SECTION 01110
TESTING AND QUALITY CONTROL

PART 1 GENERAL

1.01 – Section Includes
A. Testing and Quality Control

1.02 – Description of Work
A. Testing and Quality Control – This item includes the furnishing of material samples and testing of the Work as set forth in the Contract Documents. This includes, but is not limited to, samples and testing pertaining to pipe bedding, trench backfill, pipe leakage, turbidity and bacteriological tests, pipe deflection, pipe liners, asphalt density, asphalt mix composition, concrete strength, and pavement base compaction.

1.03 – Special Requirements
A. Testing performed by the Contractor or by the Engineer indicating acceptable results does not relieve the Contractor of the responsibility to construct the Work in accordance with the Contract Documents or responsibility to correct any defects that are present.
B. The test results submitted by the Contractor must meet the minimum requirements as established by the Contract Documents. If test results do not indicate compliance with the Contract Documents, additional tests in the area following the Contractor's re-work will be provided to the Engineer at the Contractor's expense.
C. The Contractor shall give the Engineer 24 hours notice prior to performing assurance testing.

PART 2 PRODUCTS

2.01 – Water Main
A. Disinfection Agent – Chlorine
   1. Meet requirements for
      a. Calcium Hypochlorite Granules, per ANSI/AWWA B300, approximately 65 percent available chlorine by weight.
      b. Liquid Chlorine, per ANSI/AWWA B301, 100 percent available chlorine.
      c. Sodium Hypochlorite Solution, approximately 5 to 15 percent available chlorine by weight.
   2. Chlorine containers must have AWWA stamp.

2.02 – Low Pressure Air Exfiltration Tests
A. Equipment used shall meet the following minimum requirements:
   1. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be inspected.
   2. Pneumatic plugs shall resist internal test pressure without requiring external bracing or blocking.
   3. All air used shall pass through a single control panel.
   4. Three individual hoses shall be used for the following connections:
      a. From control panel to pneumatic plugs for inflation.
      b. From control panel to sealed line for introducing the low pressure air.
      c. From sealed line to control panel for continually monitoring the air pressure rise in the sealed line.
   5. Gauges for registering air pressure shall be clearly graduated in one-half pound increments.

2.03 – Sanitary and Storm Sewer Deflection Tests
A. Mandrel for deflection test shall be a 9-arm device, stamped for the appropriate ASTM Specification, size of pipe, and maximum allowable deflection from ASTM average inside diameter.
B. "Pin-type" sled device as manufactured by Quality Test Products, 4400 Wildwood Drive, Crystal Lake, IL 60014.
C. Electronic deflectometer.

PART 3 EXECUTION

3.01 – Testing and Quality Control – General

A. The Contractor shall be responsible to perform quality assurance testing in accordance with the Contract Documents. The intent of the testing is to provide an indication of the effectiveness of the means and methods being employed by the Contractor.

B. Samples shall be tested in a State Certified Laboratory.

C. For water main extensions or service lines 3-inch in diameter or larger that are connected to the City of Cedar Rapids Water Distribution System all valves shall be operated by Water Division personnel. All flushing and filling operations shall be managed and overseen by City of Cedar Rapids Distribution System inspectors and all samples shall be taken by City of Cedar Rapids Distribution System inspectors.

3.02 – Geotechnical Testing

A. A licensed civil Engineer with geotechnical experience shall certify the sampling and testing methods meet the requirements of the Contract Documents.

B. The following assurance testing shall be required as a minimum:
   1. Trench backfill shall be tested for compaction. A minimum of three tests at varying depths shall be provided every 400 feet.
   2. For moisture and density control of subgrade under paved areas, a minimum of one test every 100 feet per lane shall be provided.

C. The Engineer may select the locations for the test.

D. The Engineer may conduct assurance testing. The Contractor shall provide access and materials as may be required by the Engineer to conduct the desired testing.

E. The Contractor may choose to perform additional quality assurance testing over and above testing required by the Contract Documents. The Contractor shall submit proctor data and compaction tests for all testing performed. The results shall include horizontal and vertical location of the test, depth of the test, type of material tested, and corresponding proctor information, in-place density, moisture content, dry density and percent compaction.

F. The testing technician shall provide to the Engineer preliminary test results prior to leaving the Site. A copy of the signed field report shall be submitted to the Engineer within 48 hours of the test.

G. A certified written record of testing results shall be submitted to the Engineer prior to placement of pavement.

H. Compaction testing shall be in accordance with ASTM D698 unless noted otherwise in the Contract Documents.

3.03 – Subgrade Preparation Testing

A. In addition to the proof roll testing of this paragraph, the Contractor shall perform tests required by paragraph 3.02.

B. Following the completion of subgrade preparation and prior to the placement of granular subbase, the Contractor shall provide a loaded tandem dump truck, with a gross weight of 20 tons, for use in proof rolling the subgrade. The Contractor shall proof roll the subgrade area as directed by the Engineer. The subgrade shall be free of excessive rutting, pumping and unstable areas.

C. Any defective areas found during the proof rolling operation, as determined by the Engineer, shall be corrected as set forth in subgrade stabilization.

3.04 – Water Main Testing

A. Tests shall be performed by the Contractor.

B. Scheduling
   1. Notify Engineer one working day in advance of testing or disinfection operations to coordinate the operations.
   2. Engineer or designated representative must be in attendance during testing or disinfection.

