

SECTION 33 01 30.13**ACCEPTANCE TESTING FOR SANITARY SEWERS****PART 1: GENERAL****1.01 PERFORMANCE REQUIREMENTS**

- A. Gravity flow sanitary sewers are required to have straight alignment and uniform grade between manholes.
- B. All new sanitary sewers shall be Mandrel Tested. If the Mandrel Test is failed, the pipe shall also be televised in accordance with the requirements outlined in this Specification. All pipe must pass Mandrel Test before final acceptance.
- C. Laser Light Profiling in accordance with the requirements outlined in this Specification is acceptable in lieu of Mandrel Test.
- D. Flexible pipe, including "semi-rigid" pipe, is required to show no more than 5 percent deflection. Test pipe using Standard Mandrel no sooner than 30 days after backfilling and compacting of line segment but prior to final acceptance to verify that installed pipe is within specified deflection tolerances.
- E. Gravity sewer pipelines may be tested using Infiltration or Exfiltration Test method or Low Pressure Air Test.
- F. Maximum allowable leakage for Infiltration or Exfiltration
 - 1. The total exfiltration, as determined by hydrostatic head test, shall not exceed 10 gallons per inch diameter per mile of pipe per 24 hours at minimum test head of 2 feet above crown of pipe at upstream manhole or 2 feet above groundwater elevation, whichever is greater.
 - 2. When pipes are installed more than 2 feet below groundwater level, use infiltration test in lieu of exfiltration test. Total infiltration shall not exceed 10 gallons per inch diameter per mile of pipe per 24 hours. Groundwater elevation must be at least 2 feet above crown of pipe at upstream manhole.
 - 3. Refer to Table 1 at the end of this section, for water test allowable leakage in sewers. Perform leakage testing to verify that leakage criteria are met.
- G. Perform Low Pressure Air Test in accordance with requirements of this Specification and the any State or local environmental agency requirements.
 - 1. Refer to Table 2 at the end of this section, for time allowed for pressure loss from 3.5 psig to 2.5 psig;
 - 2. Refer to Table 3 at the end of this section, for minimum testing times vacuum test; and
 - 3. Refer to Table 4 at the end of this section, for Average ID and minimum Mandrel diameter sizes.

- H. Lines will not be accepted until they pass all required tests.

1.02 SUBMITTALS

- A. Conform to requirements of Section - Submittals.
- B. Test Plan: Test plan shall be submitted to the AW Project Manager for review two weeks prior to testing. Test plan shall include testing procedures, methods, equipment, and tentative schedule. Contractor shall obtain advance written approval for deviations from Drawings and Specifications.
- C. Test Reports: Submit test reports for each test on each segment of sanitary sewer.
- D. Video television records shall be provided on DVD medium.

1.03 GRAVITY SANITARY SEWER QUALITY ASSURANCE

- A. Repair, correct, and retest manholes or sections of pipe which fail to meet specified requirements when tested.
- B. Provide testing reports and/or video of television inspection as directed by AW Project Manager.
- C. Upon completion of testing reports and/or video televising reviews by the AW Project Manager, Contractor will be notified regarding final acceptance of sewer segment.

1.04 SEQUENCING AND SCHEDULING

- A. Contractor shall perform testing as work progresses.
- B. Coordinate testing schedules with the AW Project Manager. Perform testing under observation of the AW Project Manager.

1.05 TELEVISION INSPECTION

Pipe shall be televised in accordance with the following requirements if it fails Mandrel Test or as directed by AW Project Manager.

- A. Quality Assurance: Submit one example video DVD of previous sewer inspection work that shows operational and structural defects in sewers, complete with audio commentary and inspection log(s).
 - 1. Video and inspection logs will be reviewed to determine if quality of CCTV image is acceptable, and if defects were properly identified and documented.
 - 2. Modify equipment and/or inspection procedures to achieve report material of acceptable quality.

