PRODUCT TESTING

American
Concrete Pipe
Association

Learning Objectives

Provide an overview of pipe testing requirements and procedures for ACPA Certification and understand why we need to do the tests.

PIPE TESTS

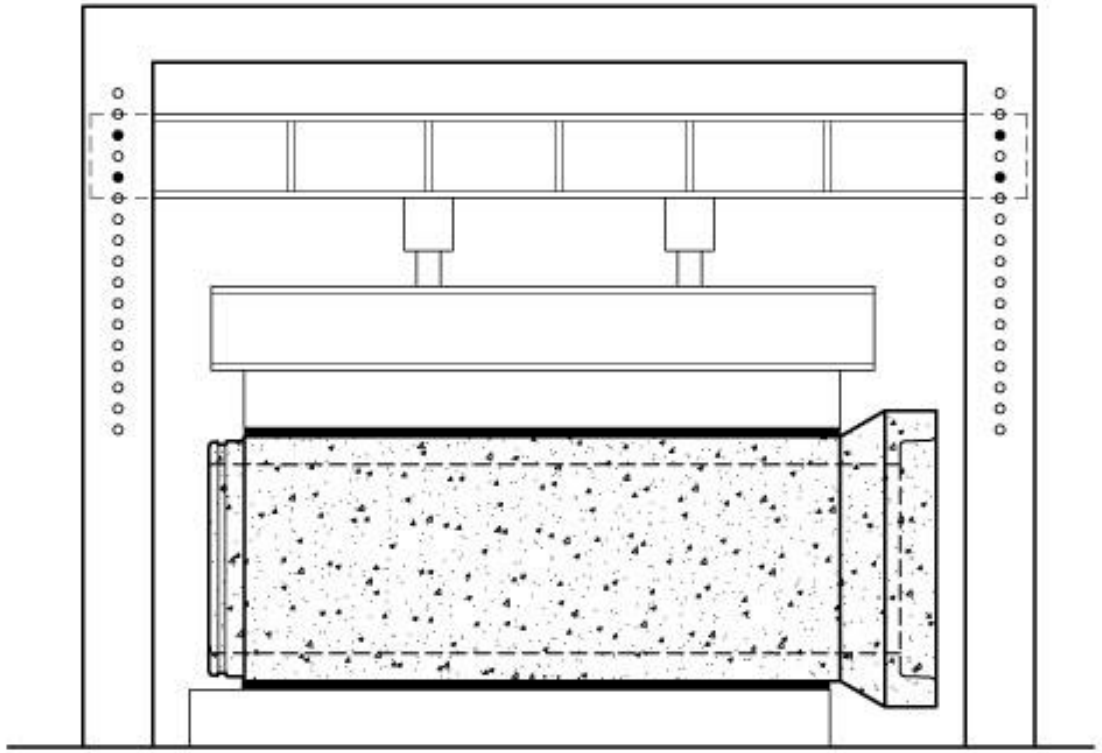
- External load crushing strength test (Three-Edge Bearing test)
- Joint shear test
- Off-center joint test
- Storm sewer and culvert joint test
- Water tightness tests

- ACPA QCast Plant Certification Manual provides specific detail of testing requirements

