Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
MICROTUNNELING

Woodbury County
IM-NHS-029-6(257)147--03-97

Effective Date
March 18, 2014

THE STANDARD SPECIFICATIONS, SERIES 2012, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

120148.01 DESCRIPTION.

A. Summary.

1. Installation of casing pipe by use of either a Slurry Pressure Balance System or an Earth Pressure Balance System Microtunneling operation as defined herein.

2. Selection of Microtunneling means and methods subject to review by Engineer.

3. Furnishing labor, equipment, and material required to complete work by Microtunneling including but not limited to; Microtunneling system, end seal placement/backfill grouting between the carrier pipe and casing pipe, spoil transportation and separation, hoisting, lifting, safety, and control equipment.

4. Furnishing labor, equipment, and material for jacking and receiving pit construction, complete in place including, but not limited to:
- **a.** Sediment Controls.
- **b.** Re-handling and disposal of unsuitable materials.
- **c.** Dewatering.
- **d.** Utility adjustments/support.
- **e.** Tests.
- **f.** Excavation sheeting and shoring.
- **g.** Backfilling.
- **h.** Cleanup.
- **i.** Security.
- **j.** Restoration of surface features.
- **k.** Other related work necessary for construction as specified or as shown on Drawings.

B. Definitions.

1. Microtunneling: Installation of casing pipe by jacking pipe behind a remotely controlled, steerable, guided Microtunnel Boring Machine (MTBM) that fully supports the excavated face with either slurry or earth pressure balance at all times.

2. Casing Pipe: Pipe capable of withstanding installation forces due to jacking and other construction or temporary loads in addition to permanent live and dead loads.

3. Jacking and Receiving Pits: Working pits between which casing is installed by means of Microtunneling technique for Microtunnel jacking and equipment retrieval.

4. Drive: Section of casing pipe installed by Microtunneling from Jacking Pit to Receiving Pit.

5. Spoil: Excavated material that has been mixed with either water or slurry and pumped to surface to be separated and recycled or disposed of properly.

6. Tunnel: Microtunneled casing pipe complete in place.

C. References.

1. American Society for Testing and Materials (ASTM).
- A139: Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over).
- A370: Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
- C94: Standard Specification for Ready-Mixed Concrete.
- C150: Standard Specification for Portland Cement.

2. American Welding Society (AWS): D1.1: Structural welding code - steel.

3. American Petroleum Institute (API): 13A: Drilling Fluid Materials.

4. American Waterworks Association (AWWA)
- C200: Steel Water Pipe, 6 In. (150 mm) and Larger
- C203: Coal-tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied.
- C206: Standard for Field Welding of Steel Water Pipe.
- M11: Steel Pipe - A Guide for Design and Installation

120148.02 MATERIALS.

A. Steel Casing Pipe.

1. Leak proof conforming to the requirements of ASTM A139 Grade B. Minimum yield strength of 35,000 psi, equipped with grout holes.
a. Steel casing pipe minimum nominal size: 84 inches in diameter.
b. Steel casing pipe minimum wall thickness: 1.25 inch.

2. Joints: Full penetration field weld in conformance with AWWA C206.

3. Surface Preparation and Shop Coatings: Inside and outside conforming to AWWA C203; factory hot applied coal-tar coating with a nominal thickness of 3/32 inches.

B. Bentonite: API Specification 13A, high swelling montmorillonite, capable of mixing with water to form a stable homogeneous suspension.

C. Portland Cement: ASTM C 150, Type I/II.

D. Water: Potable and complying with ASTM C 94.

E. Fluidifier.

1. A compound possessing such characteristics that it will tend to hold the solid constituents in suspension, and is compatible with the cement and water used in the mix. Use a fluidifier that will not contaminate the groundwater. Acceptable fluidifiers are calcium ligno-sulfonate and sodium ligno-sulfonate, that contain a shrinkage compensator.

2. Furnish in moisture-resistant paper sacks shipped in sealed containers. Handle and store so as to avoid absorption of moisture, damage, or waste. Material which has become caked due to moisture absorption will be rejected.

