Pipe Operation & Maintenance Manual

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Opening

An important aspect of stormwater management is the ongoing operation & maintenance to ensure culverts, sewers, best management practices, and water quality devices are performing at the level needed. Having a comprehensive operation & maintenance program helps municipalities and property owners keep an accurate record of the condition of their assets, as well as potentially help locate areas which need to be repaired before a more serious problem can occur. This manual is to help owners, engineers, and contractors understand the specifics of inspecting, maintaining, and repairing ADS high density polyethylene (HDPE) and polypropylene (PP) pipe products. This manual shall not serve as a replacement or substitution for local regulations and engineering requirements for the operation, inspection, maintenance or repair of sewers and culverts.

There are several resources which provide guidance regarding the inspection, maintenance, and repairing of thermoplastic pipes, for example:

- The AASHTO Culvert & Storm Drain System Inspection Guide
- ASTM F3533, “Standard Guide for Inspection and Acceptance of Installed Thermoplastic Storm and Sanitary Sewer Pipe”
- Specifications developed by the National Association of Sewer Service Companies (NASSCO, Inc.)

Many local, state, and federal agencies have developed their own standards and specifications for sewer asset management. This guide is meant to educate and provide guidance which can be implemented into asset management over the life cycle of the sewer.

A strong maintenance program can help asset owners with the following:

- Maintain proper and necessary function of ADS assets, including flow rates and velocity requirements.
- Extend the service life of ADS assets by documenting them via inspection and resolving any issues in real time
- Ensure system assets meet performance standards in accordance with the relevant agency requirements.

Safety

Safety is the highest priority when performing any maintenance or rehabilitation work, both for the individuals performing the work as well as the public at large. All personnel involved are responsible for ensuring safety measures and protocols are followed, which may include the following:

- Occupational Safety and Health Administration (OSHA) 29 CFR Part 1910 (Occupational Safety and Health Standards)
- OSHA 29 CFR Part 1926 (Safety and Health Regulations for Construction)
- State and Local Government Regulations
    - Maintenance of Traffic Guidance
    - Confined Spaced Entry Requirements
- Contractor’s Safety Guidance, Protocols & Regulations

Confined Space

Since sewers and culverts can be enclosed spaces, or have limited means of egress or air exchange, they are typically treated as confined spaces. A confined space, as defined by OSHA 1910.146, is a space that meets the following:

1. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
2. Has limited or restricted means for entry and exit; and
3. Is not designed for continuous employee occupancy

Confined spaces can be further broken into permitted and non-permitted spaces. A permitted space is a confined space that has one (1) or more of the following characteristics:

1. Contains or has a potential to contain a hazardous atmosphere;
2. Contains a material that has the potential for engulfing an entrant;
3. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross section; or
4. Contains any other recognized serious safety or health hazard.

To determine if a confined space qualifies as a permitted space, a competent person shall review the site and identify any existing or predictable hazards for both the working conditions as well as the surrounding area. This person shall also have the authority to take prompt corrective action to eliminate these hazards to the best of their ability.

Entries requiring a permit must be done by certified confined space professionals and require a detailed plan of entry as well as constant monitoring for hazards. If required, forced air or a personal breathing apparatus may also be used to ensure entrants have a constant supply of oxygen.

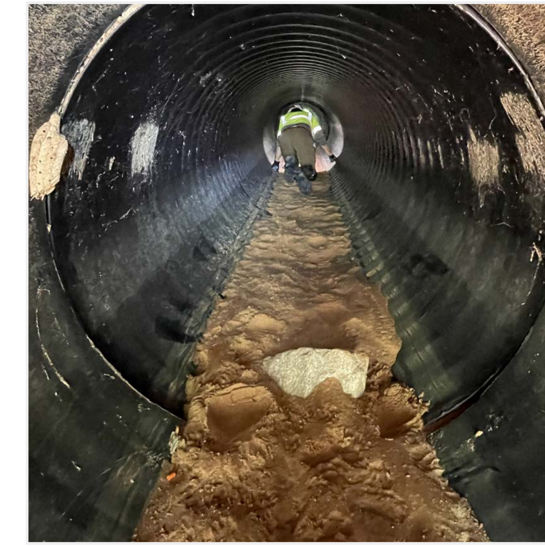
Pipe Safety Concerns

Many culverts and sewers will qualify as a permitted confined space, due to their risks of hazardous material (human waste, hydrogen sulfide (H_2S), etc.), limited egress points on long culvert runs or sewers running structure to structure and the depth of the culvert/sewer beneath grade as examples.

Other potential safety risks can include wildlife encounters. Animals may find refuge in storm sewers since they will be dry during non-storm periods and will typically have open access to an outfall. Signs of animal activity (waste, footprints, food remains) should be surveyed and monitored, particularly on pipe runs which are close in proximity to an outfall or are located in remote areas where wildlife will be more present.