QUALITY SCHOOL

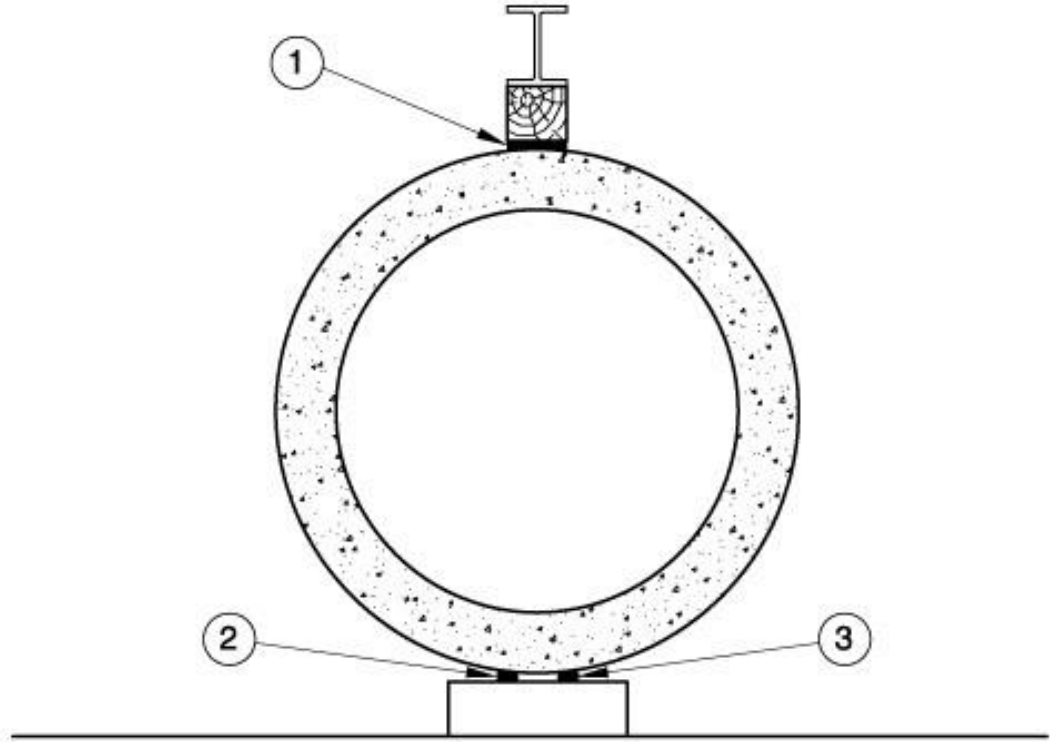
EXTERNAL LOAD CRUSHING STRENGTH TEST

THREE - EDGE BEARING TEST FRAME



QUALITY SCHOOL

THREE - EDGE BEARING TEST



THREE-EDGE BEARING TESTING

- Understand what you are doing
- Understand why you are doing it

REQUIRED READING:

- ASTM C497 - *Standard Test Methods For Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile*:
  - Section entitled - External load crushing strength test by the three-edge bearing test method

- ASTM C76 –*Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe*:
  - Tables 1-5 provide strength requirements

- ASTM C76 –Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe:
  Tables 1-5 provide strength requirements

C76 – 19b

TABLE 3 Requirements for Class III Reinforced Concrete Pipe[A]

NOTE 1—See Section 5 for basis of acceptance specified by the owner. The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack	1350
D-load to produce the ultimate load	2000

	Reinforcement, in.²/linear ft of pipe wall		
	Wall A	Wall B	Wall C
Internal Designated	Concrete Strength, 4000 psi	Concrete Strength, 4000 psi	Concrete Strength, 4000 psi

C76 – 19b

TABLE 5 Requirements for Class V Reinforced Concrete Pipe[A]

NOTE 1—See Section 5 for basis of acceptance specified by the owner.
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack	3000
D-load to produce the ultimate load	3750

	Reinforcement, in.²/linear ft of pipe wall		
	Wall A	Wall B	Wall C
Internal Designated	Concrete Strength, 6000 psi	Concrete Strength, 6000 psi	Concrete Strength, 6000 psi