F. Accelerator: As designed and selected by the Contractor's engineer.

G. Source Quality Control.

1. Manufacturer’s Certifications: Provide certifications of all testing performed by the pipe manufacturer at the manufacturing site documenting compliance with the standard specifications under which the pipe is manufactured. Certifications shall include, but not be limited to, pipe thickness, pipe stiffness, static pressure tests, material composition, and gasket test requirements.

2. Pipe Material Compliance: Engineer may select an Independent Testing Laboratory (ITL) to perform testing and inspection of pipe materials for compliance with the standards under which the pipe is manufactured. Contractor shall coordinate obtaining access for the Engineer and ITL to pipe manufacturing site for tests and inspections. Contractor shall pay cost of any failed tests or re-inspections necessitated by failure of initial tests or inspection, without any reimbursement under the allowance.

120148.03 CONSTRUCTION.

A. Pre-installation Meeting.
Two calendar weeks prior to mobilization, hold a pre-installation meeting regarding the planned tunneling operation.

B. Microtunneling Contractor Qualification Submittals.
Prior to the pre-construction meeting, submit the following:

1. Cover sheet with date, company name, address, telephone and fax numbers, email address, and contact person.

2. Resumes of managerial, supervisory and operational key personnel:
a. Experience: Minimum of three previous Microtunneling projects of similar size and scope.
b. Detailed descriptions of the three Microtunneling projects listed.

3. Summary sheet of contractor company previous projects performed using Microtunneling that demonstrates expertise and experience.
a. Minimum 3 years experience performing Microtunneling of similar size and scope.
b. List three separate projects completed that used either Slurry or Earth Pressure Balance based system.

c. Submit for each named project above, and in same order, following detailed information.
- **1)** Date, full name of project, and location.
- **2)** Contracting Authority's name, address, telephone and fax numbers, email address, and contact person.
- **3)** Client's name, address, telephone and fax numbers, email address, and contact person.
- **4)** Employees in charge of work at both head office and site.
- **5)** Description of relevant work successfully completed, including ground conditions.
- **6)** Features under which pipe passed, depth below the water table, photos, and published articles if available.
- **7)** Additional information as desired.

C. Action Submittals.

1. Product Data:
- **a.** Casing pipe.
- **b.** Casing pipe grout ports.

2. Shop Drawings
- **a.** Details of proposed casing pipe, material, length, and joint design.
- **b.** Casing pipe grout ports.

D. Tunneling Work Plan.

1. Prior to the pre-construction meeting, submit a work plan detailing the procedures and schedule to be used to execute the project.

2. Work plan should be comprehensive, realistic and based on actual working conditions for this particular project, Plan should document the thoughtful planning required to successfully complete the project.

3. The work plan should include, but not be limited to:
- **a.** A description of all equipment to be used.
  - **1)** Supply full details of the Microtunneling System to be employed.
  - **2)** Manufacturer and date(s) of manufacture.
  - **3)** Type and model number for whole system if from single source or separate details for each element of system.
  - **4)** Confirmation from manufacturer that machine set up is suitable to limit annular space, as specified, for external diameter of casing pipe proposed.
  - **5)** System of alignment monitoring and steering control and activation.
  - **6)** Jacking system maximum capacity and method of limiting jacking capacity to that of maximum capacity of specified casing. Include the number and capacities of jacks and anticipated jacking loads for the proposed overcut and with and without delays.
- **b.** Worksite layout drawings that include jacking and receiving pits, and areas for storage, material and spoil handling.
- **c.** A list of personnel and their qualifications and experience (including back-up personnel in the event that an individual is unavailable).
- **d.** A list of sub-contractor(s).
- **e.** A schedule of work activity.
- **f.** Full details of procedures and resources that will be employed to carry out work including method and sequence.
  - **1)** Establishment of drive line of MTBM and elevation at base of shaft.
  - **2)** Casing pipe handling and connections.
  - **3)** Maintaining line and grade, and reestablishment of line and grade as required.
  - **4)** Method of controlling groundwater.
  - **5)** Spoil separation and disposal.

