Learning Objectives

Provide an overview of pipe testing requirements and procedures for ACPA Certification
PIPE TESTING

Plant certification manual provides specific detail of requirements

PIPE TESTS

- External load crushing strength test (Three-Edge Bearing test)
- Joint shear test
- Off-center joint test
- Storm sewer and culvert joint test
- Water tightness tests
EXTERNAL LOAD CRUSHING STRENGTH TEST
THREE-EDGE BEARING TEST FRAME

ASTM C497

Standard Test Methods For Concrete Pipe, Manhole Sections, Or Tile
THREE-EDGE BEARING TESTING

- Understand what you are doing
- Understand why you are doing it
SELECTED READING:

- ASTM C497 - Section entitled External load crushing strength test by the three-edge bearing test method
- ASTM C76 Tables 1-5
- ASTM C506 Table 1
- ASTN C507 Table 1 & Table 2

What Does ASTM C507 Table 2 Cover?

Vertical Elliptical Pipe
WHY DO WE RUN THE THREE-EDGE BEARING TEST?

To determine the strength of our pipe using two different criteria:

A. The load to produce a crack with a width of 0.01”
B. The ultimate load

D-LOAD

Pounds per foot of length per foot of diameter

For example: ASTM C76 Class III design
D-load to produce a 0.01” crack: 1350
D-load to produce the ultimate load: 2000
SAMPLE CALCULATIONS FOR 24” DIAMETER x 8’ CLASS III

- 0.01” load = 1350 (D-load) x 8 ft (length) x 2 ft (diameter) = 21,600 lbs.
- Ultimate load = 2000 (D-load) x 8’ ft. (length) x 2 ft (diameter) = 32,000 lbs.

THREE-EDGE BEARING TEST
Load Rate

ASTM C497

For Reinforced Concrete Pipe, any rate of load application up to a maximum of 7500 lb/lineal foot of pipe per minute shall be used up to 75% of the specified design strength, at which time the rate of loading shall be reduced to a maximum uniform rate of 1/3 of the specified design strength of the pipe per minute.
### Load Rate Calculation Example

**Test Class III, 24 in. pipe, 8’ long**

- ASTM C76 design strength (0.01”) – ?
  - 21,600 lbs. 75% equals ?
  - 16,200 lbs.

- 7500 lbf/lineal foot of pipe (8’) per minute equals?
  - 60,000 lbs/min. up to 16,200 lbs. Seconds?
  - Minimum 16 seconds to reach 16,200 lbs.

- Then 1/3 design strength (21,600 lbs)/min equals?
  - 7,200 lbs/minute maximum rate. Total Time?

- Total test at least one minute. Depends on pipe size and class.

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**Notes:**

- Enter length of pipe
- Enter diameter or span of pipe
- Enter pipe class
- These are the 0.01” & Ultimate D-loads expressed in pound-force per linear foot per foot of diameter
- This is the maximum loading rate to P75% Load
- This is the load where the loading rate changes from (5) to (7)
- This is the maximum loading rate to Puult Load
- Acceptance load in the last column being tested to in. It can be either the 0.01” D-load or Ultimate D-load

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**Test Procedure:**

- Follow set-up and procedures as per ASTM C497
- Load pipe to P75% Load (6) at the specified rate (5)
- Reduce load rate from (5) to (7) until specified acceptance load is reached
- Record first crack load, 0.01” D-load, Ultimate load (if required), and maximum load applied

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**Notes:**

- Enter length of pipe
- Enter diameter or span of pipe
- Enter pipe class
- Enter load rate in ponds per lateral per annum
- This is the maximum loading rate to P75% Load
- This is the load where the load rate changes from (5) to (7)
- This is the maximum load to Puult Load
- Acceptance load in the last column being tested to in. It can be either the 0.01” D-load or Ultimate D-load
- This is the required 0.01” D-load in pounds
- This is the required Ultimate load in pounds

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**Load Rate Calculation Example**

