Title: DESIGN GUIDANCE FOR PIPE BURSTING

ADMINISTRATIVE INFORMATION:
- This Engineering Instruction (EI) is effective beginning with projects submitted for the lettings on or after September 1, 2015.
- This EI does not supersede any previous issuances.
- The information transmitted by this issuance will be included in a future revision to the Highway Design Manual, Chapter 9.

PURPOSE: The purpose of this EI is to issue design guidance for the new special specification for the rehabilitation of pipe via pipe bursting methods.

TECHNICAL INFORMATION:
- The following special specifications are being issued concurrently via EI 15-008:
  - Item 650.60XXNN17: Pipe Bursting of Pipe Less Than 12 Feet Deep
  - Item 650.61XXNN17: Pipe Bursting of Pipe Greater Than or Equal to 12 Feet Deep and Less Than 18 Feet Deep
  - Item 650.62XXNN17: Pipe Bursting of Pipe Greater Than or Equal to 18 Feet Deep

TRANSMITTED MATERIALS:
Attached is the design guidance for pipe bursting.

BACKGROUND: The pipe bursting operation consists of a cone-shaped tool (“bursting head”) inserted into an existing pipe and forced through it, fracturing the pipe and pushing its fragments into the surrounding soil. At the same time a new pipe is either pulled or pushed in the annulus left by the expanding operation. The rear of the bursting head is connected to the new pipe.

The intent of the special specification is to pay the Contractor for rehabilitating an existing length of pipe by a pipe bursting method and concurrently relining the bursted path with a new pipe.

Definitions. The following are definitions of acceptable pipe bursting methods (Ref. No. 1).

A. **Pneumatic Pipe Bursting.** A pipe bursting method which utilizes a pneumatic bursting head that uses pulsating air pressure to drive the head forward and burst the existing pipe. A small pulling device guides the head via a constant tension winch and cable.

B. **Hydraulic Expansion.** A pipe bursting method which utilizes a hydraulic bursting head that expands and closes sequentially as it is pulled through the pipe, bursting the existing pipe along its way.
C. Static Pull. A pipe bursting method which utilizes a static bursting head that has no moving internal parts. The static head is simply pulled through the existing pipe by a heavy-duty pulling device via a segmented drill rod assembly or heavy anchor chain.

REFERENCES: The definitions for the pipe bursting methods were obtained from the following:
1. US Army Corps of Engineers, Engineering Research and Develop Center (ERDC)
   *Guidelines for Pipe Bursting*
   TTC Technical Report #2001.02
   Simicevic, J. and Sterling, R.L.
2. International Pipe Bursting Assoc
   *Guidelines for Pipe Bursting*
   Division of NASSCO
3. Plastics Pipe Institute
   *Handbook of Polyethylene Pipe*
   Chapter 16 – Pipe Bursting

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PIPE BURSTING

GENERAL
The intent of the specification is to pay the Contractor for rehabilitating an existing length of pipe by a pipe bursting method and concurrently relining the bursted path with a new pipe.

The specifications are organized based on the depth of the existing pipe to be burst along with the existing pipe size and burst pipe size (XX denotes existing pipe size for bursting and NN denotes the new pipe size to be installed after bursting).

Definitions. The following are definitions of acceptable pipe bursting methods¹.

A. **Pneumatic Pipe Bursting.** A pipe bursting method which utilizes a pneumatic bursting head that uses pulsating air pressure to drive the head forward and burst the existing pipe. A small pulling device guides the head via a constant tension winch and cable.

B. **Hydraulic Expansion.** A pipe bursting method which utilizes a hydraulic bursting head that expands and closes sequentially as it is pulled through the pipe, bursting the existing pipe along its way.

C. **Static Pull.** A pipe bursting method which utilizes a static bursting head that has no moving internal parts. The static head is simply pulled through the existing pipe by a heavy-duty pulling device via a segmented drill rod assembly or heavy anchor chain.

Because pipe bursting is typically specified to minimize/eliminate disturbance to the surrounding area, the specification dictates monitoring tasks for the Contractor to perform. A survey of the existing ground surface along the path of the pipe bursting operation, prior to the start of work, will establish baseline data. The pipe bursting and pipe installation operation will be closely monitored during its progression to minimize/eliminate ground movements. The designer should ensure that the project contains Item 625.01 Survey and Stakeout.

Since host pipes almost always have some silt or debris in them, cleaning the host pipe is an appropriate first step. In addition, after the pipe bursting and installation operation, the pipe will be cleaned. The specification includes the cleaning process, prior to and after the bursting operation, in accordance with Standard Specification Section 621 Cleaning Culverts, Drainage Structures and Existing Roadside Sections.