6) Spoil and slurry containment during Microtunneling.
7) Installation of carrier pipe, including placement of grout between carrier pipe and casing pipe, and procedures to prevent floatation during grouting.

g. Design calculations demonstrating that the proposed jacking pipe is capable of supporting the maximum stresses to be imposed during jacking with a factor of safety of at least 2.5. The calculations shall take into account earth and hydrostatic loads, jacking forces, face pressure, external loads such as live loads due to traffic, and any other loads that may be reasonably anticipated during jacking. All loads shall be shown and described. Additionally, provide an estimate of the jacking force expected to complete each drive, accounting for face pressure at cutter head and frictional resistance along the pipe string. Provide hydraulic jack pressures required to develop both the anticipated and maximum possible jacking forces.

h. A safety plan (including MSDS of any potentially hazardous substances to be used).

i. A traffic control plan (if applicable).

j. An environmental protection plan.

k. Surface spill contingency plan.

l. Jacking and receiving pit working drawings and design calculations indicating plan layout, and the arrangement of supports and construction sequence for proposed support system(s) stamped by a Professional Engineer licensed in the State of Iowa. Include, but not be limited to:

1) Jacking and receiving pit configurations.
2) Details for ground support system. Show the elevation of struts or other supports as related to the depth of excavation at intermediate stages of construction. Indicate description, sizes, shapes, and material specifications for all support elements.
3) Special requirements for jacking and receiving pit penetrations, thrust blocks, backstops or other reactions required for Microtunneling, casing pipe jacking or any other jacking. Details of launch and reception portal seal system including all seals, dewatering, ground improvements, probing and other measures taken to prevent excess lost ground and inflows of water and slurry during eye cutting, face exposure for launch and reception.
4) Excavation procedures.
5) Dewatering and ground water control system layout.
6) Backfilling procedures.
7) Calculations shall include estimates of likely deflections or deformations of the support system and maximum tolerable values.
8) Calculations demonstrating that the soils behind the jacking pit thrust block can transfer the anticipated jacking forces exerted by the main jacks to the ground during pipe installation with a factor of safety of at least 2.0, without deflection or displacement.
9) Calculations demonstrating that the thrust block or shaft shoring system can safely transfer the maximum possible forces to the soil.

E. Informational Submittals During Construction.

Submit the following:

- Daily activity log.
- Test results.

F. Closeout Submittals.

Submit Record “As-Built” drawings.

G. Quality Assurance.

1. Supervision: Microtunneling and work associated with microtunneling shall be supervised by at least one person with previous experience with the microtunneling process.

2. Employ operators experienced in microtunneling with prior knowledge and ability in proper operation of systems being used.

3. **Operation.**
   a. Operate systems following manufacturer's instructions.
   b. Make available at all times copies of operations manuals to Engineer and operational personnel on site.

4. Run Test: Test full system on completion of set up and before commencing drive.

5. **Drive Start Up.**
   a. Before commencement of any drive, demonstrate to Engineer that required set up procedures and system checks are complete and required materials are at hand to commence drive.
   b. Do not commence drive until construction of Receiving Pit has been completed.

6. Perform all work in conformance with authorities having jurisdiction.

H. Delivery, Storage, and Handling.

1. Unload and handle materials with equipment of adequate capacity, equipped with slings to protect materials from damage.