High water can also pose a threat by affecting the entrant’s field of vision or mobility, as well as more severe risks such as water pathogens or drowning. Water can be diverted with bypass pumping for high flows, or if flows are low enough upstream connections can be plugged to allow for the inspection to be completed.

Inherent to any buried structure is the possibility of collapse. When surveying and preparing for a confined space entry, all personnel should be informed of any potential structural risks associated with the asset being entered, a qualified person should evaluate the structural hazards of buried structures before performing any maintenance or repair work.



Thermoplastic Pipe Overview

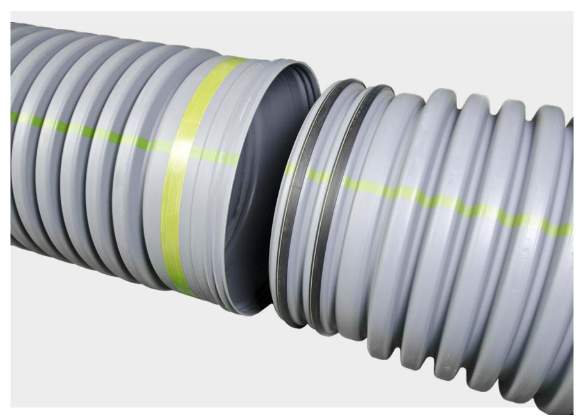
ADS manufactures several pipe products, including Single Wall, N-12®, HP Storm, and SaniTite® HP, using high-density polyethylene (HDPE) and/or polypropylene (PP). Black pipe is made from HDPE. If the interior is corrugated, the product is Single Wall; if the interior is smooth-lined, the product is N-12 Dual Wall. Both Single Wall and Dual Wall N-12 pipe offer soil-tight or watertight joint performance. A pipe connected with an external coupler functions as a “plain-end” soil-tight joint. A pipe with an integral bell and spigot can provide either soil-tight or watertight performance, depending on the gasket type and bell reinforcement. Identifying this requires inspection of the gasket or the external portion of the bell.

Grey pipe is made from PP and classified as either HP Storm or SaniTite HP. Both products deliver watertight joints in accordance with ASTM D3212. HP Storm may contain one or two watertight gaskets, while SaniTite HP always includes two. SaniTite HP is characterized by a smooth exterior in diameters 30–60 inches but is corrugated in 12-30 inches. All other ADS pipes feature a corrugated exterior.

Thermoplastic pipe relies on a soil-structure interaction to carry loading. As a vertical load is introduced to the pipe, it begins to deflect and shorten in the vertical diameter. As this is occurring, the horizontal pipe diameter is increasing and as a result begins to press and act upon the pipe backfill and surrounding subgrade. The surrounding material provides resistance to the vertical load, and therefore also resists the vertical deflection of the pipe. Deflection alone does not constitute damage or failure. ADS supports AASHTO guidance for repair and replacement of all pipe materials, which does not recommend immediate corrective action for thermoplastic pipes until vertical deformation exceeds 7.5%. For comparison, AASHTO applies the same threshold to reinforced concrete pipe when cracks exceed 0.05 inches in width.

Thermoplastic materials, including HDPE and PP, are inert, highly resistant to chemicals, and provide best-in-class abrasion resistance. These properties enable thermoplastic pipes to resist common chemicals like salts, oils, and acidic soils, to minimize invert loss, to limit increases in channel roughness, and to withstand abrasive debris or cleaning operations. However, in-service storm and sanitary pipes may be exposed to harsh chemicals, abrasive solids, high-velocity flows, and decaying organic matter. Over time, such conditions can degrade any construction material. For additional details on the abrasion and corrosion resistance of ADS pipes, refer to Tech Notes 4.01 (Chemical Resistance of Polyethylene), 4.02 (Chemical Resistance of Polypropylene), and 4.03 (Abrasion Resistance of Polypropylene).

N-12 Dual Wall Pipe



HP Storm Dual Wall Pipe

Ultra Violet (UV) radiation has the ability to degrade unprotected plastic over time. ADS products are manufactured with UV stabilizers and antioxidizing agents to protect portions of pipe which would be exposed to the sun. These agents limit radiation penetration to a thin amount along the outer pipe wall, with pipe color fading being noticeable. Ongoing testing by ADS has shown that pipe being exposed to direct sunlight and UV radiation for over a year shows no degradation in physical or rheological properties.