Pipe Installation.
The pipe bursting operation consists of a cone-shaped tool (“bursting head”) inserted into an existing pipe and forced through it, fracturing the pipe and pushing its fragments into the surrounding soil. At the same time a new pipe is either pulled or pushed in the annulus left by the expanding operation. The rear of the bursting head is connected to the new pipe.

The proposed type of pipe to replace the host pipe is limited to one which can be joined together continuously while maintaining sufficient strength and integrity during the installation process. Butt-fused, high density polyethylene pipe (HDPE) or steel casing are the most common types of casing used.

- High Density Polyethylene (HDPE) pipe of DR-9 or DR-11, meeting the requirements of ASTM F714 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) based on Outside Diameter.
• Steel pipe shall be bare steel casing pipe meeting the requirements of ASTM A53, Grade B, Types E or S, or approved equal. The ends shall be prepared for butt welding and beveled at 37 ½ degrees.

The proposed type of pipe, pipe length, and size shall be indicated in the contract documents. Refer to HDM Chapter 8 Section 8.6.2 *Pipe Design Criteria* for general discussion regarding pipe material choices, including Section 8.6.2.4 *Engineering and Economic Analysis*.

The HDPE pipe of DR-9 or DR-11 is sufficiently strong for depths to approximately 15 ft. For depths greater than 15 ft., the adequacy of the pipe for the application should be verified.

Prior to and after the pipe bursting and installation operation, video inspection/recording equipment that is specifically designed for continuous viewing and recording of images of the interior walls of pipes and fittings, and capable of providing a true-color image of the entire pipe periphery, will be utilized to inspect the host pipe and installed pipe.

The specification deals with the rehabilitation of an existing length of pipe. The treatment at the terminus of the new pipe needs to be addressed. The designer should include details in the contract documents to address the new pipe termini (end sections, cut-off walls, drop inlet inserts, connections, etc.).

**DESIGN DEVELOPMENT**

The size of pipes being burst typically ranges from 2 to 36 inches.

The host pipe diameter and the required upsize of the new pipe determine machine selection.

The replacement pipe naturally follows the line and grade of the original pipe under most conditions. However, the centerline of the replacement pipe rarely matches the centerline of the original pipe. If line and grade are critical, the designer should fully investigate all aspects of the pipe bursting operation. Figure 1 provides some illustrations on the effect of site conditions on ground displacements. The effects of ground movements on the relative position of the new pipe are also identified. To provide a tolerance and thereby ensuring the bursting head does not break out of the pipe and move substantially outside the envelope of the existing pipe, the specification does require the Contractor to locate the geometric point of origin of the new pipe to be within a distance of ½ the radius of the existing pipe from the existing pipes geometric point of origin.
The main advantage of pipe bursting over other trenchless rehabilitation methods, such as cured-in-place (CIP) pipe, fold-and-form (FF) pipe, sliplining, etc., is the ability to upsize. Upsizing by up to 30% of the original pipe diameter is common, and greater upsizing has been successfully completed. However, larger diameter pipes (more than 18 inches in diameter) in need of a high upsizing percentage require careful examination (in terms of required forces and ground displacements).

**Applicability**. Pipe bursting can be applied to a wide range of pipe sizes and types, in a variety of soil and site conditions.

The size of pipes being burst typically ranges from 2 to 36 inches, although it can be even larger (a 48 inch has been replaced). The most common pipe bursting is size-for-size, or upsizing the diameter of the existing pipe up to three sizes (e.g. 8 inch to 12 inch). Large up-sizings require more energy and cause more ground movement. They slow the replacement operation and need careful evaluation when large diameter existing pipes are upsized.

With respect to the type of existing pipe, the pipes suitable for pipe bursting are typically made of brittle materials, such as vitrified clay, cast iron, unreinforced concrete, asbestos, or some plastics. Reinforced concrete pipe (RCP) is typically not suitable for pipe bursting, especially if it is heavily reinforced. Ductile iron and steel pipes are not suitable for pipe bursting, but can be replaced using a modified method called pipe splitting.

A common bursting length is usually between 300 and 400 feet (taken from the utility industry...
based on the typical distance between sewer manholes). However, much longer bursts may be achieved when needed. A long burst generally requires more powerful equipment to complete the job.

Access also needs to be investigated. Access to both ends of the pull should be available. Site restrictions that compel the need of support/protection systems will increase costs.