C. Regulatory Requirements: Comply with requirements of Iowa Environmental Protection Commission (IAC 567, Chapters 40 thru 43) and 'Recommended Standards for Water Works (Ten States).

Sequence of Operation

1. Perform operations in the following sequence:
   a. Remove any debris from within pipe. Clean and swab out pipe if required.
   b. Secure any unrestrained pipe ends against uncontrolled movement.
   c. Fill the main and add chlorine.
   d. Wait 24 hours to check the chlorine content. Must be over 25 mg/L.
   e. Dispose of highly chlorinated water.
   f. Wait 24 hours for bacteriological testing and turbidity testing.
   g. Perform pressure and leak testing.
   h. Make taps after passing all tests.
2. Successfully complete each operation before commencing to the next operation.
3. Jurisdiction will provide reasonable quantities of water for flushing and testing.

E. Method of Chlorination

1. Chlorination will be accomplished in accordance with AWWA C651. The preferred method from that standard is the method utilizing calcium hypochlorite (HTH) granules placed in the water main as it is being installed and then filling the main with potable water when installation is complete.
2. To utilize this method, pipes and appurtenances must be kept clean and dry during construction.
3. During construction, HTH shall be placed at the upstream end of the first section of pipe, at the upstream end of the first pipe of each branch main and at approximately 60-foot intervals in all new pipe as they are laid. Quantities of HTH granules used shall be as shown in Table 1 for various pipe sizes.

Table 1. Ounces of Calcium Hypochlorite Granules to Be Placed at Beginning of Main, Beginning of Each Branch, and at Each 60-Foot Interval of Pipe.

Pipe Diameter (inches)	6	8	10	12	16	20	24	30	36	42	48
HTH Granules (oz)	1	1.5	2.5	3.5	6	9	13	21	29	44	56

4. The quantities of calcium hypochlorite granules listed in Table 1 will result in initial chlorine concentrations of 45-55 mg/L.

F. Filling and Initial Flushing

1. When installation is completed, the main shall be slowly filled by opening the inlet valve just enough turns to start the water running. Air release valves and fire hydrants shall be opened to release air pockets at the high points of the line. Check all interconnecting valves to the existing system to be sure they are completely closed. Contractor personnel are permitted to operate valves and hydrants internal to the new main only. Valves which separate the existing City distribution system from the new main are to be operated only by the Jurisdictional Water Department.
2. The chlorinated water shall remain in the pipe for at least 24 hours, during which time all valves and hydrants in the section treated shall be operated in order to disinfect the appurtenances. At the end of this 24-hour period, the disinfecting solution shall have a residual of not less than 25 mg/L as free chlorine.
3. After the completion of the 24-hour period, the heavily chlorinated water shall be flushed from the main until the chlorine concentration is less than 4 mg/L. A chlorine residual determination shall be made to ascertain that the chlorine concentration of the water in the new main is compatible with that in the City distribution system.
4. The Contractor shall furnish and install all hoses, equipment, and appurtenances necessary to direct the flushing water to the proper discharge point.
5. Highly chlorinated water shall be discharged to sanitary sewers. If sanitary sewers are not available in the area, the highly chlorinated water shall be trucked to a sanitary sewer, or neutralized by treating with one of the chemicals listed in Appendix B of AWWA C651. The rate of discharge to sanitary sewers shall be controlled to prevent surcharging the

sewer. The Jurisdictional Sewer Department shall be contacted a minimum of 48 hours prior to discharge into the sanitary sewer.

G. Final Flushing
1. Once the chlorine content of the flushing water has declined to less than 4 mg/L as determined by the Jurisdictional Water Department, the water shall be directed to natural waterways or storm sewer intakes. The Contractor is responsible to direct the flushing water away from the Site in a safe and non-destructive manner. The Contractor shall continue flushing to remove debris and sediment from the new main until preliminary grab samples indicate turbidity has been reduced sufficiently to warrant taking samples for laboratory testing. In addition to the end of the new main, hydrants at intermediate points along the main and all blowoffs on branches shall be opened and flushed.
2. Where the water system consists of looped water mains, the Contractor shall develop a Plan, subject to prior approval of the Jurisdictional Engineer, for closing valves and flushing the loop to insure that all parts of the loop are flushed completely.
3. The flushing velocity for mains 16 inches in diameter and smaller shall be 2.5 feet per second. For larger mains, flow shall be as required by the Jurisdictional Engineer. The rate of flow required to produce a velocity of 2.5 fps is shown in Table 2 along with required openings at 40-psi residual pressure to produce this flow.

Table 2. Required Openings to Flush Pipelines (40-psi residual pressure)

Pipe Size (inches)	Flow Required for 2.5 fps Velocity (gpm)	Orifice Size (inches)	Number	Hydrant Nozzle Size (inches)
4	100	1-5/16	1	2-1/2
6	220	1-3/8	1	2-1/2
8	390	1-7/8	1	2-1/2
10	610	2-5/16	1	2-1/2
12	880	2-13/16	1	2-1/2
16	1,565	3-5/8	2	2-1/2

4. With 40-psi residual pressure, one 2-1/2-inch hydrant nozzle will discharge approximately 1,000 gpm. A 4-1/2-inch hydrant nozzle will discharge approximately 2,500 gpm.