Maintenance

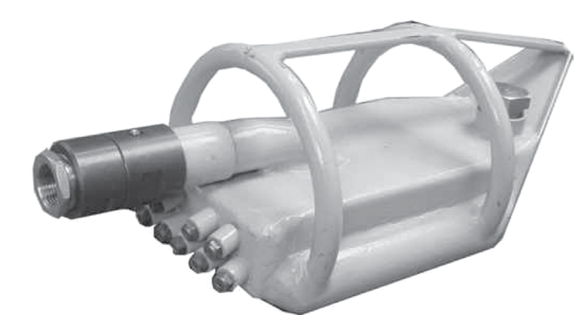
When ADS pipe products are properly installed and meet the necessary post-installation testing requirements, they are expected to perform reliably for the service life of the pipe. However, during that service life outside factors may affect the performance of the pipe. Common occurrences over time include the following:

- Signs of infiltration (pipe staining or active infiltration of water)
- Cross bores present in pipe (directional drilling)
- Debris buildup (grease, sewage, mineral deposits)
- Root infiltration
- Nearby operations (construction, industrial)

To ensure pipe performance is maintained for the life cycle of the pipe, periodic maintenance is recommended to remove these obstructions. Maintenance intervals can vary based on multiple factors, including size and function of the pipe. Based on these factors, many agencies require maintenance to be performed every 1-5 years. The most common methods for removal of build-up are sewer cleaning using jetting, using attachments such as a chain knockers, or the use of chemicals.

Water Jetting

When performing inspections, the pipe should be clean and free of large debris which may impede the inspection equipment. The use of a vacuum truck and jet nozzle is recommended to remove smaller debris, such as deposited sediment, leaves, and smaller root obstructions. **ADS recommends the jet nozzle should operate at no higher than 2000 psi.**



An important choice to make when water jetting is to determine the type of jetting nozzle to use, as different jet types are recommended for certain applications. A flushing nozzle is typically used for general cleaning purposes.

These types of nozzles are best when removing small deposits of debris which are not hardened or calcified, and a very economical option for cleaning prior to performing an inspection. Flushing nozzles will typically utilize larger nozzle sizes and prioritize a higher flow rate over operating pressure. Penetrating nozzles, also known as unblocking or clearing nozzles, are designed to maximize operating pressure to clean debris and larger deposits from the sewer.

A typical set up for cleaning would include placing the vacuum truck at the downstream end of the pipe needing to be cleaned. If typical flows through the pipe segments are high enough, external bypass may be required to allow for effective cleaning. Plugs may also be utilized to isolate the area being cleaned so that debris does not migrate to nearby sewer runs. The jetting nozzle and hose are then placed through the downstream access point and pushed upstream to another access point. Depending on the equipment used, it is possible to clean more than one pipe run at a time, however most cleaning apparatus have a limit of 500 ft. Once the jet nozzle is in the desired location upstream, the water pressure is increased and the hose is reeled in slowly back toward its original downstream location. The debris-laden water will travel downstream ahead of the jet nozzle and be picked up by the vacuum truck hose placed downstream. Cleaning in a downstream direction allows for the jetting to "push" the volume of water toward the vacuum truck, leveraging gravity and the natural slope of the system to assist flow movement and improve cleaning efficiency.

Debris Removal

There may be instances where debris and obstructions, for example large, calcified deposits or root balls, will require additional mechanical or chemical methods to remove. For smaller diameter pipes where manned-entry is not possible, tools such as chain knockers can be used to help break this debris from the pipe walls. The use of cutting tools with blades, such as root cutter attachments, is not advisable, as the blades may damage the inner wall of the pipe. When manned-entry can be made, hand tools and cutters can be used to decrease the risk of damaging the pipe.

Chemicals, such as copper sulfate or acids, can be applied in a granular or aqueous form to help remove obstructions without the use of additional tools. If choosing to clean sewers using chemicals, please consult Tech Notes 4.01 and 4.02. If using a chemical which does not appear in these Tech Notes, please contact your local ADS representative for confirmation on its use. TR-19 (Chemical Resistance of Plastic Piping Materials), first published by the Plastic Pipe Institute, Inc. in 1973, is an additional resource that can be consulted regarding the reactivity of chemicals to HDPE and PP pipe.

Inspection

The inspection of thermoplastic pipes can be completed by either man-entry or by use of a non-entry technique, such as a remote-controlled CCTV camera. Use of either technique is typically driven by the diameter and location of the pipe. Typically, pipes sized 30" and smaller are deemed too small for manned entry and non-entry inspection methods should be used. Non-entry inspection may also be advisable for long sections of pipe networks which run manhole to manhole, as these types of inspections come with safety risks and confined space entry requirements. For any man-entry inspections, crews shall follow any applicable confined space entry regulations, such as OSHA 29 CFR Part 1926 Subpart AA.

Inspection intervals are typically dependent on multiple factors, including:

- Asset Size
- Asset Location (Ex: Within roadway v. greenspace)
- Vital Infrastructure (Ex: Large Interceptor v. catch basin lateral)

Many municipalities and professional organizations with published sewer inspection criteria note that a sewer inspection should occur at a maximum of every five (5) years. Inspections are recommended any time work is to be done to the pipe or in the nearby vicinity, an example being if a road which the pipe runs beneath is scheduled to be repaved/reconstructed. Periodic inspections not only allow owners to get an as-is look at the condition of their asset, but when combined with multiple inspections can be used to create a timeline for the asset to help identify potential issues before they require a large capital expense.