**Unfavorable Conditions and Limitations**. Unfavorable conditions for pipe bursting are (1) expansive soils, (2) obstructions along the existing pipe length in form of completely collapsed pipe, (3) metallic point repairs that reinforce the existing pipe with ductile material, (4) concrete envelopment or pipes with very dense (rock) backfill, and (5) adjacent pipes or utility lines that are very close to the pipe being replaced. The obstructions do not necessarily prevent the pipe bursting, and the problem is usually solved with localized excavations.

As a general rule for close proximity pipes adjacent to a bursting operation, both horizontal and vertical distance between the pipe to be burst and the existing adjacent pipe should be a minimum of 5 ft.

All pipe bursting operations create (to some extent) vibrations of soil particles in the ground. Figure 2 provides the results of a TTC study of the velocity of vibrational ground movements from different pipe bursting techniques. In the frequency range from 30 to 100 Hz, level of 2 in./sec. may be reached within distances of 8 ft. from the bursting head.

![Compiled peak particle velocity vs. frequency for all test sites](Compiled peak particle velocity vs. frequency for all test sites)

![Velocity vs. distance from the bursting head for all test sites employing pneumatic system](Velocity vs. distance from the bursting head for all test sites employing pneumatic system)

*Figure 2 TTC study of ground vibrations. (Simicevic, J. and Sterling, R.L., 2001)*
To ensure the ground surface will not heave, there should be at least 4 ft. of cover. A rule of thumb is that the burst depth should not be less than ten times the upsize diameter (e.g. if the pipe is to be upsized by 1 ft., the required depth of cover is 10 ft.).

Limitations in applicability come from either (1) economical aspect (its comparative costs versus cost of conventional replacement), (2) safety aspect (potential damage to the neighboring utilities and structures), or (3) technical aspect (the ability to provide sufficient energy to complete the operation).

**SUBMITTAL PROCESS**

The pipe bursting specification was created as a trenchless installation alternative for rehabilitating an existing pipe where the traditional open-cut-trench replacement method is not permitted. By accepting various types of pipe bursting methods, we allow the Contractor to utilize their experience and expertise to decide on the appropriate method given the ground and groundwater conditions. This places a responsibility on the Department to define the subsurface conditions.

The Contractors submittal will include qualifications of the Contractor, designed burst path, method for pipe bursting (including a plan of operation, equipment, procedures, and design of insertion and reception pits), and method of pipe installation.

To ensure compliance with the contract documents, the pipe bursting and installation operation will be inspected via video equipment. Video inspection/recording equipment (including power source) that is specifically designed for continuous viewing and recording of images of the interior walls of pipes and fittings and capable of providing a true-color image of the entire pipe periphery will be supplied by the Contractor. Pre- and post-installation video inspection recordings will be submitted to the Engineer.

**DESIGNER GUIDANCE**

**Geotechnical Review.** Before specifying pipe bursting in the contract documents, the designer should consult with the Regional Geotechnical Engineer (RGE) to ensure the ground conditions are favorable to a pipe bursting operation. Less favorable ground conditions for pipe bursting involve densely compacted soils and backfills, soils below the water table and soils that expand in volume as they are sheared (e.g. angular sands). Each of these soil conditions tends to increase the force required for the bursting operation and to increase the zone of influence of the ground movements. See Figure 1.

- **Subsurface Conditions:** In most instances, the host pipe was installed by “trenching” and is directly surrounded by select granular fill material. The soil around the pipe (select granular fill and the native soil) has to be compressible to absorb the diameter expansion. The National Association of Sewer Service Companies (NASSCO) classified bursting projects into three classifications in terms of difficulty identified in Figure 3.

  As noted for “A – Routine”, areas containing clays and other compressible soils are best suited for upsizing. Sands and gravel are very difficult to burst because the soil tends to collapse in on itself in the void created by the expander. The collapsed soils cause very large values of skin friction on the pipe being pulled behind the bursting unit. The friction can stop the bursting head altogether. Rocks in the fill can settle back onto the
new liner and collapse it after the expander has passed. Solid rock outcrops may not expand at all.