2. Store materials on site in reasonably level well-drained area free from brush.

3. Store individual pieces and bundles with safe walking space between to allow full view for inspection purposes.

I. Microtunneling System.

1. **Microtunnel Boring Machine.**
   a. The MTBM shall be remotely controlled. No persons shall be directly in the tunneling shield.
   b. The MTBM is connected to and is followed by the casing pipe.
   c. The tunnel shield shall be a closed full face capable of supporting the soils being excavated at all times including during shutdown. The shield shall have the ability to balance the earth/water pressure encountered at the face, either by the use of compressed air or slurry.
   d. The tunnel shield/cutting head may be driven either electrically or hydraulically. Provide sufficient power and ability in normal operation to cut or crush hard material of sizes up to 1/3 internal diameter of pipe and up to 30,000 psi compressive strength.
   e. The tunnel shield shall be capable of maneuvering and articulation by trunion mounted steering jacks or other approved method to enable accurate control of line and grade. The steering system shall be capable of keeping drift and rotation, or role, to a minimum. Steering jacks and valves are typically controlled by a low pressure power pack located in the shield.
   f. When soil conditions dictate, the tunnel shield must be capable of removing cobbles and boulders. The excavation system shall be fully capable of excavating all material that it will encounter.

2. **Earth Pressure Balance System.**
   a. System that incorporates continuous flight auger enclosed in separate casing inside casing pipe being jacked that has capacity for removal of spoil in balance with excavation and advance.
   b. Positive pressure at the excavated face is maintained by an earth material plug and by regulating the volume of cuttings removed relative to advance rate of MTBM.

c. Soil volume transferred by the auger is controlled by use of pitch spacing and/or an auger gate or throttle.
d. The auger system is designed to remove the excavated soil by auger to the jacking shaft, where it is removed by conventional means. This system controls the stability of the face of the excavation by metering the amount of material that enters the auger.
e. In water bearing sands or under the water table, air is injected at the face of the excavation to help control the amount of material being removed.

3. Slurry Pressure Balance System.
a. System that mixes excavated material with slurry in a chamber located behind cutting head.
b. Low pressure slurry is used to balance ground and water pressure at face of tunnel, limit settlement and convey cuttings back to ground surface. Cuttings are removed or separated and slurry is re-circulated back to MTBM.
c. The Slurry System matches the excavated soil transportation speed to the excavation rate to achieve a minimum velocity to prevent settlement of solids in the slurry lines and to balance the ground water pressure. This is achieved by using variable speed/flow slurry pumps, pressure control valves and minimum of two flow meters, one on feed side and one on return side.
d. A slurry bypass unit is included in the system to allow the direction of flow to be changed or isolated as necessary.
e. The final stage of the slurry system is the separation equipment that removes the soil from the water in tanks. The spoil separation system shall have sufficient capacity to remove solids from the slurry flow while system is excavating spoil.

4. Jacking System.
a. The main jacks are located in the drive shaft and must be able to successfully push the tunneling shield together with a string of connected pipes.
b. The capacity of the jacks and the rate of extension are synchronized with the excavation rate of the shield, which is determined by the particular soil conditions.
c. The jacking system, including any intermediate jacks used, shall be capable of continuously monitoring the jacking pressure, the rate of advancement and the distance jacked.
d. The equipment shall have the capability of limiting the jacking force applied the pipe/tunnel shield so as not to exceed the maximum compressive loads allowed for the pipe.

5. Lubrication System.
a. A lubrication system shall be provided that injects an approved lubricant at the rear of the tunneling shield to lower the friction developed on the exterior of the pipe during jacking.
b. Include means to inject lubricant over lead pipe, if required.
c. The annular space created by the tunnel shield overcut shall be filled with the lubricant that is suitable for the soil type encountered.

6. Control Equipment.
a. Control equipment integrates the system of excavation and removal of soil and its simultaneous replacement by a pipe. As each pipe section is jacked forward, the control system synchronizes all of the operational functions to maintain the system in balance in such a way as to provide complete ground support at all times.
b. Line and grade are controlled by a laser beam transmitted from the drive shaft along the centerline of the pipe to a target mounted in the shield. The position of the laser on the target shall be transmitted back to the operator either electrically or by a closed circuit television.
1) Include the ability to control axial rotation to within 3 degrees of normal operating datum.
2) Include the ability to articulate and steer to correct vertical and horizontal deviation

from alignment datum by remote activation.

c. All functions of the system shall be monitored and transmitted to the remote operations console. The minimum information available to the operator on the console(s) shall include rate of advance, length of conduit installed, thrust force, deviation from line and grade, roll, pitch, steering attitude, inclination and valve positions (either open or closed).