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

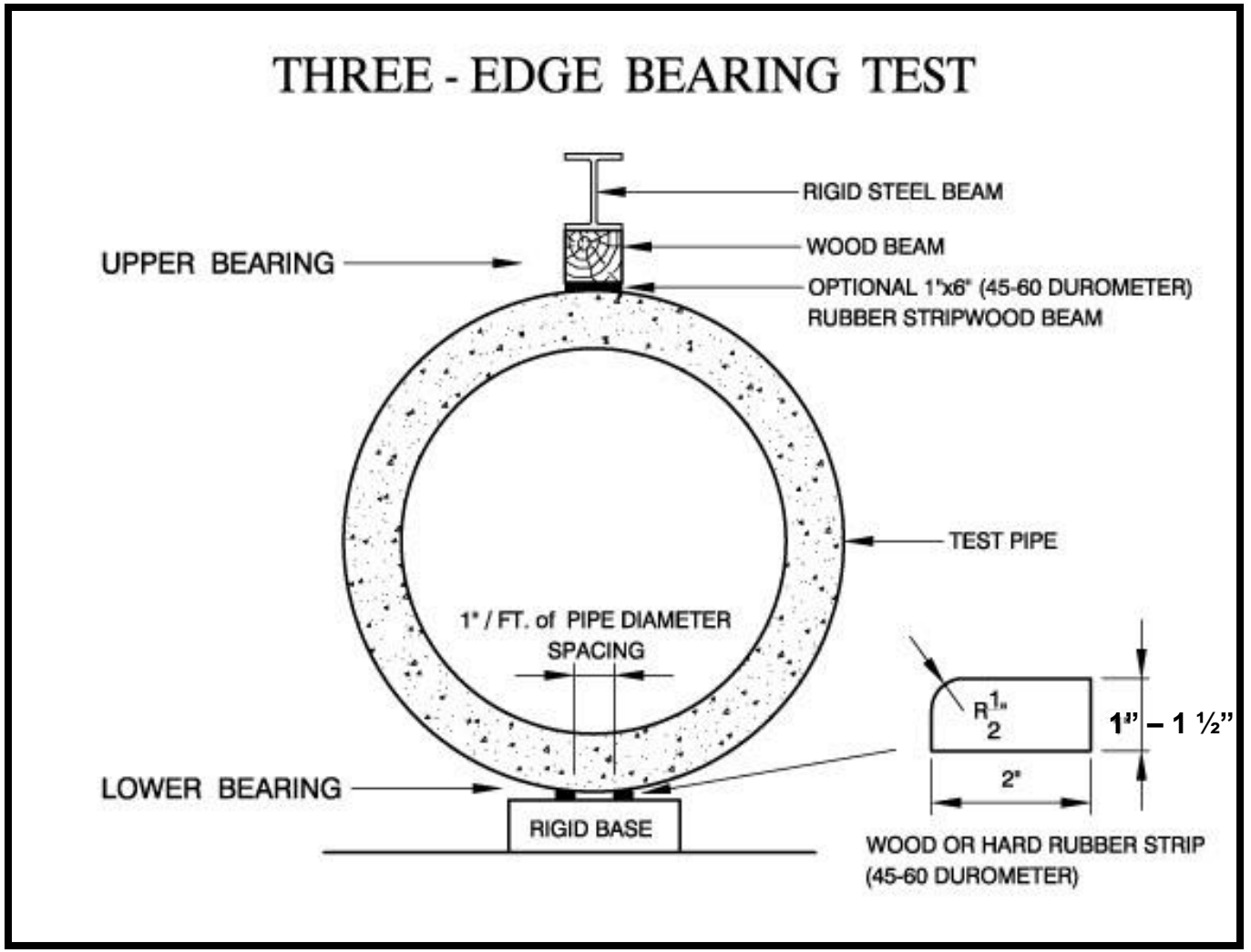
D-load to produce a 0.01” crack	1350
D-load to produce the ultimate load	2000

SAMPLE CALCULATIONS FOR 24” DIAMETER x 8’ CLASS III PIPE

- 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.