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Formula</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>P75% Load</td>
<td>D-load x L x d ft</td>
<td>21,600 lbs</td>
</tr>
<tr>
<td>Puult Load</td>
<td>Dult x L x d ft</td>
<td>32,000 lbs</td>
</tr>
<tr>
<td>R1</td>
<td>Max. Rate from Initial Load to P75% in lbs/sec</td>
<td>1,000 lbs/second maximum</td>
</tr>
<tr>
<td>R2</td>
<td>Max. Rate from P75% to Specified acceptance load lbs/sec</td>
<td>120 lbs/second maximum</td>
</tr>
<tr>
<td>L</td>
<td>Load in lbs</td>
<td>21,600 lbs</td>
</tr>
<tr>
<td>CL</td>
<td>Class of Pipe</td>
<td>3</td>
</tr>
<tr>
<td>d ft</td>
<td>Pipe Diameter or Span in feet</td>
<td>2.00 feet</td>
</tr>
<tr>
<td>P</td>
<td>Design Load in lbs</td>
<td>21,600 lbs</td>
</tr>
<tr>
<td>Puult</td>
<td>Ultimate Load in lbs</td>
<td>32,000 lbs</td>
</tr>
<tr>
<td>L</td>
<td>Load in lbs</td>
<td>75% of Design Load in lbs</td>
</tr>
</tbody>
</table>
GAUGE LEAF FOR MEASURING 0.01-INCH CRACKS

THE DEFINITION OF A 0.01-INCH CRACK IS:
"WHEN THE POINT OF THE MEASURING GAGE WILL, WITHOUT
FORCING, PENETRATE 1/16 IN. AT CLOSE INTERVALS
THROUGHOUT THE SPECIFIED DISTANCE OF 1 FT."
INSTALL SQUARELY IN FRAME

Maintain equal measure to insure squareness.
ACPA T.E.B. TEST FREQUENCIES

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>CLASS</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>12”-15”</td>
<td>Class 5 and below</td>
<td>1/1000 pcs.</td>
</tr>
<tr>
<td>18”-36”</td>
<td>Class 4 and below</td>
<td>1/800 pcs.</td>
</tr>
<tr>
<td>18”-36”</td>
<td>Class 5</td>
<td>1/400 pcs.</td>
</tr>
<tr>
<td>42”-60”</td>
<td>Class 3 and below</td>
<td>1/400 pcs.</td>
</tr>
<tr>
<td>42”-60”</td>
<td>Class 4 and 5</td>
<td>1/200 pcs.</td>
</tr>
<tr>
<td>66” and larger</td>
<td>All classes</td>
<td>As required by project specs.</td>
</tr>
</tbody>
</table>

Pipe shall be tested to the D-load specified in the ASTM tables for the 0.01-inch crack. Pipe meeting these requirements shall be accepted for use.

ACPA requires:

one piece, per size and class produced, shall be tested to the ultimate D-load at least one per year.
JOINT SHEAR TEST

- SPECIFIED IN ASTM C497
- SANITARY CERTIFICATION ONLY
JOINT SHEAR TEST REQUIREMENTS

4000 lbs/ft of pipe diameter including the weight of the pipe.
WHAT IS A PASSING TEST?

Load Joint to 4000 lbs/ft

Crack Width less than 0.01” after the load is released.
Using the 3EB Test Frame
### Pipe Data

- **Date Cast**: 10/06
- **Date Tested**: 10/06
- **Description**:

### Test Results
A force of 7,000 pounds was applied to the top radius block as shown on the attached drawing. The total shear load at the joint was 4000 lbs R of internal diameter. No cracks were observed.

### Test Setup

![Test Diagram]
DOCUMENTATION

A proof of design test for the lowest class of each pipe size and joint style should be retained on file as a permanent record.

• Expect to run a joint shear test during the audit (sanitary) unless done at another company plant (must be certified).