G. Project Conditions.

1. Perform Microtunneling so as not to interfere with, interrupt or endanger surface and activity thereon, and minimize subsidence of surface, structures, and utilities above and near tunnel.

2. Repair and restore damaged property from tunnel operation settlement to its original condition before being disturbed at no cost to Contracting Authority.

3. Review and interpret available geotechnical reports and investigate work site soil conditions before bidding.

4. Follow applicable ordinances, codes, statutes, rules, and regulations of applicable Federal, State and Local authorities.

H. Preparation.

1. Maintain clean working conditions inside jacking operation area and remove spoil, debris, equipment, and other material not required for operations.

2. For construction below railroads, highways and utilities perform installation to prevent interference or disruption with normal operation of these facilities.

3. During construction, maintain access to private and commercial properties at all times, unless approval from both property owner and Engineer has been obtained. Costs associated with providing alternative access will be at no additional cost to Contracting Authority.

4. Provide power generation equipment and other equipment operating on or with fuel or lubrication oils with suitable barriers and safeguards to ensure no loss of oil to drains or waterways or to contaminate ground.

I. Jacking and Receiving Pit Construction.

1. Jacking and receiving pit excavation, support and backfilling shall conform to the Contractor’s Work Plan.

2. Jacking and receiving pits shall be constructed as small as practicable but shall provide sufficient room for the proper installation of both the casing and carrier pipes.

3. When the construction requires operations within a street, the "footprint" of the microtunneling operation, including the construction of the jacking and receiving pits shall be limited and confined to one traffic lane or one-half of the roadway, whichever is less.

4. The contractor shall furnish and install all pump and related equipment to keep the jacking and receiving pits free of water.

5. The design of the shafts shall ensure safe exit from the driving shaft and entry into the receiving shaft of the tunneling shield and provide sufficient backstop capacity to resist forces developed by the thrust jacks.

J. Dewatering System Installation.
Conform to Contractor's Work Plan.

K. Water Control.

1. Keep tunnel and pit subgrades continuously free from standing groundwater and surface waters during operations.

2. Conduct dewatering prior to the start of tunneling to a minimum of 1 foot below tunnel invert or use a tunneling method that prevents groundwater flow into the tunnel.

3. Use consolidation grout stabilization as necessary for groundwater control along and at the tunnel face if required.

4. Design tunneling equipment together with the cuttings removal system to control groundwater from entering the tunnel.

5. Direct discharge from dewatering operations into approved receiving basins in accordance with all applicable regulatory requirements.

L. Settlement and Damage Control.

1. Operate tunneling equipment to minimize lost ground and to comply with specified limits for preventing settlement, movement, cracking, or damage of roadways, roadbeds, tunnels, surface structures, utilities, or adjacent structures. If any movement or settlement occurs or which causes or might cause damage over, along, or adjacent to the work, stop tunneling operations immediately except for those activities which will assist in making the work secure and prevent further movement, settlement, or damage.
   a. Keep settlements within limits specified in Special Provisons for Instrumentation, Monitoring and Settlement Control. Conduct remedial activities if settlements are greater than specified.
   b. Resume tunneling operations only after conditions specified in Special Provisions for Instrumentation, Monitoring and Settlement Control are met.

2. If roadways, roadbeds, tunnel, utilities, or structures are damaged by tunneling operations, repair or replace them as necessary to restore them to a condition equal to that at the beginning of tunneling operations.