H. Sampling Procedure
1. Once preliminary samples indicate turbidity has been reduced sufficiently to warrant laboratory testing, samples shall be collected from blowoffs and hydrants at the end of the main, and at intermediate branches and hydrants. In the case of looped mains, valves shall be operated to insure samples are drawn from all parts of the new main. Samples shall be collected by Jurisdictional Water Department personnel in sterile bottles treated with sodium thiosulfate as required by Standard Methods **and in accordance with AWWA C651.** No hose shall be used in the collection of samples.

I. Special Conditions
1. If, during construction, trench water has entered the main, or if in the opinion of the Engineer, excessive quantities of dirt or debris have entered the main, bacteriological samples shall be taken at intervals of approximately 200 feet and shall be identified as to location. Samples shall be taken of water that has stood in the main for at least 16 hours after final flushing has been completed.

J. Turbidity and Bacteriological Testing
1. Samples shall be tested by the Department for turbidity and bacteriological quality in accordance with Standard Methods procedures. Turbidity shall be 1.0 ftu or less, and bacteriological tests shall show the absence of coliform organisms. A standard plate count may be required at the option of the Jurisdictional Engineer.
2. If satisfactory turbidity and bacteriological test results are obtained from the initial disinfection process, no further disinfection is required and the Contractor may proceed with pressure testing of the main.
3. If the test results are not satisfactory, further flushing and testing of the main is required.

K. Redisinfection
1. If the initial disinfection fails to produce satisfactory bacteriological samples, the main shall be reflushed and resampled. If check samples show the presence of coliform

organisms, then the main shall be rechlorinated by the continuous feed or slug method of chlorination until satisfactory results are obtained.

L. Pressure and Leak Testing
   1. Isolate new piping from the existing water system.
   2. Fill and flush all new piping with potable water. Ensure that all trapped air is removed.
   3. Pressurize the new pipe to the test pressure at the highest point in the isolated system. Do not pressurize to more than 5 psi over the test pressure at the highest point in the isolated system.
   4. Test the completed piping system at 1-1/2 times the system working pressure or 150 psi, whichever is greater, for two hours.
   5. Monitor the pressure in the line for a period of not less than two hours.
   6. If at any time during the test the pressure drops to five psi below the test pressure, repressurize the pipe by pumping in potable water in sufficient quantity to bring the pressure back to the original test pressure.
   7. Accurately measure the amount of water required to repressurize the system to the test pressure.

Table 3. Maximum Allowable Leakage Rate – 150 PSI Test

Pipe Diameter (inches)	4	6	8	10	12	14	16	18	20	24	30	36
Maximum Allowable Leakage Rate (gal/hr per 1,000 ft of pipe	**0.33**	**0.50**	**0.66**	**0.83**	**0.99**	**1.16**	**1.32**	**1.49**	**1.66**	**1.99**	**2.48**	**2.98**

NOTE: For unusual conditions or for waterlines shorter than 500 feet, consult Jurisdictional Engineer for allowable leakage rate. The following formula shall apply:

$$L = \frac{(S)\,(D)\,(P)^{1/2}}{148{,}000}$$

Where:
L = leakage, allowable, in gallons
S = length of pipe test section, in feet
D = pipe diameter, in inches
P = average test pressure, psig

   8. If the average measured leakage per hour exceeds the maximum allowable leakage rate, repair and retest the water line.
   9. Repair all visible leaks regardless of the amount of leakage.

M. Continuous Feed Method of Chlorination
   1. Prepare a chlorine-water solution by dissolving granules of calcium hypochlorite in water in the proportion required for desired concentration. A one percent chlorine solution requires approximately one pound of calcium hypochlorite in eight gallons of water.
   2. The chlorine solution shall be applied to the water main with a pump suitable for pumping chlorine solutions and the head conditions at the point of application. The point of application shall be through a tap in the new main within 10 feet downstream of the valve to be used for turning water into the new pipe. Water from the existing distribution system shall be turned into the new pipe at a constant measured rate. The rate may be measured with a hydrant meter mounted on the discharge outlet. The chlorine solution shall be fed at a rate to produce a chlorine concentration in the pipe of at least 25 mg/L free chlorine. Table 4 shows the minimum rate of chlorine solution to feed to obtain a 25 mg/L chlorine residual at various water flow rates. Feed rates may need to be adjusted upward to compensate for ammonia content of the water.

Table 4. Minimum Feed Rates for One Percent Chlorine Solutions to Obtain 25 mg/L Chlorine Concentration	
Water Flow Rate in Water Main (gpm)	1.0% Chlorine Solution Feed Rate (gpm)
100	0.25
200	0.50
300	0.75
400 (max. for meter)	1.00

3. During application of the chlorine, valves shall be positioned to prevent the strong chlorine solution from contacting water in the existing distribution system. Chlorine application shall not cease until the main is completely filled with the chlorine solution. The chlorine solution shall remain in the main for at least 24 hours, during which period all valves and hydrants in the section being treated shall be operated in order to disinfect the appurtenances. At the end of this 24-hour period, the treated water in all parts of the main shall have a residual of not less than 10 mg/L free chlorine.
4. After the applicable retention period, the heavily chlorinated water shall be flushed from the main as specified above.