QUALITY SCHOOL

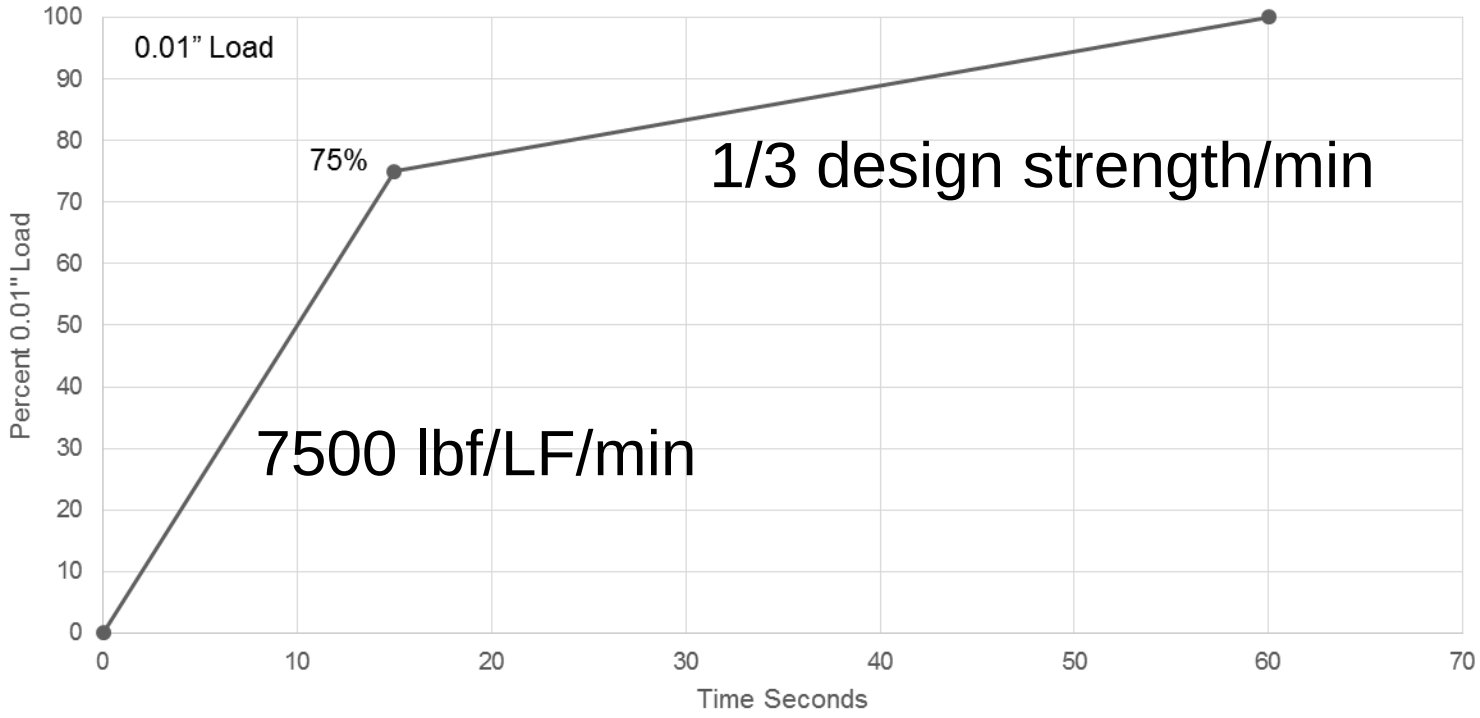


Load Rate

ASTM C497

For Reinforced Concrete Pipe, any rate of load application up to a maximum of 7500 lbf/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.

Loading Rate for TEB Testing



Load Rate Calculation Example

- Test Class III, 24 in. pipe, 8’ long
- {ASTM C76} 0.01” load = 1350 (D-load) x 8 ft (length) x 2 ft (diameter) = 21,600 lbs
  - 75% of 21,600 lbs is 16,200 lbs.
- Maximum Rate up to 75% is 7500 lbf/lineal foot of pipe (8’) per minute
  - 7500*8’= 60,000 lbs/minute / (60s/min) = 1,000 lbs/sec
  - 16,200 lbs / 1,000 lbs/sec = 16 seconds
  - Minimum 16 seconds to reach 16,200 lbs.