M. Tolerances.

1. Maintain alignment and elevation of the carrier pipe or jacked carrier pipe consistently throughout the tunneling operation within the following tolerance limits.
   a. Construct to the dimensions, alignment and grade shown. The maximum permitted deviations shall be such as to permit installation of pipe sewers to the line and grade specified or designated without intermediate high or low points that may trap liquid or air in the pipe after installation.
   b. Elevation: Plus or minus 2 inches from elevation shown on the plans.
   c. Horizontal Alignment: A maximum deviation of 3 feet 4 inches from plan location.
   d. Prevent abrupt deviations from planned horizontal and vertical alignment and in any case not more than 1/2 inch in 10 feet.
   e. Maintain the minimum clearance between the initial support and carrier pipe as shown on the plans.

2. Monitor and record grade and alignment as necessary to ensure that the pipe is or can be installed to the required tolerances. Allow the Engineer access to verify alignment and grade.

N. Tunneling (General).

1. Provide full support and control of the ground during all phases of the work and permit control of alignment and grade of the pipe.

2. Tunnel in a manner to prevent the over excavation of material that would cause raveling of the soil and would develop voids outside the initial support or jacked carrier pipe. Use and operate tunnel equipment features to prevent the amount of voids and ground loosening around the tunnel. Place consolidation grouting as specified in Special Provisions for Tunnel Grouting to prevent voids from occurring at the excavated face that may result in liner overloading or ground surface settlement and to protect overlying utilities.

3. Closely review Special Provision for Baseline Subsurface Conditions Summary for tunneling and boring information and carefully investigate soil conditions at the work site prior to submitting the bid. Select equipment, materials, and methods to cope with the baseline conditions.

4. Design and supervise the execution of the Consolidation, Contact, Compaction, Replacement and Backfill grouting programs as specified in Special Provisions for Tunnel Grouting.

5. Conduct a settlement monitoring program as specified in Special Provisions for Instrumentation, Monitoring and Settlement Control.

6. Do not mine ahead of the front of the casing. Consolidation grout ahead and around boulders if required for excavation ahead of the shield.

7. Control groundwater through initial support of carrier pipe during construction. Methods used control the loss of ground between supports should include grouting and the use of a filter fabric.

O. Microtunneling of Casing Pipe.

1. Overcut: Maximum overcut between the cutting tools and the outside of the tunnel shield, measured on the radius, shall be no greater than 1 inch.

2. If the pipe is not jacked in one continuous operation (delay less than 4 hours), take precautions to prevent the pipe from becoming immovable.

3. Install intermediate boring and jacking stations as required in the event they are needed to overcome jacking forces higher than the main pipe jacks or pipe can withstand.

4. Incorporate a provision for injecting bentonite slurry or other approved lubricant as required to permit even and accurate installation of the pipe.

5. It is not necessary to complete jacking work in one continuous, non-stop, operation. If work is interrupted or stopped prior to completion at the Contractor’s discretion, bear all costs related to the stoppage and restarting operations without additional payment.

6. The microtunneling pipe jacking system shall be designed to ensure that the jacking force is evenly distributed over the pipe section and adequately sustained by a reaction frame or by the back wall of the jacking pit.

7. Cushions shall be installed in joints between successive sections of pipe to provide even transfer of jacking loads.

8. Do not apply thrust greater than the thrust pressure capacity the casing pipe can sustain without damage. Provide a means to monitor jacking pressure.

9. Assemble pipe joints in the jacking pit before pushing. Bevel each end of steel casing pipe sections with a single v-groove. Use full penetration butt welds on the outside of the casing in accordance with the applicable portions of AWWA C206 for field welded steel pipe joints. Butt weld joints of the steel casing prior to the jacking operation. Wire brush and paint the welded joints with coat-tar enamel coating in accordance with AWWA C203. Furnish details and provide for welding the outside bottom of pipe.

10. After the casing pipe has been completely installed, thoroughly clean the pipe interior and remove all excess material leaving a smooth interior throughout.

11. Obtain written permission from the Engineer before disassembling jacking equipment in any reach. The purpose of this is to allow for replacement of damaged or misaligned pipe. Remove by in-place demolition any damaged pipe deemed by the Engineer to be un-repairable and replace it by advancing the pipe string.