It is also recommended that visual inspections occur after the pipe is initially installed. This is typically performed during post-installation testing, which should occur no sooner than thirty (30) days after the pipe run is completed, as a majority of deflection of the pipe will occur during this time period. Requiring a visual inspection after installation provides the owner with a clear image of the condition of the assets of which they will assume ownership, and when carried across all material types promotes higher quality installations.

Inspections should be done by a certified professional, such as an individual certified through the Pipeline Assessment Certification Program (PACP) offered by NASSCO, Inc. Certified professionals will be equipped with the knowledge and tools to be able to all inspection types (manned-entry, remote crawler, laser profiling, etc.), as well as understand the severity of items which may be found during a condition assessment.

Condition Assessment

The purpose of a condition assessment in asset management is to provide a detailed understanding of an asset's physical condition, enabling informed decision making for proactive maintenance, capital planning, risk mitigation, and resource allocation. The best predictor of a high-quality asset in the future is a high quality installation. ADS trench details as well as technical notes on cover requirements and post installation testing can assist in providing a quality and cost effective installation.

Condition assessments typically use a grading system, such as the AASHTO Culvert & Storm Drain System Inspection Guide's Condition Rating System, to help qualify different deficiencies in a consistent manner. AASHTO and the Plastic Pipe Institute endorse the following rating scale for condition assessment:

	1	2	3	4
	Good	**Fair**	**Poor**	**Severe**
Condition	Like new, with little to no deterioration of the pipe. Functions as intended.	Slight deterioration of the pipe, however structurally sound and functions as intended.	Significant issue with deterioration of pipe, function of pipe, or both. Immediate remediation may be necessary.	Very poor conditions that show threat of imminent failure, or a failure which can threaten public safety.
Action Required	N/A	Inform maintenance personnel. No immediate actions required, however may be advisable to perform more frequent inspections.	Inspector to evaluate and make recommendation in report.	Immediate corrective action required. Engineer to evaluate and specify repair/repair methods required.

Pipe deficiencies vary by pipe material; however, asset grading systems should promote consistency by evaluating comparable deficiencies equivalently across all common storm pipe materials. This approach encourages fair, data-driven assessments and supports balanced asset management decisions. When inspecting pipe of any material, the following should be reviewed and evaluated:

- Pipe Alignment (both vertical and horizontal directions)
- Joint integrity (gaps, misalignments, gasket protrusions, infiltration/exfiltration)

Due to the manner which the material types carry and disperse the load that is exerted onto them, different attributes need to be inspected. Where rigid pipes, such as reinforced concrete, should be inspected for deficiencies such as cracking, rust staining and spalling, thermoplastic pipes should be reviewed on the following:

- Pipe Shape (deflection, uniformity, flattening)
- Inner Liner Damage (abrasions/scratches, UV degradation, punctures & other impact damage)
- Buckling (excessive surface rippling, changes in curvature)
- Cracking (circumferential & longitudinal)

As municipalities and jurisdictions may use different assessment scales, the table below shows an aggregate of several condition assessment scales and how plastic pipe should be evaluated as a low-severity, medium-severity, and high-severity deficiency.