OFF CENTER JOINT TEST REQUIREMENTS

• VACUUM or HYDROSTATIC or LOW PRESSURE AIR
• Proof of design test on file. All pipe sizes and joint designs.
OFF CENTER HYDROSTATIC JOINT TEST
SANITARY CERTIFICATE ONLY

Figure 1
Off Center Hydrostatic Joint Test Setup

JOINTS HOLD WATER UNDER PRESSURE
w/ CONCRETE TO CONCRETE CONTACT

1600 LBS. / FT. of DIAMETER
(INCLUDING WEIGHT OF WATER
AND PIPE)

3/4 " OPEN
CONCRETE TO
CONCRETE CONTACT

American Concrete Pipe Association
OFF CENTER HYDROSTATIC JOINT TEST

Example Tools

www.concrete-pipe.org
OFF CENTER JOINT TEST

- Test must be run during the audit (sanitary) unless testing performed at another company plant that is certified.
STORM SEWER AND CULVERT
JOINT TEST REQUIREMENTS

• VACUUM, HYDROSTATIC OR AIR

• PROOF OF DESIGN TESTS FOR ALL GASKETED PIPE SIZES AND JOINT DESIGNS

Accepted Test Methods

• Full Barrel Test using Bulkheads (Traditional)

• Joint Test (Internal)

• Joint Test (External)

www.concrete-pipe.org
STORM SEWER AND CULVERT JOINT TEST

WOOD SUPPORTS

STORM SEWER & CULVERT JOINT TEST

STRAIGHT ALIGNMENT

OPEN 1/2"

MAXIMUM DEFLECTION POSITION
Full Barrel (Traditional Method)

Joint Test Only (Internal)
External Test Method

Apply Test Pressure Between the Gaskets

WATER TIGHTNESS TESTS

In-plant quality control tests
- 12”-36” pipe vacuum test
- 12”-24” pipe air test
- 12”-36” pipe hydrostatic test
- 42” and larger pipe and manhole hydrostatic or vacuum test
BULKHEAD STYLES

- Flat Plate
- Joint Bulkheads

JOINT BULKHEAD OPTIONS

- Fiberglass (Vacuum Only)
- Fabricated Steel
ACPA PIPE PLANT CERTIFICATION
Requires 100% plant testing
12”-36” Sanitary Sewer Pipe

- 12”-36” Vacuum Test
- 12”-24” Air Test
- 12”-36” Hydrostatic Test
12” - 36” VACUUM TEST

- Found in Appendix A of QCAST Certification Manual
- Starting vacuum is 7” Hg
PRESSURE MEASURING DEVICES

PRESSURE GAGE
0-25 PSI

VACUUM GAGE
0-30 in. Hg

GAGES DON'T WORK WELL FOR MEASURING PRESSURE CHANGES OF 1/10 PSI OR 1/10 IN. HG

MANOMETERS

CLEAR TUBING
HEIGHT OF LIQUID IN COLUMN IS MEASURE OF PRESSURE OR VACUUM
STEEL PRESSURE CHAMBER
VENT
LIQUID VESSEL

MANOMETER FOR MEASURING POSITIVE AIR PRESSURE
MANOMETER FOR MEASURING VACUUM
MANOMETER COLUMN HEIGHTS
3 1/2 PSI or 7 in. Hg (7.14 in. Hg)

WATER
SPECIFIC GRAVITY 1

MANOMETER OIL
SPECIFIC GRAVITY 2.945

MERCURY
SPECIFIC GRAVITY 13.594

(1) A pressure increase of 0.1083" Hg was chosen because it corresponds to a change in water column height of approximately 1-1/2" and a change in manometer oil column height (specific gravity 2.945) of 1/2".

(2) If a larger pressure increase is desired, test times can be increased proportionately.

(3) Two leakage rates are used in calculating test times because field air and vacuum tests vary by location. The 0.003 CFM/ft² is the ACPA Plant Certification minimum requirement.

VACUUM TEST TABLE
Test Time, Seconds (2)