<table>
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<th>Criteria</th>
<th>A – Routine (all of the criteria below apply)</th>
<th>B - Moderately Difficult to Challenging</th>
<th>C – Challenging to Extremely Challenging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>Less than 12 feet</td>
<td>12 ft to 18 ft</td>
<td>More than 18 ft</td>
</tr>
<tr>
<td>Existing Pipe</td>
<td>4 - 12</td>
<td>12 to 20</td>
<td>20 - 36</td>
</tr>
<tr>
<td>New Pipe Diameter</td>
<td>Size for size or one diameter upsize</td>
<td>Two diameter upsize</td>
<td>Three or more diameter upsize</td>
</tr>
<tr>
<td>Burst Length</td>
<td>Less than 350 feet</td>
<td>350 feet to 450 feet</td>
<td>More than 450 feet</td>
</tr>
<tr>
<td>Trench Width</td>
<td>Relatively wide trench compared to upsized diameter</td>
<td>Trench width less than 4 wider than upsize diameter</td>
<td>Incompressible soils (very dense sand, hard clay or rock) outside trench</td>
</tr>
<tr>
<td>Soil</td>
<td>Compressible soils outside trench (soft clay, loose sand)</td>
<td>Moderately compressible soils outside trench (medium dense to dense sand, medium to stiff clay)</td>
<td>Constricted trench geometry (width less than or equal to upsize diameter)</td>
</tr>
</tbody>
</table>

**Figure 3 Summary of NASSCO Pipe Bursting Classification**
*(Plastic Pipe Institute)*

Another important consideration is that the base soil be able to support the weight of the tool, expander and the new pipe. A pipe that has been leaking for some time may have cavities and pockets around it and may not be able to support this weight.

The designer and RGE should ensure the groundwater conditions are favorable to a pipe bursting operation. Pipe bursting below the groundwater table increases the difficulty as in saturated fine soil can cause the water pressure to rise around the bursting head (unless the soil has a high enough permeability to allow the water pressure to dissipate quickly). The rise in water pressure causes the effective stress in the soil to drop and may cause the soil to behave more like a viscous fluid. When the fluidized soil displaces the surrounding soil, the ground movements tend to be more extensive and nearby services may displace more easily.

- **Groundwater Conditions**: One concern regarding the groundwater table with respect to the bursting operation is that, in fine soil conditions, groundwater will cause the annulus to close in quickly behind the expanding head thus increasing pipe drag and theoretically reducing the practical burst lengths. However, as mentioned above under **Subsurface Conditions**, in most instances the host pipe was installed by "trenching" and is directly surrounded by select granular fill material.

Another concern is, if the groundwater level is above the invert level of the host pipe, the groundwater may enter the annulus between the host pipe and replacement pipe through any leaking joints/corrosion holes etc. in the host pipeline. The resulting external hydrostatic pressure of water on the replacement pipe has the potential to cause the replacement pipe to collapse (buckle).

The designer and the RGE should discuss the subsurface conditions (type of soil, groundwater elevation, original pipe installation method and materials, existing utilities, etc.), length of burst, sensitivity of existing aboveground structures, etc., and contact the Geotechnical Engineering
Bureau to determine the appropriateness of utilizing the specification.

**Materials Review.** The designer should consult with the Regional Materials Engineer (RME) to ensure the host pipe is favorable to a pipe bursting operation.

Most brittle pipe materials make good candidates for pipe bursting. Ductile pipes may be scored and then slit in a pipe splitting operation, a variant to the pipe bursting method. Pipes made of non-ductile abrasive material but with ductile reinforcing are the most difficult to replace using most pipe replacement techniques.

Good candidates for bursting include clay pipes, plain concrete pipes, and cast iron pipes. Reinforced concrete pipes present difficulty unless the concrete and reinforcing steel is deteriorated. They may be burst with powerful enough equipment but careful evaluation may be needed if the pipes are more than lightly reinforced and are not significantly deteriorated. Steel and ductile iron pipes are not good candidates for pipe bursting. They are strong and ductile. In smaller diameters, they may be replaced using pipe splitting techniques. PVC and other plastic pipes may be replaced using an appropriate combination of bursting and splitting techniques according to the strength and ductility of the pipe.

Particular consideration should be given to the type of pipe to be burst in relation to the type of pipe to be installed. Although clay and cast iron pipes are good candidates for bursting, fragments from the bursting may be sharp, leaving some level of concern about gouging or scoring of the replacement pipe and eventual point loading on the replacement pipe. A sacrificial external sleeve pipe may be used to ensure protection for the replacement pipe. However, the size of the bursting head must be increased to accommodate the external sleeve pipe thickness and the annular space required for the replacement pipe to be inserted. This increased diameter increases power requirements for the bursting and also increased the extent of ground movements surrounding the bursting head.

**Utility Review.** The designer should consult with the Regional Utilities Engineer (RUE) to discuss the location of existing utilities. Existing utilities can affect the location of insertion and reception pits. Utilities that interfere with or may be damaged by the burst should be located and exposed prior to the burst.