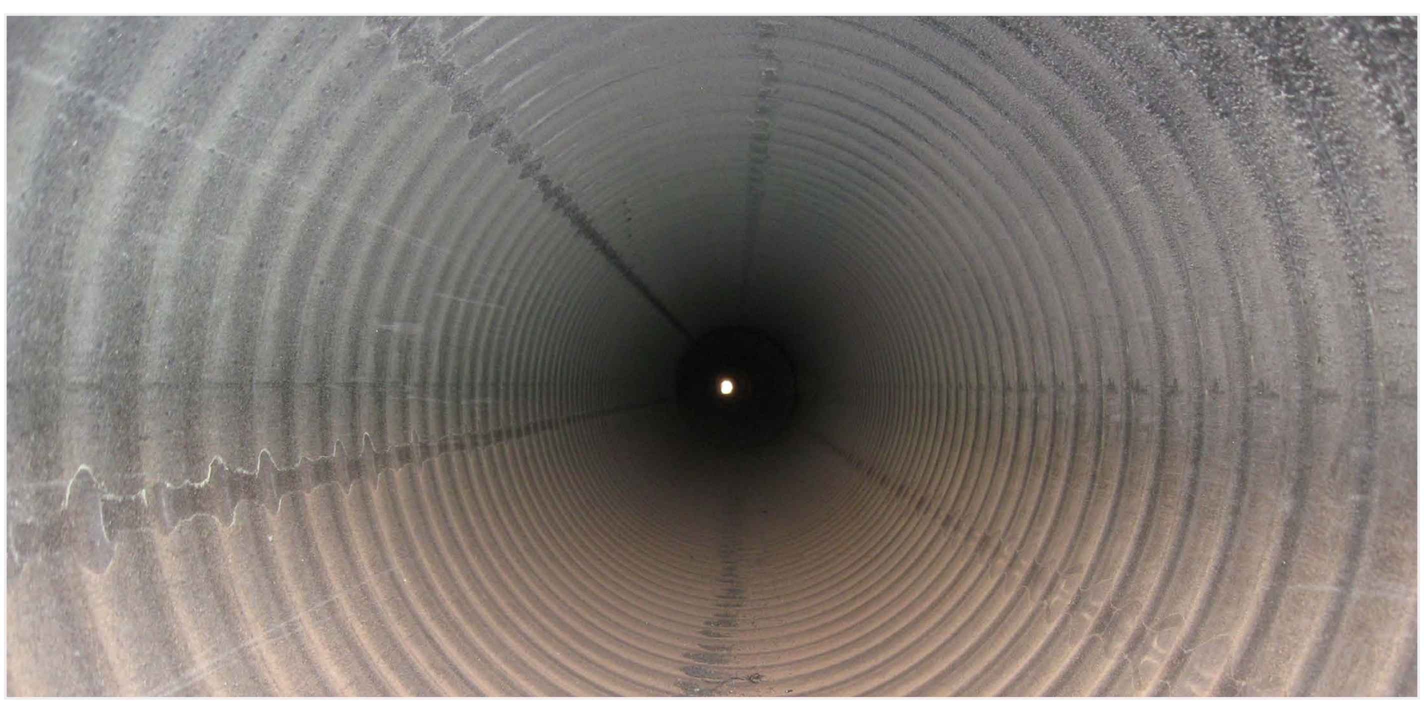
Deficiency	Fair	Poor	Severe
Pipe Alignment	Minor deviations, including sagging, heaving in the vertical direction or horizontal deviations not noted at install which have no negative effects on joint or structural integrity.	Horizontal alignment shows deviations at one or more joint which are affecting joint structure and performance (infiltration) Vertical alignment shows heaves or sags which cause water ponding or sediment accumulation equaling up to 25% of the pipe inner diameter. Alignment deviations beginning to show noticeable decrease to hydraulic performance.	Horizontal alignment causing noticeable distress at numerous joints (buckling, infiltration), creating structural and hydraulic deficiencies. Vertical alignment showing heaves and sags over 25% of pipe inner diameter. Significant reduction to hydraulic performance.
Pipe Shape	Signs of slight wall-flattening, deflection ranging between 5% and 7.5% of pipe inner diameter.	Significant wall-flattening, resulting in an increased wall curvature. Pipe deflection measured from 7.5% to 10% of pipe inner diameter. Signs of asymmetry in pipe shape.	Wall-flattening resulting in complete change in curvature (i.e. global buckling), pipe deflection measured over 10% of pipe inner diameter. Clear visual signs of asymmetry in pipe and pipe being "out-of-round".
Inner Liner Damage	Minor signs of wear and abrasion from use, slight signs of UV degradation/staining.	Wear or abrasion into the inner wall which measure more than 10% of the inner wall thickness, clear signs of discoloration of pipe ends due to UV exposure.	Wear & abrasion into the inner wall measuring over 25% of the inner wall thickness. Punctures through the inner wall. Pipe becoming brittle and cracked due to UV degradation.
Buckling & Cracking	Local buckling noted as rippling in the inner wall not noted during post-installation inspection. Cracks and splits along the circumference of the pipe, measuring less than 25% of the pipe circumference.	Wide spread local buckling noted as excessive rippling. Circumferential cracks and splits of the pipe, measuring up to 50% of the circumference. Longitudinal cracks measuring less than one foot.	Local buckling resulting in portions of liner having "whitening" and kinks. Circumferential cracks and splits measuring over 50% of the circumference. Longitudinal cracking measuring larger than one foot. Cracks or splits showing noticeable signs of infiltration of soil or water.
Joint Integrity	Measurable joint gap (straight alignment or askew), with no signs of infiltration or gasket exposure.	Joint shows signs of infiltration (soil or water, if water tightness required), measurable joint gap outside of manufacturer's tolerance for gasket engagement, gasket material noticeable at joint.	Actively leaking joint (soil or water, if water tightness required), joint separated and backfill visible, gasket completely unengaged or damaged.

There are several methods of obtaining information for a condition assessment, including remote rover closed-circuit television (CCTV), visual inspection (manned-entry), and LiDAR inspection to name a few. Each inspection method offers a distinct balance between information accuracy and associated cost.

Remote rover inspections allow for the inspection of the asset without requiring a confined-space entry, and rovers can be used for smaller pipes which cannot be accessed by a person. The recording setup for remote rover will also typically use software which has built-in deficiency and severity codes, allowing for a more streamlined inspection. However, remote rovers may not come equipped standard with accessories to measure gaps, which then requires the rover operator to use their best judgement to determine measurements. For remote inspections requiring more precise measurements, rovers can be equipped with laser profiling attachments. This allows the rover to determine precise measurements for items such as deflection, ovality, and joint gaps using a combination of light rings and laser points. In order for inspection results to remain consistent, periodic calibration of the equipment needs to be performed to ensure proper function. Along with periodic calibrations, laser profiling often requires additional software and analysis tools beyond what a typical remote rover inspection uses which may coincide with additional operator training. For additional information on Laser Profiling of Flexible Pipes, please consult ADS Technical Note 5.08.