3. Do not commence work prior to approval of report by the AW Project Manager.
- B. Inspection Logs: Unless otherwise indicated, submit inspection logs that include the following as a minimum:
1. Project title
 2. Name of American Water
 3. Time of day
 4. System map number
 5. Manhole to manhole pipe section
 6. Pipe segment length
 7. Pipe material
 8. Line size
 9. Compass direction of viewing
 10. Direction of camera's travel
 11. Pipe depth
 12. Operator name
 13. Tape counter reading at beginning and end of each manhole to manhole pipe segment.
- C. Video DVD's: Submit completed video DVD's after sanitary sewer main installation, cleaning and/or rehabilitation.
- D. Maintain copy of all inspection documentation (DVD's, databases, and logs) for duration of Work and warranty period.

PART 2: PRODUCTS

2.01 DEFLECTION MANDREL

- A. Mandrel Sizing. Rigid mandrel shall have OD equal to 95 percent of inside ID of pipe. ID of pipe, for purpose of determining OD of mandrel, shall be average OD minus two minimum wall thicknesses for OD controlled pipe and average ID for ID controlled pipe, dimensions shall be per appropriate standard. Statistical or other "tolerance packages" shall not be considered in mandrel sizing.
- B. Mandrel Design. Rigid mandrel shall be constructed of metal or rigid plastic material that can withstand 200 psi without being deformed. Mandrel shall have nine or more "runners" or "legs" as long as total number of legs is odd number. Barrel section of mandrel shall have length of at least 75 percent of ID of pipe. Rigid mandrel shall not have adjustable or collapsible legs which would allow reduction in mandrel diameter during testing. Provide and use proving ring for modifying each size mandrel.
- C. Proving Ring. Furnish "proving ring" with each mandrel. Fabricate ring of 1/2-inch-thick, 3-inch-wide bar steel to diameter 0.02 inches larger than approved mandrel diameter.
- D. Mandrel Dimensions (5 percent allowance). Average ID and minimum mandrel diameter are specified in Table 4, Pipe vs. Mandrel Diameter, at end of this

Section. Mandrels for higher strength, thicker wall pipe or other pipe not listed in table may be used when approved by AW Project Manager.

2.02 EXFILTRATION TEST

A. Test Equipment:

1. Pipe plugs.
2. Pipe risers where manhole cone is less than 2 feet above highest point in pipe or service lead.

2.03 INFILTRATION TEST

A. Test Equipment:

1. Calibrated 90 degree V-notch weir.
2. Pipe plugs.

2.04 LOW PRESSURE AIR TEST

A. Minimum Requirement for Equipment:

1. Control panel
2. Low-pressure air supply connected to control panel.
3. Pneumatic plugs: Acceptable size for diameter of pipe to be tested; capable of withstanding internal test pressure without leaking or requiring external bracing.
4. Air hoses from control panel to:
 1. Air supply.
 2. Pneumatic plugs.
 3. Sealed line for pressuring.
 4. Sealed line for monitoring internal pressure.

- ### B. Testing Pneumatic Plugs: Place pneumatic plug in each end of length of pipe on ground. Pressurize plugs to 25 psig; then pressurize sealed pipe to 5 psig. Plugs are acceptable when they remain in place against test pressure without external aids.

2.05 GROUND WATER DETERMINATION

- ### A. Equipment: Pipe probe or small diameter casing for ground water elevation determination.