N. Disinfection Procedures When Cutting Into or Repairing Existing Mains
1. The following procedures apply primarily when mains are wholly or partially dewatered. After the appropriate procedures have been completed, the main may be returned to service prior to completion of bacteriological testing in order to minimize the time customers are out of water.
2. Leaks or breaks repaired with clamping devices while the mains remain full of water under pressure present little danger of contamination and require no disinfection.
   a. Trench Treatment
      i. When an old main is opened, either by accident or design, the excavation will likely be wet and may be badly contaminated from nearby sewers. Liberal quantities of hypochlorite applied to open trench areas will lessen the danger from such pollution. Tablets have the advantage in such a situation because they dissolve slowly and continue to release hypochlorite as water is pumped from the excavation.
   b. Swabbing with Hypochlorite Solution
      i. The interior of all pipe and fittings used in making the repair (particularly couplings and sleeves) shall be swabbed or sprayed with a one percent hypochlorite solution before they are installed.
   c. Flushing
      i. Thorough flushing is the most practical means of removing contamination introduced during repairs. If valve and hydrant locations permit, flushing toward the Work location from both directions is recommended. Flushing shall be started as soon as the repairs are completed and shall be continued until discolored water is eliminated.

O. Putting Water Main in Service
1. Obtain Jurisdictional Engineer's approval to put the completed water system in service.

3.05 – Sanitary Sewer Tests

A. Tests shall be performed by the Contractor and at the Contractor's expense. Tests will be required for all sections between manholes, including services within the public right-of-way. Sanitary sewer services shall be in place prior to air tests. The Contractor shall furnish water and air for the tests. The Engineer shall determine the test method.

B. If, in the opinion of the Engineer, damage or excess infiltration exists in a new section of sewer, the Engineer may require the Contractor to televise all sewer sections being installed under the Contract. If damage or excess infiltration is found, televising shall be at Contractor's expense. If damage or excess infiltration is not found, televising shall be at Owner's expense.

C. The sanitary sewer pipe, joints, and manholes shall be watertight to the extent that infiltration and exfiltration shall not exceed 100 gallons per mile of pipe per 24 hours per inch of pipe diameter during the maintenance period covered by this Contract. Where infiltration tests are not practical because of low groundwater conditions, as determined by the Engineer, the Contractor shall perform exfiltration tests. The allowable leakage is based on an average head of water, in the upstream manhole of the section of line being tested, two feet above the crown of the pipe.

D. The Engineer shall decide whether the Contractor shall use the infiltration, exfiltration, or air test on any length of sewer. If one test is not satisfactory, an additional test may be ordered. The Contractor shall be aware that all new sanitary sewer construction will be tested, and that such Work shall be considered incidental to the new sewer pipe.

E. For repair or replacement Projects, televised inspection may be allowed in lieu of infiltration, exfiltration, or air test, subject to Engineer's approval. Video camera shall be a pan-and-tilt 3-lux color camera.

F. Water Testing for Exfiltration

1. Exfiltration tests shall be performed as soon as the section of sewer together with its laterals connected thereto have been constructed between manholes, and the manholes have been completed. A suitable plug manufactured for that purpose shall be inserted in the lower manhole and the section filled with water to a head of 10 feet measured from the mid-diameter of the pipe.
2. The exfiltration test shall be conducted by the use of a standpipe assembly or a manhole.
3. If a standpipe assembly is used, a tapped plug is inserted and tightened in the inlet pipe of the downstream manhole to which the water supply connection is made for filling the pipe. The upper manhole is plugged and securely tightened for connection to the standpipe. The standpipe must be of sufficient length to handle 10 feet of water head. Water is then supplied into the line at the downstream manhole until the standpipe in the upstream manhole has been completely filled. By filling the line from the lower level, the air in the line is easily pushed ahead and finally dispelled through the standpipe at the upper end of the test section. The rate of drop in the standpipe may be quite rapid until all the air has been expelled. After the line is filled, it should be allowed to stand for five minutes, thus allowing the system to stabilize. After the stabilization period check the level in the standpipe and add water if necessary. At the time the water level is brought to the required head (10 ft) the test should begin. The drop in the standpipe is to be measured and recorded over a 15-minute period. This result should be verified by a second 15-minute test following the same procedure. The measured drop in the standpipe can then be converted to leakage rates in terms of gallons per inch diameter per mile per day.

   The chart below gives conversions for various sizes of pipe or manhole to equivalent capacity of gallons per inch drop.

Standpipe or Manhole Diameter (inches)	3	4	6	8	42	48
Gallons per Inch Drop in Sandpipe	0.031	0.54	0.122	0.218	6.00	7.83
NOTE: Use figures for 42-inch pipe for a 48-inch manhole and tapered top section.						

   The actual rate of exfiltration can then be determined by the following procedure:

   a. (A) Measured Drop x (B) Equivalent gal/inch drop = (C) gals/15 min
   b. (C) x 4 x 24 = (D) gals/day
   c. $\dfrac{\text{(D) x 5280 ft/mile}}{\text{(G) Pipe Diameter}} = \dfrac{\text{(F) gals/mile/day}}{\text{(H) gals/inch diameter/mile/day}}$

4. If a manhole is to be used to conduct the test, the test procedure is exactly the same as for a standpipe; however, the test period should last at least 30 minutes. In determining the rate of exfiltration for manholes, adjust the "4" in line b. above as required to obtain gals/day (i.e., use 2 for a 30-minute test).

   Caution shall be exercised during the performance of exfiltration tests on sewer lines on steep grades. On exfiltration testing the maximum internal pressure should not exceed

25 ft of head or 10.84 psi. The water level, in such cases, will have to be adjusted in the standpipe.