**Environmental Review.** The designer should identify potential impacts the pipe bursting operation may have on existing environmental and cultural resources and identify watercourses, wetlands, etc., which may require protection from lubricant used in the pipe insertion or the final pipe cleaning and disposal of surplus excavated materials.

Particular consideration should be given to asbestos pipe, as disturbance created by pipe bursting would be subject to regulation under the Asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP), the OSHA Construction Standard 29 CFR 1926.1101 and Part 56 of Title 12 of the Official Compilation of Codes, Rules and Regulations of the State of New York (12 NYCRR Part 56). Any use of this method on asbestos pipe/conduit would need to be used in conjunction with Section 210 Removal and Disposal of Asbestos-Containing Material (Buildings, Bridges and Highways). In addition, Regional Environmental staff and/or the Environmental Science Bureau should be consulted regarding applicability of the Department’s current regulatory variance (NYSDOT Blanket Variance #14).

**Right-Of-Way Review.** The designer should identify potential impacts the pipe bursting operation may have on existing right-of-way restrictions with respect to the location of the
insertion and reception pits.

REFERENCES

1. US Army Corps of Engineers, Engineering Research and Develop Center (ERDC)  
   Guidelines for Pipe Bursting  
   TTC Technical Report #2001.02  
   Simicevic, J. and Sterling, R.L.  

2. International Pipe Bursting Assoc  
   Guidelines for Pipe Bursting  
   Division of NASSCO  
   January, 2012 –  

3. Plastics Pipe Institute  
   Handbook of Polyethylene Pipe  
   Chapter 16 – Pipe Bursting  
PIPE BURSTING

GENERAL
The intent of the specification is to pay the Contractor for rehabilitating an existing length of pipe by a pipe bursting method and concurrently relining the bursted path with a new pipe.

The specifications are organized based on the depth of the existing pipe to be burst along with the existing pipe size and burst pipe size (XX denotes existing pipe size for bursting and NN denotes the new pipe size to be installed after bursting).

Definitions. The following are definitions of acceptable pipe bursting methods¹.

A. Pneumatic Pipe Bursting. A pipe bursting method which utilizes a pneumatic bursting head that uses pulsating air pressure to drive the head forward and burst the existing pipe. A small pulling device guides the head via a constant tension winch and cable.

B. Hydraulic Expansion. A pipe bursting method which utilizes a hydraulic bursting head that expands and closes sequentially as it is pulled through the pipe, bursting the existing pipe along its way.

C. Static Pull. A pipe bursting method which utilizes a static bursting head that has no moving internal parts. The static head is simply pulled through the existing pipe by a heavy-duty pulling device via a segmented drill rod assembly or heavy anchor chain.

Because pipe bursting is typically specified to minimize/eliminate disturbance to the surrounding area, the specification dictates monitoring tasks for the Contractor to perform. A survey of the existing ground surface along the path of the pipe bursting operation, prior to the start of work, will establish baseline data. The pipe bursting and pipe installation operation will be closely monitored during its progression to minimize/eliminate ground movements. The designer should ensure that the project contains Item 625.01 Survey and Stakeout.

Since host pipes almost always have some silt or debris in them, cleaning the host pipe is an appropriate first step. In addition, after the pipe bursting and installation operation, the pipe will be cleaned. The specification includes the cleaning process, prior to and after the bursting operation, in accordance with Standard Specification Section 621 Cleaning Culverts, Drainage Structures and Existing Roadside.

Pipe Installation.
The pipe bursting operation consists of a cone-shaped tool (“bursting head”) inserted into an existing pipe and forced through it, fracturing the pipe and pushing its fragments into the surrounding soil. At the same time a new pipe is either pulled or pushed in the annulus left by the expanding operation. The rear of the bursting head is connected to the new pipe.

The proposed type of pipe to replace the host pipe is limited to one which can be joined together continuously while maintaining sufficient strength and integrity during the installation process. Butt-fused, high density polyethylene pipe (HDPE) or steel casing are the most common types of casing used.

- High Density Polyethylene (HDPE) (HDPE) pipe of DR-9 or DR-11, meeting the requirements of ASTM F714 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) based on Outside Diameter.
Steel pipe shall be bare steel casing pipe meeting the requirements of ASTM A53, Grade B, Types E or S, or approved equal. The ends shall be prepared for butt welding and beveled at 37 ½ degrees.

The proposed type of pipe, pipe length, and size shall be indicated in the contract documents. Refer to HDM Chapter 8 Section 8.6.2 Pipe Design Criteria for general discussion regarding pipe material choices, including Section 8.6.2.4 Engineering and Economic Analysis.