2.06 SMOKE TESTING

A. Equipment:

1. Pneumatic plugs.

2. Smoke generator.
3. Blowers producing 2500 scfm minimum.

2.07 TELEVISION INSPECTION MATERIALS AND EQUIPMENT

- A. DVD: Standard size medium usable in laptop and television DVD players.
 1. Audio portion of composite DVD shall be sufficiently free from electrical interference and background noise to provide complete intelligibility of oral report.
 2. Identify each tape with tape labels showing Project Name, Contractor's name, and each manhole-to-manhole pipe segment of sewer line represented on tape.
- B. Television Inspection Camera(s): Equipped with rotating head, capable of 90-degree rotation from horizontal and 360-degree rotation about its centerline.
 1. Minimum Camera Resolution: 400 vertical lines and 460 horizontal lines.
 2. Camera Lens: Not less than 140 degree viewing angle, with automatic or remote focus and iris controls.
 3. Focal Distance: Adjustable through range of 6 inches (152 mm) to infinity.
 4. Camera(s) shall be intrinsically safe and operative in 100 percent humidity conditions.
 5. Lighting Intensity: Remote-controlled and adjusted to minimize reflective glare.
 6. Lighting and Camera Quality: Provide clear, in-focus picture of entire inside periphery of sewer.
- C. Footage Counter: Measures distance traveled by camera in sewer, accurate to plus or minus 2 feet in 1,000 feet .
- D. Video Titling: Video equipment shall include genlocking capabilities to extent that computer generated data (such as footage, date, and size as determined by SDR), can be overlaid onto video, and be indicated on television monitor and permanently recorded on inspection DVD.

2.08 LASER LIGHT PROFILING

- 2.08.1 Laser profiling assessment shall identify and quantify deformation, physical damage, and other pipe anomalies after installation, providing valuable means and methods for determining the quality of workmanship and compliance with project specifications.

- 2.08.2 Contractors accredited as CCTV operators must demonstrate to AW Project Manager's satisfaction that they have undergone training in the use of the Laser Light profiler and are competent in its use.
- 2.08.3 The laser light profiling practice shall be in accordance with all applicable ASTM Standards (ASTM F3080, ASTM F3095, etc). The Laser Light profiling equipment shall be regularly serviced and certified per ASTM standards.
- 2.08.4 The viewing and analysis of outputs shall be completed to AW Project Managers' satisfaction.

PART 3: EXECUTION

3.01 PREPARATION

- A. Provide labor, equipment, tools, test plugs, risers, air compressor, air hose, pressure meters, pipe probe, calibrated weirs, or any other device necessary for proper testing and inspection.
- B. Determine selection of test methods and pressures for gravity sanitary sewers based on ground water elevation. Determine ground water elevation using equipment and procedures conforming to Control of Ground Water and Surface Water.

3.02 MANDREL TESTING FOR GRAVITY SANITARY SEWERS

- A. Perform deflection testing on flexible and semi-rigid pipe to confirm pipe has no more than 5 percent deflection. Mandrel testing shall conform to ASTM D3034. Perform testing no sooner than 30 days after backfilling of line segment, but prior to final acceptance testing of line segment.
- B. Pull approved mandrel by hand through sewer sections. Replace any section of sewer not passing mandrel. Mandrel testing is not required for stubs.
- C. Retest repaired, replaced, re-excavated, or re-compacted sewer sections.

3.03 LEAKAGE TESTING FOR GRAVITY SANITARY SEWERS

- A. Test Options:
1. Test gravity sanitary sewer pipes for leakage by either exfiltration or infiltration methods, as appropriate, or with low pressure air testing.
 2. Test new or rehabilitated sanitary sewer manholes with water or vacuum test. Manholes tested with low pressure air shall undergo physical inspection prior to testing.
 3. Perform leakage testing after backfilling of line segment, and prior to tie-in of service connections.
 4. If no installed piezometer is within 500 feet of sewer segment, provide temporary piezometer for this purpose.
- B. Compensating for Ground Water Pressure:

1. Where ground water exists, install pipe nipple at same time sewer line is placed. Use $\frac{1}{2}$ -inch capped pipe nipple approximately 10-inches long. Make installation through manhole wall on top of sewer line where line enters manhole.
 2. Immediately before performing line acceptance test, remove cap, clear pipe nipple with air pressure, and connect clear plastic tube to nipple. Support tube vertically and allow water to rise in tube. After water stops rising, measure height in feet of water over invert of pipe. Divide this height by 2.3 ft/psi to determine ground water pressure to be used in line testing.
- C. Exfiltration test:
1. Determine ground water elevation.
 2. Plug sewer in downstream manhole.
 3. Plug incoming pipes in upstream manhole.
 4. Install riser pipe in outgoing pipe of upstream manhole when highest point in service lead (house service) is less than 2 feet below bottom of manhole cone.
 5. Fill sewer pipe and manhole or pipe riser, when used, with water to point 2-1/2 feet above highest point in sewer pipe, house lead, or ground water table, whichever is highest.
 6. Allow water to stabilize for one to two hours. Take water level reading to determine drop of water surface, in inches, over one-hour period, and calculate water loss (1 inch of water in 4 feet diameter manhole equals 8.22 gallons) or measure quantity of water required to keep water at same level. Loss shall not exceed that calculated from allowable leakage according to Table 1.
- D. Infiltration test: Ground water elevation must be not less than 2 feet above highest point of sewer pipe or service lead (house service).
1. Determine ground water elevation.
 2. Plug incoming pipes in upstream manhole.
 3. Insert calibrated 90 degree V-notch weir in pipe on downstream manhole.
 4. Allow water to rise and flow over weir until it stabilizes.
 5. Take five readings of accumulated volume over period of 2 hours and use average for infiltration. Average must not exceed that calculated for 2 hours from allowable leakage according to Table 1.
- E. Low Air Pressure Test: When using this test conform to ASTM C 828, ASTM C 924, or ASTM F1417, as applicable, with holding time not less than that listed in Table 2 below.
1. Air testing for sections of pipe shall be limited to lines less than 27-inch average inside diameter. Larger pipe diameters can be low pressure air tested if the testing protocol is designed by a local P.E and if approved by

AW Project Manager.

2. Lines 27-inch average inside diameter and larger shall be tested at each joint. Minimum time allowable for pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch during joint test shall be 10 seconds, regardless of pipe size.
3. For pipe sections less than 27-inch average inside diameter:
 - a. Determine ground water level.
 - b. Plug both ends of pipe. For concrete pipe, flood pipe and allow 2 hours to saturate concrete. Then drain and plug concrete pipe.
 - c. After manhole-to-manhole section of sanitary sewer main has been sliplined and prior to any service lines being connected to new liner, plug liner at each manhole with pneumatic plugs.
 - d. Pressurize pipe to 4.0 psig. Increase pressure 1.0 psi for each 2.3 feet of ground water over highest point in system. Allow pressure to stabilize for 2 to 4 minutes. Adjust pressure to start at 3.5 psig (plus adjustment for ground water table). See Table 2.
 - e. To determine air loss, measure time interval for pressure to drop to 2.5 psig. Time must exceed that listed in Table 2 for pipe diameter and length. For sliplining, use diameter of carrier pipe.

F. Retest: Repair and retest any section of pipe which fails to meet requirements.

3.04 TEST CRITERIA TABLES

- A. Exfiltration and Infiltration Water Tests: Refer to Table 1 , for water test allowable leakage.
- B. Low Pressure Air Test:
 1. Time in Table 2, allowed for pressure loss from 3.5 psig to 2.5 psig, are based on equation from Texas Commission on Environmental Quality (TCEQ) Design Criteria 217.57(a)(1). If the State where the project is being completed has more stringent times, the local state's requirements will apply.

		$T = 0.0850(D)(K)/(Q)$
where:	T =	Time for pressure to drop 1.0 pounds per square inch gauge in seconds
	K =	0.000419 DL, but not less than 1.0
	D =	Average inside diameter in inches
	L =	Length of line of same pipe size in feet
	Q =	Rate of loss, 0.0015 ft ³ /min./sq.ft. internal surface

2. Since K value of less than 1.0 shall not be used, there are minimum testing times for each pipe diameter as given in Table 2, for minimum testing times for low pressure air test.