5. Should any test on any section of pipeline disclose an exfiltration rate greater than 100 gallons per inch of pipe diameter per mile per day, the Contractor shall, at his own expense, locate and repair defective joints or pipes until the exfiltration is within specified allowances.

G. Low Pressure Air Exfiltration Tests

1. The sewer mains and/or laterals shall be tested for leakage by the use of low pressure air as specified hereinafter. Each section between manholes will be tested separately as the construction progresses, before trench surface restoration, and preferably with not more than four manhole runs constructed ahead of testing. Air testing of the sewer mains and/or laterals shall be allowed in lieu of water testing.
2. All pneumatic plugs shall be seal tested before being used in the actual test installation. One length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to 25 psig. The sealed pipe shall be pressurized to 5.0 psig. The plugs must hold against this pressure without having to be braced.
3. After a reach of pipe has been backfilled and cleaned, and the pneumatic plugs are checked by the above procedure, the plugs shall be placed in the line at each manhole and inflated to 25 psig. Low pressure air shall be introduced into this sealed line until the internal air pressure reaches 4.0 psig greater than the average back pressure of any groundwater that may be over the pipe. At least two minutes shall be allowed for the air pressure to stabilize.
4. After the stabilization period (3.5 psig minimum pressure in the pipe), the air hose from the control panel to the air supply shall be disconnected. The portion of line being tested shall be termed “Acceptable” if the time required in minutes for the pressure to decrease from 3.5 to 2.5 psig (greater than the average back pressure of any groundwater that may be over the pipe) shall not be less than the time shown for the given diameters in Table 5.
5. In areas where groundwater is known to exist, the Contractor shall install a ½-inch diameter capped pipe nipple, approximately 10 inches long, through the manhole wall on top of one of the sewer lines entering the manhole. This shall be done at the time the sewer line is installed. Immediately prior to the performance of the line acceptance test, the ground water shall be determined by removing the pipe cap, blowing air through the pipe nipple into the ground so as to clear it, and then connecting a clear plastic tube to the nipple. The plastic tube shall be held vertically and a measurement of the height in feet of water over the invert of the pipe shall be taken after the water has stopped rising in this plastic tube. The height in feet shall be divided by 2.3 to establish the pounds of pressure that will be added to all readings. (For example, if the height of water is 11.5 feet, then the added pressure will be 5.0 psig. This increases the 3.5 psig to 8.5 psig, and the 2.5 psig to 7.5 psig. The allowable drop of one pound and the timing remain the same.)
6. The air test may be dangerous if, because of ignorance or carelessness, a line is improperly prepared. It is extremely important that the various plugs be installed and braced in such a way as to prevent blowouts. Inasmuch as a force of 250 lbs. is exerted on an 8-inch plug by an internal pipe pressure of 5.0 psi, it should be realized that sudden expulsion of a poorly installed plug or of a plug that is partially deflated before the pipe pressure is released can be dangerous.
7. As a safety precaution, pressurizing equipment should include a regulator set at perhaps 9.0 psi to avoid over pressurizing and damaging an otherwise acceptable line. No one shall be allowed in the manholes during testing.
8. The test requirements shall be met for every section (between manholes) of pipe; they are not a cumulative average over several sections of pipe.

Table 5. TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q = 0.0015 (Applicable to PVC, PVC Truss, DIP, and ESVCP Materials)

Pipe Dia-meter (in)	Minimum Time (min:sec)	Length for Min. Time (ft)	Time for Longer Length (sec)	Specification Time for Length (L) Shown (min:sec)							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	3:46	597	0.380L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	0.854L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.574L	22:47	34:11	45:34	56:56	58:22	79.46	91:10	102:33
27	25:30	88	17.306L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.356L	35:37	53:25	71:13	89:02	105:50	124:38	142:26	150:15
33	31:10	72	25.852L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768L	51:17	75:55	102:34	128:12	153:50	179:29	205:07	230:46

H. Infiltration Tests (generally to be used for sanitary sewer sections submerged in groundwater)
   1. Plug the upper section of line.
   2. Rates of infiltration shall be determined by means of V-notch weirs or pipe spigot in an approved manner and at such times and locations as may be directed by the Engineer during the progress and at the completion of the Work. The Contractor shall provide and install weir plates or other materials required and at such times and locations as may be directed by the Engineer.
   3. The maximum allowable amount of infiltration measured by test shall be at a rate of not greater than 100 gallons per inch of pipe diameter per mile per day.
   4. Should any test on any section of pipeline disclose an infiltration rate greater than that permitted, the Contractor shall, at Contractor expense, locate and repair defective joints or pipes until infiltration is within specified allowances.

I. The deflection of PVC pipe, including truss pipe, shall be not greater than five percent of the diameter within one year of construction.