The HDPE pipe of DR-9 or DR-11 is sufficiently strong for depths to approximately 4.5 m. For depths greater than 4.5 m, the adequacy of the pipe for the application should be verified.

Prior to and after the pipe bursting and installation operation, video inspection/recording equipment that is specifically designed for continuous viewing and recording of images of the interior walls of pipes and fittings, and capable of providing a true-color image of the entire pipe periphery, will be utilized to inspect the host pipe and installed pipe.

The specification deals with the rehabilitation of an existing length of pipe. The treatment at the terminus of the new pipe needs to be addressed. The designer should include details in the contract documents to address the new pipe termini (end sections, cut-off walls, drop inlet inserts, connections, etc.).

**DESIGN DEVELOPMENT**

The size of pipes being burst typically ranges from 50 mm to 915 mm.

The host pipe diameter and the required upsize of the new pipe determine machine selection.

The replacement pipe naturally follows the line and grade of the original pipe under most conditions. However, the centerline of the replacement pipe rarely matches the centerline of the original pipe. If line and grade are critical, the designer should fully investigate all aspects of the pipe bursting operation. Figure 1 provides some illustrations on the effect of site conditions on ground displacements. The effects of ground movements on the relative position of the new pipe are also identified. To provide a tolerance and thereby ensuring the bursting head does not break out of the pipe and move substantially outside the envelope of the existing pipe, the specification does require the Contractor to locate the geometric point of origin of the new pipe to be within a distance of ½ the radius of the existing pipe from the existing pipes geometric point of origin.
The main advantage of pipe bursting over other trenchless rehabilitation methods, such as cured-in-place (CIP) pipe, fold-and-form (FF) pipe, sliplining, etc., is the ability to upsize. Upsizing by up to 30% of the original pipe diameter is common, and greater upsizing has been successfully completed. However, larger diameter pipes (more than 450 mm in diameter) in need of a high upsizing percentage require careful examination (in terms of required forces and ground displacements).

**Applicability**. Pipe bursting can be applied to a wide range of pipe sizes and types, in a variety of soil and site conditions.

The size of pipes being burst typically ranges from 50 mm to 915 mm, although it can be even larger (a 1220 mm has been replaced). The most common pipe bursting is size-for-size, or upsizing the diameter of the existing pipe up to three sizes (e.g. 200 mm to 300 mm). Large upsizings require more energy and cause more ground movement. They slow the replacement operation and need careful evaluation when large diameter existing pipes are upsized.

With respect to the type of existing pipe, the pipes suitable for pipe bursting are typically made of brittle materials, such as vitrified clay, cast iron, unreinforced concrete, asbestos, or some plastics. Reinforced concrete pipe (RCP) is typically not suitable for pipe bursting, especially if it is heavily reinforced. Ductile iron and steel pipes are not suitable for pipe bursting, but can be replaced using a modified method called pipe splitting.

A common bursting length is usually between 90 m and 120 m (taken from the utility industry...
based on the typical distance between sewer manholes). However, much longer bursts may be achieved when needed. A long burst generally requires more powerful equipment to complete the job.

Access also needs to be investigated. Access to both ends of the pull should be available. Site restrictions that compel the need of support/protection systems will increase costs.

**Unfavorable Conditions and Limitations**. Unfavorable conditions for pipe bursting are (1) expansive soils, (2) obstructions along the existing pipe length in form of completely collapsed pipe, (3) metallic point repairs that reinforce the existing pipe with ductile material, (4) concrete envelopment or pipes with very dense (rock) backfill, and (5) adjacent pipes or utility lines that are very close to the pipe being replaced. The obstructions do not necessarily prevent the pipe bursting, and the problem is usually solved with localized excavations.

As a general rule for close proximity pipes adjacent to a bursting operation, both horizontal and vertical distance between the pipe to be burst and the existing adjacent pipe should be a minimum of 1.5 m.

All pipe bursting operations create (to some extent) vibrations of soil particles in the ground. Figure 2 provides the results of a TTC study of the velocity of vibrational ground movements from different pipe bursting techniques. In the frequency range from 30 to 100 Hz, level of 50 mm/sec. may be reached within distances of 2.4 m from the bursting head.

![Compiled peak particle velocity vs. frequency for all test sites](image1.png)

![Velocity vs. distance from the bursting head for all test sites employing pneumatic system](image2.png)

*Figure 2 TTC study of ground vibrations. (Simicevic, J. and Sterling, R.L., 2001)*
To ensure the ground surface will not heave, there should be at least 1.2 m of cover. A rule of thumb is that the burst depth should not be less than ten times the upsize diameter (e.g. if the pipe is to be upsized by 0.3 m, the required depth of cover is 3 m).