Notes:

1. When two sizes of pipe are involved, compute time by ratio of lengths involved.
2. If joint test is used, perform visual inspection of joint immediately after testing.
3. Testing may be terminated if no pressure loss has occurred during the first 25% of the calculated testing time as described in this section.
4. For joint test, pipe is to be pressurized to 3.5 psi greater than pressure exerted by groundwater above pipe. Once pressure has stabilized, time allowable for pressure to drop from 3.5 pounds psi gauge to 2.5 psi gauge shall be a minimum of 10 seconds.

3.05 LEAKAGE TESTING FOR MANHOLES

- A. After completion of manhole construction, wall sealing, or rehabilitation, test manholes for water tightness using hydrostatic or vacuum testing procedures.
- B. Plug influent and effluent lines, including service lines, with suitably-sized pneumatic or mechanical plugs. Ensure plugs are properly rated for pressures required for test; follow manufacturer's safety and installation recommendations. Place plugs minimum of 6 inches outside of manhole walls. Brace inverts to prevent lines from being dislodged when lines entering manhole have not been backfilled.
- C. Vacuum testing:
 1. Install vacuum tester head assembly at top access point of manhole and adjust for proper seal on straight top section of manhole structure. Following manufacturer's instructions and safety precautions, inflate sealing element to recommended maximum inflation pressure; do not over-inflate.
 2. Evacuate manhole with vacuum pump to 10-inches mercury (Hg), disconnect pump, and monitor vacuum for time period specified in Table - 3, Vacuum Test Time Table.
 3. If drop in vacuum exceeds 1- inch Hg over specified time period tabulated in Table - 3, locate leaks, complete repairs necessary to seal manhole and repeat test procedure until satisfactory results are obtained.
- D. Perform hydrostatic exfiltration testing as follows:
 1. Seal wastewater lines coming into manhole with internal pipe plug. Then fill manhole with water and maintain it full for at least one hour.
 2. The maximum leakage for hydrostatic testing shall be 0.025 gallons per foot diameter per foot of manhole depth per hour.
 3. If water loss exceeds amount tabulated above, locate leaks, complete repairs necessary to seal manhole and repeat test procedure until satisfactory results are obtained.

3.06 SMOKE TEST PROCEDURE FOR POINT REPAIRS

- A. Application: Perform smoke test to:
 - 1. Locate points of line failure for point repair.
 - 2. Determine when point repairs are properly made.
 - 3. Determine when service connections have been reconnected to rehabilitated sewer.
 - 4. Check integrity of connections to newly replaced service taps to liners and to existing private service connections.
- B. Limitations: Do not backfill service taps until completion of this test. Test only those taps in single manhole section at one time. Keep number of open excavations to minimum.
- C. Preparation: Prior to smoke testing, give written notices to area residents no fewer than 2 days, nor more than 7 days, prior to proposed testing. Also give notice to local police and fire departments 24 hours prior to actual smoke testing.
- D. Isolate Section: Isolate manhole section to be tested from adjacent manhole sections to keep smoke localized. Temporarily seal annular space at manhole for sliplined sections.
- E. Smoke Introduction:
 - 1. Operate equipment according to manufacturer's recommendation and as approved by AW Project Manager.
 - 2. Conduct test by forcing smoke from smoke generators through sanitary sewer main and service connections. Operate smoke generators for minimum of 5 minutes.
 - 3. Introduce smoke into upstream and downstream manhole as appropriate. Monitor tap/connection for smoke leaks. Note sources of leaks.
- F. Repair and Retest: Repair and replace taps or connections noted as leaking and then retest. Taps and connections may be left exposed in only one manhole section at time. When repair or replacement, testing or retesting, and backfilling of excavation is not completed within one work day, properly barricade and cover each excavation as approved by AW Project Manager.
- G. Service Connections: On houses where smoke does not issue from plumbing vent stacks to confirm reconnection of sewer service to newly installed liner pipe, perform dye test to confirm reconnection. Introduce dye into service line through plumbing fixture inside structure or sewer cleanout immediately outside structure and flush with water. Observe flow at service reconnection or downstream manhole. Detection of dye confirms reconnection.