J. Deflection Testing for PVC and PVC Truss Pipe
   1. The Contractor shall be required to measure such vertical interior deflection, no earlier than 30 days after installation, in the presence of the Engineer.
   2. Maximum allowable vertical ring deflection of the inside pipe diameter shall be five percent.
   3. Sewers must be cleaned before testing with a “Go-No GO” device. With the Pin-Type device the unit can be pulled through without the pin-gage installed to determine the gage in a deflected area.
   4. Recommendations of the pipe and/or testing device manufacturers shall be followed in the deflection testing procedures. **The testing device shall be hand-pulled by one (1) person. Use of winches or other mechanical means is not permitted.**
   5. Sections of sewer line not passing the pipe deflection test shall be repaired or replaced by the Contractor at no additional cost.
   6. Deflection mandrel diameters are as follows:

Pipe Diameter (inches)	Solid PVC ASTM D3034	Composite ASTM D2680	Solid ABS ASTM D2751	Corrugated PVC ASTM F949
	5%	5%	5%	5%
6	5.59”	5.46”	5.75”	5.61”
8	7.49”	7.36”		7.48”
10	9.37”	9.26”		9.35”
12		11.16”		
15		14.01”		

K. Televising of Lines: Owner may televise any line at Owner’s cost, except as provided in 3.05

3.06 – Storm Sewer Pipe Tests

A. All sewer pipe delivered to the construction Site shall be free from spalls and other defects. Any pipe found to have defects will be marked by the Inspector and must be removed from the Site.

B. Pipe furnished under Specifications shall be produced in a plant where both the manufacturing methods and quality of product have been approved by the Engineer prior to the date of award of Contract. No manufacturing process of sewer pipe shall be approved that will not consistently produce pipe having accurate dimensions, sound construction, acceptable joints, and meeting all the requirements in the Specifications.

C. The Contractor may be required to provide the Engineer with experience and performance records of sewer pipe manufactured in a similar manner. The Contractor shall also furnish the Engineer with sufficient evidence that all pipe proposed to be used in the Project will meet the requirements as outlined herein. This may require periodic testing by an acceptable testing laboratory in which all costs shall be paid by the Contractor.

D. The Engineer may require tests of specimens, not to exceed five percent of the quantity of pipe to be furnished, to prove the acceptability of the pipe.

E. At Engineer’s request, the manufacturer shall furnish a test of suitable design and construction to be located near the plant and approved by the Engineer. Strength tests will be made only on pipe that have been manufactured in the manner proposed for the regular production of pipe, and which is of a quality the manufacturer proposes as the minimum at which pipe will be delivered. In the event of winter operations or with the temperature below 50ºF., concrete pipe shall be cured either in a steam room or another suitable building, which meets the conditions for curing outlined herein.

F. Materials used in the manufacture of the sewer pipe complying with these Specifications will be accepted from any approved source of supply, except that the Engineer reserves the right to reject the entire output of any source from which it is impossible to secure a continuous supply of satisfactory materials, or a source where conditions are such that the use of unfit materials can be prevented only by extraordinary methods. The Engineer may require the taking and testing of preliminary samples of materials from any source before that source is approved for the delivery of materials on any Contract. The Contractor shall notify the Engineer as to the sources from which the Contractor expects to obtain materials in order that efficient arrangements can be made for their inspection.

G. Deflection Testing for PVC, HDPE, and Other Plastic Pipe
   1. Where deemed necessary to monitor vertical deflection of plastic pipe in place the Contractor shall be required to measure such vertical interior deflection, in the presence of the Engineer.
   2. Maximum allowable vertical ring deflection of the inside pipe diameter shall be five percent. Flexible plastic pipe with stiffness below 46 psi should require five percent maximum deflection testing 30 days or later after installation.
   3. Sewers must be cleaned before testing with a “Go-No Go” device. With this Pin-Type device the unit can be pulled through without the pin-gage installed to determine the gage in a deflected area.
   4. Recommendations of the pipe and/or testing device manufacturers shall be followed in the deflection testing procedures.

5. Sections of sewer line not passing the pipe deflection test shall be repaired or replaced by the Contractor at no additional cost.

H. Televising of Lines: The Owner may televise any line at Owner's cost.

3.07 – Cured-in-Place Pipe Liner Testing

A. Where feasible, testing sample shall be obtained from existing host pipe after installation of liner. If not feasible to sample from host pipe, liner test sample shall be installed and cured under same conditions as host pipe.
   1. Tensile Strength
      a. Test in accordance with ASTM D638.
      b. Specimens tested shall be actual thickness of fabricated liner.
      c. Do not machine specimen on surface.
      d. Tensile strength shall be average of five specimens tested.
   2. Flexural Strength and Modulus of Elasticity
      a. Test in accordance with ASTM D790.
      b. Specimens tested shall be actual thickness of fabricated liner.
      c. Do not modify specimen in any way prior to testing.
      d. Make test with smooth (inner) face in compression using five specimens.

3.08 – Concrete Testing

A. Quality Control
   1. Laboratory Tests
      a. Materials requiring testing or advance examination according to methods referenced, or as required by the Engineer.
   2. Compression Test Cylinders
      a. For laboratory trial batches, make in accordance with American Concrete Institute ACl 301 Method 1. Test to consist of four compression test cylinders for each class of concrete with two broken at seven days and two broken at 28 days; ASTM C192 and ASTM C39.
   3. Flexural Test Beams
      a. According to ASTM C78 and ASTM C296.
   4. The Contractor shall notify the Engineer if additional test cylinders or beams will be required for early strength tests. If the Contractor fails to do so, no early strength tests will be provided for or performed.