Limitations in applicability come from either (1) economical aspect (its comparative costs versus cost of conventional replacement), (2) safety aspect (potential damage to the neighboring utilities and structures), or (3) technical aspect (the ability to provide sufficient energy to complete the operation).

**SUBMITTAL PROCESS**

The pipe bursting specification was created as a trenchless installation alternative for rehabilitating an existing pipe where the traditional open-cut-trench replacement method is not permitted. By accepting various types of pipe bursting methods, we allow the Contractor to utilize their experience and expertise to decide on the appropriate method given the ground and groundwater conditions. This places a responsibility on the Department to define the subsurface conditions.

The Contractors submittal will include qualifications of the Contractor, designed burst path, method for pipe bursting (including a plan of operation, equipment, procedures, and design of insertion and reception pits), and method of pipe installation.

To ensure compliance with the contract documents, the pipe bursting and installation operation will be inspected via video equipment. Video inspection/recording equipment (including power source) that is specifically designed for continuous viewing and recording of images of the interior walls of pipes and fittings and capable of providing a true-color image of the entire pipe periphery will be supplied by the Contractor. Pre- and post-installation video inspection recordings will be submitted to the Engineer.

**DESIGNER GUIDANCE**

**Geotechnical Review.** Before specifying pipe bursting in the contract documents, the designer should consult with the Regional Geotechnical Engineer (RGE) to ensure the ground conditions are favorable to a pipe bursting operation. Less favorable ground conditions for pipe bursting involve densely compacted soils and backfills, soils below the water table and soils that expand in volume as they are sheared (e.g. angular sands). Each of these soil conditions tends to increase the force required for the bursting operation and to increase the zone of influence of the ground movements. See Figure 1.

- **Subsurface Conditions:** In most instances, the host pipe was installed by 'trenching' and is directly surrounded by select granular fill material. The soil around the pipe (select granular fill and the native soil) has to be compressible to absorb the diameter expansion. The National Association of Sewer Service Companies (NASSCO) classified bursting projects into three classifications in terms of difficulty identified in Figure 3.

  As noted for “A – Routine”, areas containing clays and other compressible soils are best suited for upsizing. Sands and gravel are very difficult to burst because the soil tends to collapse in on itself in the void created by the expander. The collapsed soils cause very
large values of skin friction on the pipe being pulled in behind the bursting unit. The friction can stop the bursting head altogether. Rocks in the fill can settle back onto the new liner and collapse it after the expander has passed. Solid rock outcrops may not expand at all.

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<th>C – Challenging to Extremely Challenging</th>
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<td>Depth</td>
<td>Less than 3.7 meters</td>
<td>3.7 meters - 5.5 meters</td>
<td>More than 5.5 meters</td>
</tr>
<tr>
<td>Existing Pipe</td>
<td>1.2 - 3.7</td>
<td>3.7 - 6</td>
<td>6 - 10</td>
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<tr>
<td>New Pipe Diameter</td>
<td>Size for size or one diameter upsize</td>
<td>Two diameter upsize</td>
<td>Three or more diameter upsize</td>
</tr>
<tr>
<td>Burst Length</td>
<td>Less than 107 meters</td>
<td>107 meters - 137 meters</td>
<td>More than 137 meters</td>
</tr>
<tr>
<td>Trench Width</td>
<td>Relatively wide trench compared to up sized diameter</td>
<td>Trench width less than 4 wider than upsize diameter</td>
<td>Incompressible soils (very dense sand, hard clay or rock) outside trench</td>
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<tr>
<td>Soil</td>
<td>Compressible soils outside trench (soft clay, loose sand)</td>
<td>Moderately compressible soils outside trench (medium dense to dense sand, medium to stiff clay)</td>
<td>Constricted trench geometry (width less than or equal to upsize diameter)</td>
</tr>
</tbody>
</table>

**Figure 3 Summary of NASSCO Pipe Bursting Classification**

(Plastic Pipe Institute)

Another important consideration is that the base soil be able to support the weight of the tool, expander and the new pipe. A pipe that has been leaking for some time may have cavities and pockets around it and may not be able to support this weight.