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>0.0017 CFM/ft² (3)</th>
<th>0.003 CFM/ft² (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;</td>
<td>32</td>
<td>18</td>
</tr>
<tr>
<td>15&quot;</td>
<td>41</td>
<td>23</td>
</tr>
<tr>
<td>18&quot;</td>
<td>49</td>
<td>28</td>
</tr>
<tr>
<td>21&quot;</td>
<td>57</td>
<td>32</td>
</tr>
<tr>
<td>24&quot;</td>
<td>64</td>
<td>36</td>
</tr>
<tr>
<td>27&quot;</td>
<td>73</td>
<td>41</td>
</tr>
<tr>
<td>30&quot;</td>
<td>81</td>
<td>46</td>
</tr>
<tr>
<td>33&quot;</td>
<td>90</td>
<td>51</td>
</tr>
<tr>
<td>36&quot;</td>
<td>97</td>
<td>55</td>
</tr>
<tr>
<td>42&quot;</td>
<td>114</td>
<td>64</td>
</tr>
<tr>
<td>48&quot;</td>
<td>128</td>
<td>72</td>
</tr>
<tr>
<td>54&quot;</td>
<td>146</td>
<td>82</td>
</tr>
<tr>
<td>60&quot;</td>
<td>162</td>
<td>92</td>
</tr>
<tr>
<td>66&quot;</td>
<td>180</td>
<td>102</td>
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<tr>
<td>72&quot;</td>
<td>194</td>
<td>110</td>
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<tr>
<td>75&quot;</td>
<td>209</td>
<td>118</td>
</tr>
<tr>
<td>84&quot;</td>
<td>226</td>
<td>128</td>
</tr>
<tr>
<td>90&quot;</td>
<td>243</td>
<td>138</td>
</tr>
<tr>
<td>96&quot;</td>
<td>256</td>
<td>144</td>
</tr>
</tbody>
</table>
1. Connect the digital manometer to the bulkhead by connecting hose directly to the manometer. Do not use quick disconnect coupling!
2. Turn on the unit. Set the function for millibars.
3. Turn on vacuum.
4. Bring vacuum to 275 millibars. This is your condition line.
5. Hold at 275 for a minimum of 30 seconds up to 2 minutes to let temperature and pressure stabilize.
6. After conditioning, lower vacuum down to 253 millibars.
7. The starting test pressure is 250. Start the stopwatch as soon as the gauge drops to 250.
8. Ending test pressure is 246. Stop the stopwatch as soon as the gauge turns to 246, or until you have met the time requirements listed on Appendix A, page 23.
9. Record time and digital reading on the report.

### Digital Manometer Test Times

<table>
<thead>
<tr>
<th>DIAMETER</th>
<th>FAIL SECONDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;</td>
<td>Less than 35</td>
</tr>
<tr>
<td>15&quot;</td>
<td>Less than 44</td>
</tr>
<tr>
<td>18&quot;</td>
<td>Less than 52</td>
</tr>
<tr>
<td>21&quot;</td>
<td>Less than 61</td>
</tr>
<tr>
<td>24&quot;</td>
<td>Less than 70</td>
</tr>
<tr>
<td>27&quot;</td>
<td>Less than 79</td>
</tr>
<tr>
<td>30&quot;</td>
<td>Less than 87</td>
</tr>
<tr>
<td>33&quot;</td>
<td>Less than 96</td>
</tr>
<tr>
<td>36&quot;</td>
<td>Less than 105</td>
</tr>
<tr>
<td>48&quot; Manhole</td>
<td>Less than 78*</td>
</tr>
</tbody>
</table>

* Based on leakage rate of 0.0017 cfm/ft² except for 48" manholes which are 0.003 cfm/ft²
12” - 24” AIR TEST

- Found in Appendix A of Certification Manual
- Starting pressure 3.5 psi

12” - 24” AIR TEST

- Found in Appendix A of Certification Manual
- Starting pressure 3.5 psi – Drop of 0.054 psi (1-1/2” water or ½” manometer oil)

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>0.0017 CFM/ft² (3)</th>
<th>0.003 CFM/ft² (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12”</td>
<td>32</td>
<td>18</td>
</tr>
<tr>
<td>15”</td>
<td>41</td>
<td>23</td>
</tr>
<tr>
<td>18”</td>
<td>49</td>
<td>28</td>
</tr>
<tr>
<td>21”</td>
<td>57</td>
<td>32</td>
</tr>
<tr>
<td>24”</td>
<td>64</td>
<td>36</td>
</tr>
</tbody>
</table>
12” - 36” HYDROSTATIC (Water)

- 100% OF SANITARY PIPE (Option - air or vacuum)
- 13 psi FOR 2 1/2 MINUTES
- NO VISIBLE LEAKAGE

42” AND LARGER HYDROSTATIC or VACUUM TEST

- ACPA QCAST certification manual
- Hydrostatic test - 13 psi for 2-1/2 minutes with no visible leakage
- Vacuum test per table
- 1/100 minimum of two
QUESTIONS?