LiDAR inspection uses pulsed laser lights to measure precise distances from the emitter to the object it is reflecting off of and provide a 3D rendered image of the pipe. This would then allow for a certified professional to then review the data and comment on it without having to physically enter the sewer. Depending on the tolerance of the equipment, some can provide clear 3D images showing deficiencies which cameras or the human eye may have difficulty finding. LiDAR will also pick up other materials in the pipe, including solids buildup or standing water, which may negatively impact the 3D model. LiDAR inspections will typically cost the most, and availability can vary by region.

Manned-entry inspections are most prevalent, and sometimes required, when inspection larger pipes and structures. Inspections may be completed using a handheld recording system, or with technology advancing the use of smaller helmet cameras. Manned-entry also allows for personnel to bring tools into the pipe, including measuring tapes, vials for collecting samples and other small hand tools which can help ensure accuracy when measuring things like solids deposits or deflection. Most equipment can be purchased for a relatively small amount and maintenance for that equipment is typically inexpensive as well. One drawback, however, to manned-entry is that most inspections will require a permitted confined-space entry, which requires additional equipment such as fall protection, air monitoring equipment, air exchanging equipment and additional personnel.



When performing video inspection, it is important that the crawler or operator progress at a proper speed to ensure video comes out clear and depicts the pipe’s condition accurately. Typical inspection specifications require that video inspections be performed at a speed no faster than 30 feet per minute. When deficiencies or items of note are found while progressing through the pipe, the camera should stop and provide clear images of the area. If the deficiency is circumferential, it is recommended the camera provide a full 360° view of the area.

Along with stopping at any noticeable deficiencies, ADS recommends the camera stop at every joint and provide a 360° view, as well as stopping at any locations where a connection is made. These can include laterals as well as break-ins at the crown of the pipe to connect surface inlets or cleanouts. A typical inspection will run from access point to access point, however if the inspection is performed on multiple segments sequentially, the camera should also stop at each access point to provide visual.

While video inspection can provide visuals of the pipe, it very seldom can provide exact measurements for things such as deflection and joint gaps. The use of a remote rover provides may provide measuring accessories depending on the rover type, however many times will defer to the knowledge and training of the operator to make an estimate based on reference points. Manned-entry inspections allow an inspector to measure and review items as they proceed with the inspection. For exact values, LiDAR and other laser measuring technologies can be used. Common uses of laser profiling technology include deflection across the entire pipe segment, measuring circumferential items such as joint gaps which differ along the circumference, as well as measuring crack propagation. Many remote rovers can be equipped with both a camera and laser profiling gear so that the inspection types can be performed concurrently.

Condition assessments also need to take into account the supporting site and installation information to provide context for notable inspection findings. For example, if a larger than expected increase to deflection is noted, a follow-up would be to know if the topography over the pipe has changed. Determining if nearby construction activities potentially disturbed the buried structure is also advisable.

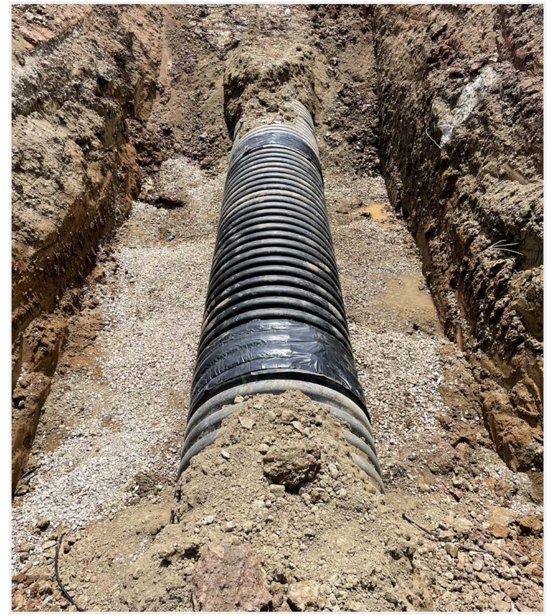
If any issues come up during the assessment process, contact the local ADS Regional Engineer or Applications Engineering Department and they can assist with any questions or assist in reviewing.

Inspection Deliverables

When finalizing inspection reports, it is important that all pertinent information be given so that an accurate review of the assessment can be done by a registered engineer if necessary. Though many municipalities and agencies have their own deliverable requirements and inspection log formats, ADS would recommend that the following information be, at minimum, included with any inspection report:

- Location of item being called out. This is typically shown as a distance from the starting access point of the inspection.
- Item type, including deficiency types, joint location, lateral break in location, etc.
- Severity grade of item, if noting a deficiency.
- Additional comments from inspector. These will add context to the severity grade given to the item. For example, noting low-severity for joint integrity with a comment stating: *"Joint gap, askew. Widest at 9 o'clock position, measures 1.1 inches. No signs of leakage or gasket disengagement."*

Along with the report itself, any and all data should be included as well. This can include video footage, laser profiling results, and hand written notes and measurements (if inspection done via manned-entry). This information together can be uploaded to a service such as a GIS (geographic information system), or kept as local hard copies for future reference.



