AND WARRANTIES, EXPRESSED OR IMPLIED, ON THE PART OF DYNALINER CONCERNING THE PRODUCTS, INCLUDING, WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. DYNALINER NEITHER ASSUMES NOR AUTHORIZES ANY OTHER PERSON, FIRM, OR CORPORATION TO ASSUME ANY LIABILITY OR OBLIGATION ON DYNALINER'S BEHALF. DYNALINER EXPRESSLY DISCLAIMS ANY WARRANTIES, EXPRESSED OR IMPLIED, OTHER THAN THOSE EXPRESSLY SET FORTH HEREIN.

DESIGN PARAMETERS

8" DIAMETER SDR-35 LINER

Liner Dimensions

Liner outer diameter (D_o)		8.00	in.
Liner thickness (t)		0.229	in.
Liner SDR		35	

Liner Physical Properties

Initial tensile strength		5,000	psi
Initial flexural strength	>	5,000	psi
Initial flexural modulus of elasticity (E)	>	280,000	psi
Long-term modulus of elasticity (E_L) (estimated)		100,000	psi

Assumed Existing Pipe Characteristics

Existing pipe diameter (in)	8.00	in
Height of water above invert of pipe (ft)	10.67	ft
Existing pipe slope	0.5%	
Ovality (assumed)	2.00%	
Height of soil above top of pipe (ft)	10.00	ft

Soil Characteristics

Soil unit weight (γ) (assumed)	120	pcf
Modulus of soil reaction (E') (assumed)	1,000	psi

Factor of Safety

2.0

Project Description: Sample Liner Design
Close-Fit Pipe Liner for 8" diameter host pipe.

NOTES:

1. This document is for ***informational purposes only*** and is ***not*** an official design by a licensed Professional Engineer.
2. Existing design conditions have been assumed for purposes of this sample design.
3. "Partially deteriorated" host pipe condition assumes: host pipe has no longitudinal cracks and retains structural integrity; groundwater surface as shown above.
4. "Fully deteriorated" host pipe condition assumes: soil cover and groundwater surface elevation as shown above; modulus of soil reaction; highway loads.
5. Pipe relining is one component of pipeline rehabilitation, and other rehabilitation methods, e.g., grouting, point repairs, may be required depending on existing host pipe conditions. Pipe liner system is designed to withstand external hydrostatic pressure and soil and traffic loads, but is not intended as a full structural replacement of host pipe system.

1. Determine External Pressure on Pipe (Partially Deteriorated)

Hydrostatic Pressure: $P_w = \frac{\gamma_w H_w}{144\ ^{in^2}/_{ft^2}}$

P_w = Hydrostatic pressure at pipe invert (psi)	4.62	psi
Y_w = Specific weight of water (lb/ft^3)	62.4	lb/ft^3
H_w = Height of water from invert of pipe (ft)	10.67	ft

2. Thickness Required for Buckling Pressure

Base equation:
[ASTM F 1947-04, X1.1]

$$P = \frac{2KE_L}{(1-v^2)} \times \frac{1}{(DR-1)^3} \times \frac{C}{N}$$

Let DR = D/t,
solve for min wall thickness (t):

$$t = \frac{D_o}{\left(\sqrt[3]{\frac{2KE_LC}{P(1-v^2)N}}\right)+1}$$

D_o = Liner outer diameter (in)	8.00	in	
N = Safety factor	2.0		
P = External pressure on pipe (psi)	4.62	psi	
K = Enhancement factor, typically K = 7	7.00		
Ovality (%)	2.00%		
C = Ovality factor	0.836		
E_L = Long-term modulus of elasticity (psi)	100000	psi	
v = Poisson's ratio	0.380		
t_{min} = Minimum required thickness	0.148	in	
t = Design liner thickness	0.229	in	
Design v. Minimum	0.229	>	0.148
		OK	

3. Determine External Loading on Pipe (Fully Deteriorated)

Total Load = Soil Load + Surface Load

Soil Load: $W_c = H * \gamma * B_c$

(Prism load)	W_c = Soil load (lbs/lf)	800	lbs/lin. ft
	H = Soil height from top of pipe (ft)	10.00	ft
	γ = Soil density (pcf)	120	pcf
	B_c = Breadth of Conduit (diameter of pipe) (ft)	0.67	ft

Surface Load: $W_l = \frac{C_s * P * F'}{L}$ (Moser, eq. 2.13)

(Wheel load)	W_l = Live (wheel) load (lbs/lf)	149	lbs/lin. ft
	C_s = load coefficient (Moser, Table 2.6)	0.028	
	P = concentrated loads, lb	16000	lbs
	F' = impact factor (Moser, Table 2.5)	1	
	L = effective length of conduit (3 ft typical), ft	3	ft
Total Load	**$W_{tot} = W_c + W_l$**	949	lbs/lin. ft