3.07 TELEVISION INSPECTION PROCEDURES

A. SEWER FLOW REQUIREMENTS

- 1. Do not exceed depth of flow shown in Table below for respective pipe sizes as measured in manhole when performing TV inspection.

2. When depth of flow at upstream manhole of sewer line section being worked is above maximum allowable for TV inspection, reduce flow to level shown in table below, by plugging or blocking of flow, or by pumping and bypassing of flow as specified.

Maximum Depth of Flow for TV Inspection

Nominal Pipe Diameter	Maximum Depth of Flow
6" - 10"	20 percent of pipe diameter
12" - 24"	25 percent of pipe diameter

B. SEQUENCE OF WORK

Perform Work in the following sequence:

1. Clean sewer lines and manholes in accordance with requirements of Specifications".
2. Perform TV inspection to comply with requirements of this specification.

C. INSPECTION REQUIREMENTS

1. Access: AW shall have access to observe monitor and other operations at all times.
2. DVD Commentary: Record the following information on audio track of DVD inspection tape: narrative of location, direction of view, manhole numbers, pipe diameter and material, date, time of inspection, and location of laterals and other key features
 - a. DVD shall visually display this information at beginning and end of each manhole-to-manhole pipe segment.
 - b. DVD between manholes shall visually display length in feet from starting point of given segment.
3. Sewer Identification: DVD and inspection documentation shall include sewer line and manhole identifiers shown on Drawings. After installation of liner, use upstream manhole as identifier in conjunction with distance meter.
4. Image Perspective: Camera image shall be down center axis of pipe when camera is in motion.
 - a. Provide 360-degree sweep of pipe interior at points of interest, to more fully document existing condition of sewer.
 - b. Points of interest may include, but are not limited to the following: defects, encrustations, mineral deposits, debris, sediment, and any

location determined not to be clean or part of proper liner installation, and defects in liner that include, but are not limited to bumps, folds, tears, and dimples.

- c. Cabling system employed to transport camera and transmit its signal shall not obstruct camera's view.
- 5. Sewer Reach Length: Physically measure and record length of each sewer reach from centerline of its terminal manholes.
- 6. Inspection Rate: Camera shall be pulled through sewer in either direction, but both inspections are to be in same direction. Maximum rate of travel shall be 30 feet (9 m) per minute when recording.

D. FIELD QUALITY CONTROL

- 1. AW will review DVD's and logs to ensure lines are clean and free of visible defects.
- 2. If sewer line, in sole opinion of AW, is not adequately clean, and free of visual defects it shall be re-cleaned and CCTV-inspected by Contractor at no additional cost.

TABLE 1
WATER TEST ALLOWABLE LEAKAGE

DIAMETER OF RISER OR STACK IN INCHES	VOLUME PER INCH OF DEPTH		ALLOWANCE LEAKAGE*	
	INCH	GALLONS	PIPE SIZE IN INCHES	GALLONS/MINUTE PER 100FT.
1	0.7854	.0034	6	0.0039
2	3.1416	.0136	8	0.0053
2.5	4.9087	.0212	13	0.0066
3	7.0686	.0306	12	0.0079
4	12.5664	.0306	15	0.0099
5	19.6350	.0544	18	0.0118
6	28.2743	.1224	21	0.0138
8	50.2655	.2176	24	0.0158
			27	0.0177
			30	0.0197
			36	0.0237
			42	0.0276
For other diameters, multiply square of diameters by value of 1" diameter			Equivalent to 50 gallons per inch of inside diameter per mile per 24 hours	

* Allowable leakage rate shall be reduced to 10 gallons per inch of inside diameter per mile per