Repair

Like all construction materials, ADS pipes may occasionally require repairs due to errors, mishaps, or unexpected conditions in construction applications. When selecting a repair method, it is important to identify several items which can help determine the type of repair which will be most effective for the specific situation. These items may include:

- Does the pipe in question have a performance requirement (watertightness, chemical resistance)?
- Where is the repair needed (joint, pipe barrel, green space, roadway crossing)?
- Is there visible pipe imperfection (missing section, noticeable buckling)?
- Is the imperfection localized or is it spread across a large section of pipe?

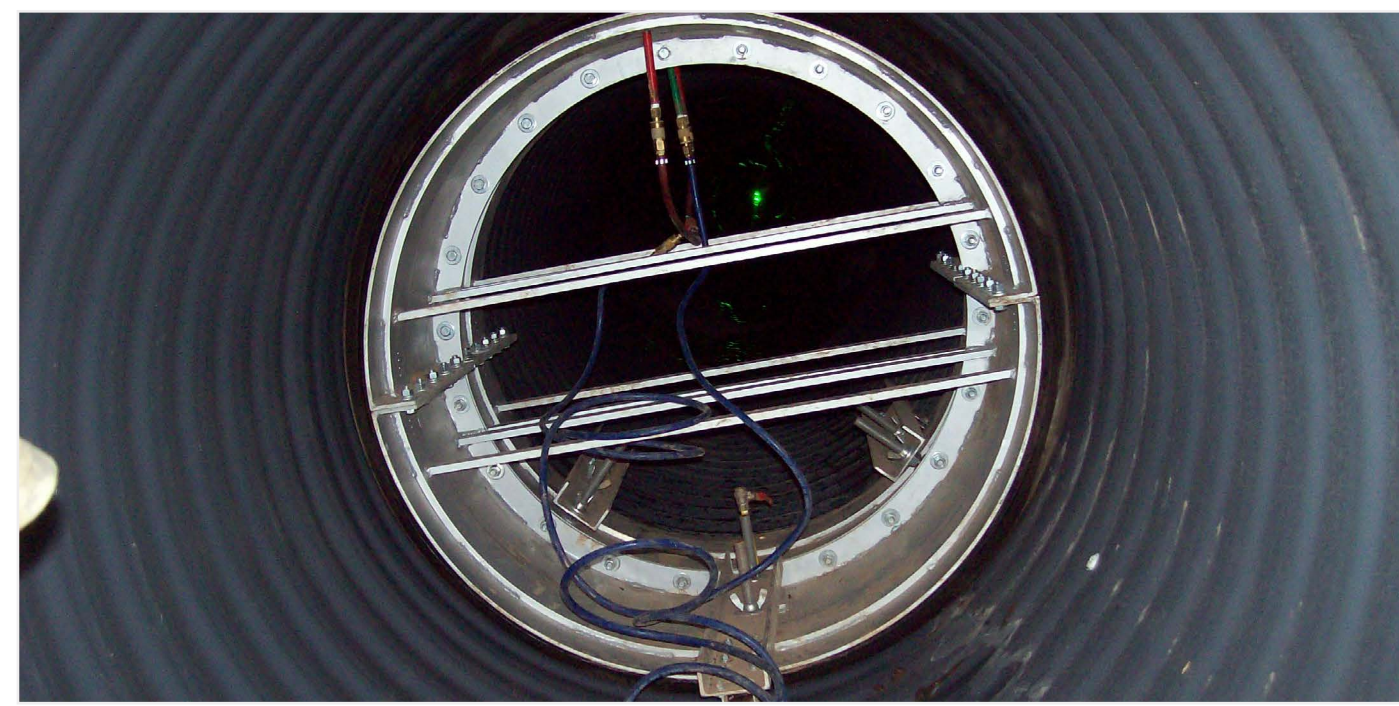
Performance Criteria

A system's performance requirements may also help select what type of repair is best suited for the application. These requirements may include knowing if a repair needs to be proven watertight through installation testing, ensuring if a repair needs to withstand certain chemicals and abrasive materials, and if the repair needs to meet a certain structural design life.

Where pipe is allowed to remain soil-tight, meaning the pipe joints are designed to stop soil particles from entering but will allow the infiltration/exfiltration of water, non-gasketed solutions such as a split coupler or snap coupler are acceptable. Where pipe must be watertight, repairs are recommended to be lab testable per ASTM D3212 as well as field testable to ensure proper installation. These repairs will typically require a gasket or flexible rubber material be installed to act against the pipe and repair material being used.