12. Conduct all operations such that trucks and other vehicles do not interfere with traffic or create a mud, dust, or noise nuisance in the streets and to adjacent properties. Promptly clean up, remove, and dispose of mud and spoils.

13. All work shall be done so as to minimize disturbance to roadways, adjacent structures, existing tunnel, or existing utilities. Any damage shall be immediately repaired to previous condition at no additional cost to the Contracting Authority

14. Whenever there is a condition that is likely to endanger the stability of the excavation or adjacent structures, operate with a full crew 24 hours a day, including weekends and holidays, without interruption, until those conditions no longer jeopardize stability.

P. Carrier Pipe Installation.
Install carrier pipe inside casing pipe (initial support as specified in Special Provisions for Tunneling with Initial Support.

Q. Contact Grouting.
Complete Contact Grouting in accordance with Special Provisions for Tunnel Grouting.

R. Backfill Grouting.
Backfill grout between casing and carrier pipe as specified in Special Provisions for Tunneling with Initial Support.

S. Field Quality Control.

1. Survey the in-place pipe and furnish results of alignment plots to Engineer. Superimpose these plots on a copy of the design alignment for comparison to verify compliance with alignment tolerances.

2. Contractor shall be allowed to correct errors in grade of a casing pipe in order to achieve design grade of the carrier pipe by pouring an invert in the casing pipe, or by shimming the carrier pipe to a uniform grade, provided adequate clearance remains for proper installation of the carrier pipe.

3. **Record As-Built Drawings.**
   - **a.** Maintain at construction site complete set of field drawings for recording as-built conditions.
   - **b.** Mark or note thereon up to date as-built conditions properly dated.

4. **Daily Activity Log.**
   - **a.** Maintain daily activity log during jacking operations for casing. Submit to Engineer for record purposes on a daily basis.
   - **b.** Start and finish time of casing pipe advancement.
   - **c.** Total length of casing pipe installed.
   - **d.** Horizontal and vertical alignment deviation at not greater than I foot intervals or period not exceeding 5 minutes, whichever is most frequent.
   - **e.** Maximum jacking force exerted during installation of each casing pipe section including forces required to re-initiate jacking following periods of system shutdown.
   - **f.** General description for each discernible ground condition mined.
   - **g.** Settlement monitoring readings.

5. Where Microtunneling system utilizes an electronic data logger, set up so the above information is recorded and can be readily identified. Identify known errors with recorded data and explain in daily log submittal.

T. Site Restoration.

1. Following pipe installation and backfill operations, restore the profile of the site to within 0.5 inch of original profile. Construct sidewalks and fencing, if applicable, to match existing conditions. Install sodding or seeding to match existing conditions, in conformance with requirements of the Specifications and as shown on the Drawings.

2. Design and supervise by the Contractor's engineer the execution of a compaction grouting program to prevent surface settlement, pavement settlement, or structure movement beyond the specified tolerances if found to be necessary and in consultation with the Engineer. Conduct a settlement monitoring program to include monitoring in accordance with Special Provisions for Instrumentation, Monitoring and Settlement Control.

3. Remove all equipment, supplies, excess excavation materials and miscellaneous items associated with the tunneling operation and leave the site in a clean and tidy condition.

4. If required by the owner of the right-of-way, coordinate and schedule a final inspection of the work by the owner of the right-of-way.

5. Promptly replace damaged pavement and structures above the tunnel pipe. Restore pavement around entry and exit pits as soon as work specified in this Special Provision is completed, even if this pavement will later be removed by other work.

120148.04 METHOD OF MEASUREMENT.
Microtunneling: Incidental to bid item Sanitary Sewer Gravity Main with Casing Pipe, Trenchless, Reinforced Concrete Pipe (RCP), 370D (Class V), 54 in.

120148.05 BASIS OF PAYMENT.
Microtunneling: Incidental to bid item Sanitary Sewer Gravity Main with Casing Pipe, Trenchless, Reinforced Concrete Pipe (RCP), 370D (Class V), 54 in. and will not be paid for separately.