24 hours, when sewer is identified as located within 25-year flood plain

TABLE 2
ACCEPTANCE TESTING FOR SANITARY SEWERS
LOW PRESSURE AIR TEST
TIME ALLOWED FOR PRESSURE LOSS FROM 3.5 PSIG TO 2.5 PSIG

Pipe (In)	Specification Time for Lengths Below (Min:Sec)											Time for Longer Length (Sec)
	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft	500 ft	550 ft	600 ft	
6	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:25	7:07	7:50	8:33	0.854 x L (ft)
8	7:33	7:33	7:33	7:33	7:36	8:52	10:08	11:24	12:40	13:56	15:12	1.519 x L (ft)
10	9:27	9:27	9:27	9:54	11:52	13:51	15:50	17:48	19:47	21:46	23:45	2.374 x L (ft)
2	11:20	11:20	11:20	14:15	17:06	19:57	22:48	25:39	28:30	31:20	34:11	3.419 x L (ft)
15	14:10	14:10	17:48	22:16	26:43	31:10	35:37	40:04	44:31	48:58	53:25	5.342 x L (ft)
18	17:00	19:14	25:39	32:03	38:28	44:52	51:17	57:42	64:06	70:31	76:56	7.692 x L (ft)
21	19:50	26:11	34:54	43:38	52:21	61:05	69:48	78:32	87:15	95:59	104:42	10.47 x L (ft)
24	22:48	34:11	45:35	56:59	68:23	79:47	91:10	102:34	113:58	125:22	136:46	13.67 x L (ft)
27	28:51	43:16	57:42	72:07	86:33	100:58	115:24	129:49	144:14	158:40	173:05	17.3 x L (ft)
30	35:37	53:25	71:14	89:02	106:51	124:39	142:28	160:16	178:05	195:53	213:41	21.36 x L (ft)
33	43:06	64:38	86:11	107:44	129:17	150:50	172:23	193:55	215:28	237:01	258:34	25.85 x L (ft)

TABLE 3
MINIMUM TESTING TIMES FOR SANITARY MANHOLES –
VACCUM TEST TIME TABLE

DEPTH IN FEET	TIME IN SECONDS BY PIPE DIAMETER		
	48"	60"	72"
4	10	13	16
8	20	26	32
12	30	39	48
16	40	52	64
20	50	65	80
24	60	78	96
*	5.0	6.5	8.0
*Add T times for each additional 2-foot depth.			

TABLE 4
PIPE VS. MANDREL DIAMETER

Material and Wall Construction	Nominal Size (Inches)	Average I.D (Inches)	Minimum Mandrel Diameter (Inches)
PVC-Solid (SDR 26)6	6	5.764	5.476
	8	7.715	7.329
	10	9.646	9.162
PVC-Solid (SDR 35)12	12	11.737	11.150
	15	14.374	13.655
	18	17.629	16.748
	21	20.783	19.744
	24	23.381	22.120
	27	26.351	25.033
PVC-Truss	8	7.750	7.363
	10	9.750	9.263
	12	11.790	11.201
	15	14.770	14.032
PVC-Profile (ASTM F794)	12	11.740	11.153
	15	14.370	13.652
	18	17.650	16.768
	21	20.750	19.713
	24	23.500	22.325
	27	26.500	25.175
	30	29.500	28.025
	36	35.500	33.725
	48	47.500	45.125
HDPE-Profile	18	18.000	17.100
	21	21.000	19.950
	24	24.000	22.800
	27	27.000	25.650
	30	30.000	28.500
	36	36.000	34.200
	42	42.000	39.900
	48	48.000	45.600
	60	60.000	57.000
Fiberglass (Class SN 46)	12	12.85	11.822
	18	18.66	17.727
	20	20.68	19.646
	24	24.72	23.484
	30	30.68	29.146
	36	36.74	34.903
	42	42.70	40.565
	48	48.76	46.322
	60	60.38	57.361

END OF SECTION 33 01 30.13