Though ADS pipe products themselves show positive performance in resisting abrasion damage as well as resisting most common chemicals in storm and sanitary flow, desired repair methods may not have the same resistance. Since repairs can be made with differing materials, such as grouts and elastomers, it is important to know how these materials will react with the in service requirements of your asset. Consulting with a repair manufacturer's engineering team can provide the insight needed to have confidence the repair will not fail during ordinary operation.

The design life of a repair will also help inform an owner on what their repair options are. While ADS products are designed with a 75 to 100 year design service life (depending on the product line), different materials and product designs may have a longer or shorter design life. Products such as cured in place pipe (CIPP) are typically designed for the specific application and design life required.



Repair Location

The type of pipe repair is often influenced by accessibility. Key factors include pipe diameter, burial depth, site conditions, and proximity to access points. Ultimately, the decision should balance the system's performance requirements with the most cost-effective option. Typically, external pipe repairs are the most economical option but can be limited by the accessibility and performance factors previously mentioned.

Internal repairs are typically performed by specialized contractors but can be limited by contractor and equipment capabilities. There are specialized products designed specifically for structural and joint repairs, capable of restoring watertightness and structural integrity to a pipe joint. ADS recommends consulting local contractors to evaluate repair conditions when deciding the feasibility of an internal pipe repair. Full removal and replacement may be required when pipe repairs are not feasible.

Visible Damage

Visible damage to HDPE or PP pipe can occur from a multitude of activities, which can range from the pipe being improperly installed to activities adjacent to the pipe creating instabilities. When damage is noticed, it is important to investigate and determine the cause and if a repair is required. Below are some examples of pipe issues which may been seen during an inspection, what may be the root cause, and recommendations on whether further action needs to be taken:

Imperfection Type:	Potential Causes:	Action Needed?
Missing Section(s)	Directional drilling machine bored into pipe during operations	Industry accepted standard: Damage <15% Pipe Inner Diameter: Split Coupler over damaged area (soil-tight repair) Damage <30% pipe inner diameter: Geotextile wrap & encase in concrete or flowable fill (soil-tight repair) Damage >30% pipe inner diameter: Remove & Replace Section
Circumferential Crack	Differential settlement of the pipe Over-compaction of backfill material	Less than 50% circumference: Continue to monitor, crack is typically isolated to the liner which does not greatly impact structural performance. If crack widens, repair may be necessary for cosmetic/hydraulic purposes. More than 50% circumference: Repair of section is suggested, as this can indicate a weak soil-structure interaction.
Longitudinal Crack	Poor backfill support	Less than 12”: Continue to closely monitor crack, preemptive remediation may be advisable if asset is of high importance. More than 12”: Registered engineer to review and provide guidance for remediation.
Global Buckling	Construction / Live Loading	Section must be repaired to remove/remediate structurally compromised region, typical remove & replace or CIPP (cured in place pipe) liner
Liner Pinching	Over-homing spigot into bell Nylon straps pinching pipe during installation	Monitor as needed, typically no effect to structural capacity of pipe. If imperfection located in flow line, may cause negative consequences to hydraulic performance.
Liner Bubbling	Manufacturing Process	Location of “bubble” may influence typical hydraulic performance of pipe, advisable to remediate if imperfection is located below springline of pipe.
Lateral Connection Damage	Improper installation	Damage at the connection point between the mainline sewer and lateral may require removal and replacement. Contractors should contact the connection manufacturer for review and to determine if there is an in-situ repair option available.

Repair Method Matrix

See below for a chart noting several popular repair method types, the level of post-installation performance they provide, as well as if the method can be used to repair structural imperfections:

Installation Method	Repair Method	Soil-Tight (ST)	Watertight (WT) (Per ASTM D3212*)	Structural Re-pair
EXTERNAL*	Snap/Split Coupler	✓		
	Bell-Bell Coupler		✓	
	PVC Slip Coupling		✓	
	Mastic Coupler		✓ (per manufacturer)	
	Concrete Collar / Encasement	✓	✓ (using waterstop gaskets)	✓
	Flexible Coupler		✓	
INTERNAL**	Joint Seal		✓	
	Chemical Grout / Sealing		✓	
	Extrusion Welding		✓	
	Cured In Place Pipe (CIPP) Liner		✓	✓

** - ASTM D3212 Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals*

*** - Internal repairs may slightly restrict the inside diameter of the pipe. This should be considered when assessing the risk of debris obstruction.*

For additional information regarding pipe repair methods, please review ADS Tech Notes 5.17 and 5.22.

Closing

Thermoplastic materials have been used in both private and public infrastructure for decades with proven long-term performance. However, like all infrastructure, age and service conditions can impact performance and require maintenance to ensure its continued longevity. This manual, together with ADS Technical Notes and supporting guidance, provides the information necessary to maintain the service life of ADS pipe assets.

For unique conditions not addressed in this manual or reference materials, contact the local ADS Regional Engineer or Applications Engineering Department for assistance.

adspipe.com