B. Maturity Method Testing (by Contractor)
   1. The method of testing the strength of Portland cement concrete pavement using the Maturity Method shall be in accordance with this section and the Iowa DOT IM 383.
   2. Personnel performing maturity testing shall be Iowa DOT Level II PCC certified plant inspectors, with training for maturity testing. The certified inspector may supervise other persons who may then perform temperature testing of constructed pavement.
   3. The Contractor and the Engineer shall jointly develop a plan for performing the maturity testing. The plan shall include:
      a. The time and location of the development of the maturity curve. The Contractor and Engineer shall work together in the development of the curve.
      b. The frequency and location of the temperature monitoring probes in the constructed pavement. The Contractor and Engineer shall work together in the temperature monitoring process.
   4. Should circumstances arise which are beyond the Contractor's and Engineer's control and strength cannot be determined by maturity method, the minimum age, minimum flexural strength, and fly ash restrictions shall apply.
   5. Any change of a material source or proportion in the concrete mixture shall require a new maturity curve.
   6. Establishment of Maturity-Strength Relationship. To establish a maturity-strength relationship for a concrete mix, a maturity meter or a thermal meter and a hydraulic testing machine are needed. The following procedure shall be used:

a. Cast a minimum of 12 beams, 6-inch by 6-inch by 20-inch. Test the entrained air content and slump of the concrete being used to cast the beams. Record these values. The concrete shall meet specifications.
b. Embed a thermal couple wire near each end of a test beam (when flexural strength is to be determined) to monitor the temperature. This beam will be the last to be tested. A probe shall be inserted near each of the beam ends to the approximate mid-depth and such that they are approximately 3 inches (75 mm) from each side and each end. Loop the wire around the beam box handles to prevent the wire from being inadvertently pulled out of the beam. The average of the two readings will be used in the development of the maturity-strength curve. When a maturity meter is used, the values are computed by the meter. Refer to Iowa DOT IM 318 for the use of a thermal meter. Twelve test specimens shall be tested as described in (d) below.
c. Cast, cure, and test the beams at the plant site. This will allow a maturity meter to be protected from the weather and theft. The meter can be stored in a lab trailer or vehicle with the probes run outside to the beam in the sand pit. The beams shall be covered with plastic immediately after casting and prior to form removal. If possible, wet burlap should be placed over the surface of the beams under the plastic. The forms shall be removed the following day. Cure all beams in a pit of wet sand or temperature-controlled water tank after form removal, until they are tested.
d. Determine maturity values and strength at four different ages. Test a minimum of two specimens for strength at each age and calculate the average strength at each age. The maturity value shall be calculated from a temperature reading at the time the specimen is tested for strength. The tests shall be spaced such that they are performed at somewhat consistent intervals of time and span a range of strength that includes the opening strength desired. The table below gives suggested maturity values for each test of three standard mixture classes. This is only a guide and may need to be modified upon approval of the Engineer, depending on specific mixtures and conditions.

Table 6. Approximate Maturity Values (TTF)

	Test 1	Test 2	Test 3	Test 4
PART 5 B Mix	1500	3500	5500	7500
C Mix	750	1500	2500	3500
M Mix with CaCl	100	200	300	400

These values assume opening strength of 500 psi for the B and C mixtures, and a 5-hour opening for the M Mixture with calcium chloride. If the maturity curve is intended to be used to determine the time to begin joint sawing, testing must begin at lower maturity values.

The first test (Test 1) for Class C mixes normally would be performed at an age of approximately 12 hours when hot, summer temperatures prevail. During cooler conditions, the first test may be performed at the beginning of the day following casting of test specimens.

Additional test specimens may be cast at a later time and tested at earlier ages to add data to the strength-maturity relationship as an aid to determining the appropriate time to saw.

e. Plot the measured strength against the corresponding values of maturity at different ages, as determined by the maturity meter or by hand methods. Use a computer program to determine maturity-strength relationship. The TTF number corresponding to the opening strength shall be used to determine when the pavement has reached opening strength.

7. Field Procedure
   a. Placement of the Temperature Probes

      Strip the coating from each end of the two wires and twist the ends together before inserting them into the fresh concrete. Insert the temperature probe into the concrete until the end is at approximately the pavement mid-depth and 1.6 ft from the edge of the pavement. The wire ends are the points at which the temperature

measurement is taken. Insertion may be accomplished by attaching the wire ends to a wooden dowel and embedding it into the slab. Verify the concrete is consolidated around the dowel. The portion of the dowel protruding above the pavement should be cut or broken after the testing is completed.

b. Probes may be placed at any point along the pavement slab. A minimum of two probes shall be placed in each day's placement. On days when there is a large difference between daytime high temperatures and nighttime low temperatures, placing probes near the beginning of the day's run and at a point near the midday location would provide helpful information. This would be helpful to those sawing the pavement as well as those determining the opening time. It has been found that the concrete does not always gain strength at the same rate. Therefore, concrete placed during the middle of the day can gain strength faster than concrete placed at the beginning of the day.

c. Data collection

i. The other probe wire ends, not placed in the concrete, shall be connected to a plug, unless the temperature-measuring device must be connected to the probe directly with bare wires. The plug is then inserted into the maturity meter or thermal meter. Normally a thermal meter can be used to collect field data. Be careful to connect the copper wire to the copper plug prong (+). When a thermal meter is used, refer to Iowa DOT IM 383.

ii. Do not disconnect the wire from the maturity meter until the test is completed. The data collection must be uninterrupted. Also the maturity meter must be protected from rain or water. If water finds its way inside the meter, permanent damage will result.