4. Determine External Pressure on Pipe

Hydrostatic Pressure: $P_w = \frac{\gamma_w H_w}{144\ ^{in^2}/_{ft^2}}$

P_w = Hydrostatic pressure at top of pipe (psi)	4.33	psi
Y_w = Specific weight of water (lb/ft^3)	62.4	lb/ft^3
H_w = Height of water above top of pipe (ft)	10.00	ft

Soil/Surface Load Pressures: $P_{SL} = \frac{W_c + W_l}{D_o * 144\ ^{in^2}/_{ft^2}}$

W_c = Dead load on conduit	800	lbs/lin. ft
P_c = Dead load pressure on conduit	8.33	psi
W_l = live load	149	lbs/lin. ft
P_l = Live load pressure on conduit	1.56	psi
D_o = Pipe diameter (ft)	0.67	ft
P_{SL} = Soil/Surface load pressure (psi)	9.89	psi

Soil pressure + Surface pressure + Hydrostatic Pressure = Total External Pressure

$P_{tot} = P_w + P_{SL}$ = Total external pressure on pipe (psi)	**14.22**	**psi**

5. Thickness Required for Buckling Pressure (Fully Deteriorated)

Base equation:
[Moser, p. 113; ASTM F 1947-04, X1.6]

$$q_t = \frac{C}{N}[32R_w B' E'_s \left(\frac{E_L I}{D^3}\right)]^{\frac{1}{2}}$$

Let $I = t^3/12$, solve for min wall thickness (t):
[ASTM F1947-04, X.1.7]

$$t = 0.721\, D \left[\frac{\left(q_t \frac{N}{C}\right)^2}{E_L R_w B' E'_s}\right]^{1/3}$$

D_o = Liner outer diameter (in)	8.00	in
N = Safety factor	2.00	
P_{tot} = External pressure on pipe (psi)	14.22	psi
Ovality (%)	2.00%	
C = Ovality factor	0.836	
R_w = Bouyancy factor	0.670	
B' = coefficient of elastic support	0.324	
E_L = Long-term modulus of elasticity (psi)	100,000	psi
E'_s = Modulus of soil reaction	1,000	psi
t_{min} = Minimum required thickness	0.217	in
t = Design liner thickness	0.229	in

Design v. Minimum	0.229	>	0.217
		OK	

6. Check Flow Capacity

Base Formula: $$V = \frac{(1.486)R^{2/3}s^{1/2}}{n}$$

V_H = Flow velocity (host pipe)	2.12	ft/sec
V_L = Flow velocity (lined pipe)	2.78	ft/sec
R_H = Hydraulic radius (host pipe) (D_i / 4)	0.17	ft
R_L = Hydraulic radius (lined pipe) (D_i / 4)	0.16	ft
s = Slope of pipe run	0.005	ft/ft
n_H = Manning's friction coefficient (host pipe)	0.015	
n_L = Manning's friction coefficient (lined pipe)	0.011	

Base Formula: Q = V*A

Q_H = Flow rate (host pipe)	0.74	cu.ft./sec
Q_L = Flow rate (lined pipe)	0.86	cu.ft./sec
V_H = Flow velocity (host pipe)	2.12	ft/sec
V_L = Flow velocity (lined pipe)	2.78	ft/sec
A_H = Area (host pipe) at 85% capacity	0.35	sq.ft.
A_L = Area (lined pipe) at 85% capacity	0.31	sq.ft.

Q_H =	0.74	cu.ft./sec
Q_L =	0.86	cu.ft./sec
Q (increase) =	0.12	cu.ft./sec
Increase in Flow Capacity	16.53%	

SUMMARY OF RESULTS

1 Buckling Pressure (Partially Deteriorated)

Minimum Liner Thickness	t_{min} =	0.148	in
Design Liner Thickness	t =	0.229	in

Design Liner Thickness > Minimum Liner Thickness

2 Buckling Pressure (Fully Deteriorated)

Minimum Liner Thickness	t_{min} =	0.217	in
Design Liner Thickness	t =	0.229	in

Design Liner Thickness > Minimum Liner Thickness

3 Flow Capacity

Host pipe flow capacity	Q_H =	0.74	cu.ft./sec
Lined pipe flow capacity	Q_L =	0.86	cu.ft./sec
Percentage increase in capacity	=	16.53%	

DESIGN REFERENCES

Buried Pipe Design, 3rd Edition
A. P. Moser and Steven Folkman

American Society for Testing and Materials
ASTM Standard Practice F1947-04
Standard Practice for Intallation of Folded Poly (Vinyl Chloride) (PVC) Pipe into Existing Sewers and Conduits