The designer and RGE should ensure the groundwater conditions are favorable to a pipe bursting operation. Pipe bursting below the groundwater table increases the difficulty as in saturated fine soil can cause the water pressure to rise around the bursting head (unless the soil has a high enough permeability to allow the water pressure to dissipate quickly). The rise in water pressure causes the effective stress in the soil to drop and may cause the soil to behave more like a viscous fluid. When the fluidized soil displaces the surrounding soil, the ground movements tend to be more extensive and nearby services may displace more easily.

- **Groundwater Conditions:** One concern regarding the groundwater table with respect to the bursting operation is that, in fine soil conditions, groundwater will cause the annulus to close in quickly behind the expanding head thus increasing pipe drag and theoretically reducing the practical burst lengths. However, as mentioned above under Subsurface Conditions, in most instances the host pipe was installed by "trenching" and is directly surrounded by select granular fill material.

Another concern is, if the groundwater level is above the invert level of the host pipe, the groundwater may enter the annulus between the host pipe and replacement pipe through any leaking joints/corrosion holes etc. in the host pipeline. The resulting external hydrostatic pressure of water on the replacement pipe has the potential to cause the replacement pipe to collapse (buckle).

The designer and the RGE should discuss the subsurface conditions (type of soil, groundwater
elevation, original pipe installation method and materials, existing utilities, etc.), length of burst, sensitivity of existing aboveground structures, etc., and contact the Geotechnical Engineering Bureau to determine the appropriateness of utilizing the specification.

**Materials Review.** The designer should consult with the Regional Materials Engineer (RME) to ensure the host pipe is favorable to a pipe bursting operation.

Most brittle pipe materials make good candidates for pipe bursting. Ductile pipes may be scored and then slit in a pipe splitting operation, a variant to the pipe bursting method. Pipes made of non-ductile abrasive material but with ductile reinforcing are the most difficult to replace using most pipe replacement techniques.

Good candidates for bursting include clay pipes, plain concrete pipes, and cast iron pipes. Reinforced concrete pipes present difficulty unless the concrete and reinforcing steel is deteriorated. They may be burst with powerful enough equipment but careful evaluation may be needed if the pipes are more than lightly reinforced and are not significantly deteriorated. Steel and ductile iron pipes are not good candidates for pipe bursting. They are strong and ductile. In smaller diameters, they may be replaced using pipe splitting techniques. PVC and other plastic pipes may be replaced using an appropriate combination of bursting and splitting techniques according to the strength and ductility of the pipe.

Particular consideration should be given to the type of pipe to be burst in relation to the type of pipe to be installed. Although clay and cast iron pipes are good candidates for bursting, fragments from the bursting may be sharp, leaving some level of concern about gouging or scoring of the replacement pipe and eventual point loading on the replacement pipe. A sacrificial external sleeve pipe may be used to ensure protection for the replacement pipe. However, the size of the bursting head must be increased to accommodate the external sleeve pipe thickness and the annular space required for the replacement pipe to be inserted. This increased diameter increases power requirements for the bursting and also increased the extent of ground movements surrounding the bursting head.

**Utility Review.** The designer should consult with the Regional Utilities Engineer (RUE) to discuss the location of existing utilities. Existing utilities can affect the location of insertion and reception pits. Utilities that interfere with or may be damaged by the burst should be located and exposed prior to the burst.

**Environmental Review.** The designer should identify potential impacts the pipe bursting operation may have on existing environmental and cultural resources and identify watercourses, wetlands, etc., which may require protection from lubricant used in the pipe insertion or the final pipe cleaning and disposal of surplus excavated materials.

Particular consideration should be given to asbestos pipe, as disturbance created by pipe bursting would be subject to regulation under the Asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP), the OSHA Construction Standard 29 CFR 1926.1101 and Part 56 of Title 12 of the Official Compilation of Codes, Rules and Regulations of the State of New York (12 NYCRR Part 56). Any use of this method on asbestos pipe/conduit would need to be used in conjunction with Section 210 Removal and Disposal of Asbestos-Containing Material (Buildings, Bridges and Highways). In addition, Regional Environmental staff and/or the Environmental Science Bureau should be consulted regarding applicability of the Department’s current regulatory variance (NYSDOT Blanket Variance #14).
**Right-Of-Way Review.** The designer should identify potential impacts the pipe bursting operation may have on existing right-of-way restrictions with respect to the location of the insertion and reception pits.

**REFERENCES**

1. US Army Corps of Engineers, Engineering Research and Develop Center (ERDC)  
   *Guidelines for Pipe Bursting*  
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2. International Pipe Bursting Assoc  
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3. Plastics Pipe Institute  
   *Handbook of Polyethylene Pipe*  
   Chapter 16 – Pipe Bursting  