iii. Once the wires are placed, an initial temperature of the concrete shall be taken and recorded, when a thermal meter is being used. Temperature readings should be taken in the morning before beginning work and in the late afternoon before leaving the site, as a minimum, for standard B and C mixtures. For the fast setting mixtures, readings should be taken every few hours, depending on weather conditions and mixture. If a maturity meter is being used, it should be connected to the probe as soon as possible to begin data collection.

d. Measuring the maturity

The maturity number can be read directly from the maturity meter or calculated from the temperature readings obtained by the thermal meter. This number is then used to enter the strength-maturity chart that was established as described above and the strength is then determined. NOTE: An instruction sheet accompanies each maturity meter. It is important to follow these instructions to initialize the instrument.

e. Verification

Once per month verifications tests shall be conducted to determine if concrete strength is being represented by the current maturity curve. Cast and cure three beams using the same procedure and manner as used to develop the current maturity curve. Test all three beams at a maturity value determined to represent the opening strength of the pavement. If the average of these tests is within ± 50 psi of the strength set for the opening, the test shall be considered as validating the current maturity curve. If the average value is not within these limits, a new maturity curve shall be developed.

3.09 – Asphalt Testing

A. Where Gyratory Mix Design testing is specified or shown in the Contract Documents, testing shall be according to the Quality Control Program requirements of Iowa DOT **Standard Specifications for Highway and Bridge Construction, Section 2303,** latest revision. Otherwise, testing shall be as specified below.

B. A minimum of one on-grade sample of uncompacted asphaltic concrete will be taken for each day's placement for each mixture. The Engineer will perform sampling accordance with IDOT Materials I.M. 322. The sample will be tested for laboratory density, laboratory voids, and specific gravity. Laboratory voids shall be within the following limits:

1. Minimum Values:

Course	75 Blow Marshall Design	75 or 50 Blow Marshall Design	50 Blow Marshall Design		
ADT	>10,000	10,000-5,000	ADT 5,000-2,000	2,000-1,000	<1,000
Surface	3.5%	3.5%	3.5%	3.0%	2.5%
Base/Binder	3.5%	3.5%	3.0%	3.0%	2.5%

2. Maximum value for all mixtures and traffic volumes is 6 percent.
3. Voids determined to be outside these limits will require adjustments in the asphalt mix before further production is allowed.

C. Density
1. Samples of asphaltic concrete are required for testing by Engineer. Contractor shall cut samples from the finished pavement where marked by Engineer and patch the sample area. The Engineer shall test the sample not later than the next Working day following the respective construction. Sampling shall be in accordance with IDOT Materials I.M. 320.
2. When the mixture is being placed in irregular areas, or for wedge, leveling, or strengthening courses, the Engineer may waive sampling for density, provided compaction has been thorough and effective.
3. Samples shall be tested for percent of laboratory density and percent of laboratory voids. Average voids of compacted asphalt shall not exceed eight percent.

D. Thickness
1. In order to ascertain the actual thickness of the completed pavements, the Engineer reserves the right to drill cores from the pavement at any location. If core thickness and variability are not within the tolerances specified in the Contract Documents, the Contractor shall reconstruct or build up the pavements to the prescribed thickness at no additional cost.

E. Quality Index (Q.I.) Density Calculations
1. The quality index for each lot shall be determined by the following formula:

$$\text{Quality Index (Q.I.) Density} = \frac{\text{Average Density \% - Specified Density \%}}{\text{Standard Deviation Density \%}}$$

2. When the quality index is less than 0.73 based on seven samples, the Contractor shall take corrective action to improve the density of the mixture to be placed. For a negative quality index, the corrective action may include removal of the defective asphalt cement concrete. All corrective action shall be subject to the approval of the Engineer.

F. Quality Index (Q.I.) Basis of Payment for Density of Surface Course

For the number of tons each class and category of mixture, including fillets, the Contractor will be paid the respective Contract unit price per ton or for the number of square yards of each category of mixture, the Contractor will be paid the respective Contract unit price per square yard. Payment will be adjusted by the following percentages for the quality index (density) determined for the lot:

Quality Index (Density): 7 Samples or 6 Samples and 1 Outlier[1]	**Percent of Full Payment**
0.73	100
0.40 to 0.72	95
0.00 to 0.39	85
All Negative Values[2]	75 Maximum

[1] Only one outlier will be allowed.
[2] The Engineer may declare the lot or parts of the lot defective.

3.10 – Concrete Pavement Cores

A. Public Projects

1. **When specified in the contract documents, Iowa DOT Instructional Memorandum IM346, including appendices, shall apply for taking and evaluating and reporting on pavement cores.**

2. **Pavement core locations shall be determined by the Jurisdictional Engineer after completion of paving operations.**

B. Private Contracts for Facilities to be Accepted by Jurisdiction

1. **The Contractor shall take pavement cores at a rate of one (1) core for each three hundred feet (300 ft) of full width paving with the additional requirements:**
   a. **If a private contract involves more than one pavement thickness, a minimum of one (1) core will be required for each pavement thickness.**
   b. **If total pavement length under a private contract is less than 300 ft, a minimum of one core will be taken.**
3. **Pavement core locations shall be determined by the Jurisdictional Engineer after completion of paving operations.**
4. **Pavement cores shall be labeled and delivered to the Jurisdictional Engineer.**

END OF SECTION 01110