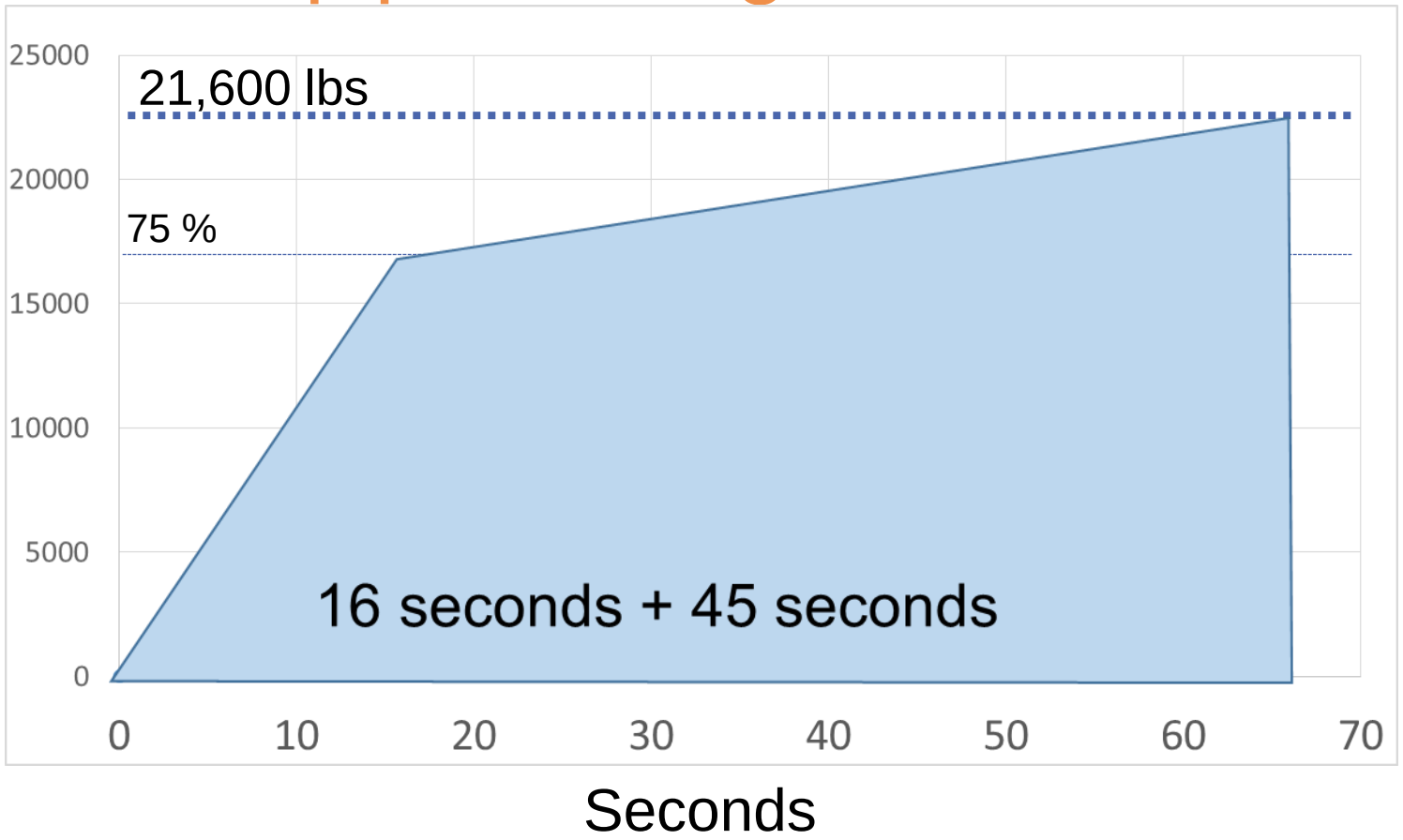
Maximum Loading Rate for TEB
Class III, 24 in. pipe, 8’ long

Load Rate Calculation Example (cont.)
Class III, 24 in. pipe, 8’ long

- After 75% - reduce rate to 1/3 design strength / minute
  - 1/3 of 21,600 lbs = 7,200 lbs/minute / (60s/min) = 120 lbs/sec
  - Max rate of 120 lbs/sec between 16,200 lbs and 21,600 lbs.
  - Time equals 21,600-16,200 [5,400 lbs] / 120 lbs/sec = 45 seconds.

  - Total test time equals 16 secs + 45 secs = 61 seconds minimum
  - At least one minute but depends on pipe size and class.

Maximum Loading Rate for TEB
Class III, 24 in. pipe, 8’ long



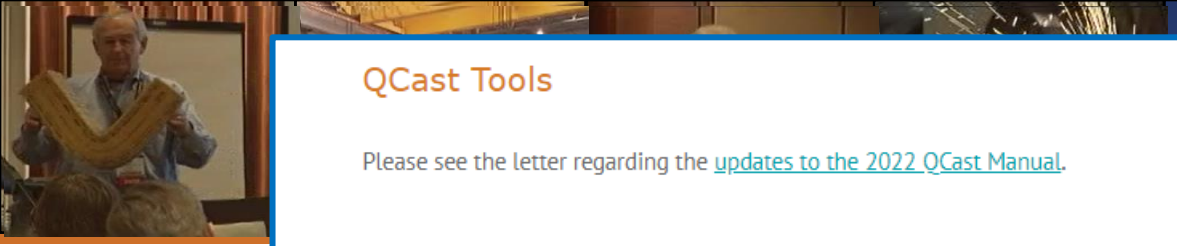
D-Load Rate Calculator

Found On The ACPA Member's Website:

Q-Cast Tools

DETERMINING LOAD RATES FOR REINFORCED CONCRETE PIPE

1	L = Pipe Length in feet	8	feet
2	d_{in} = Pipe Diameter or Span in inches [diameter for circular pipe, span for elliptical pipe]	24	inches
3	CL = Class of Pipe	3	
	d_{ft} = Pipe Diameter or Span in feet	2.00	feet
	$P_{1/3}$ = One-Third of Design Load in lbs = P / 3	7,200	lbs
4	D_{load} = D-Load in lbs/lin ft/ft diameter [based on class of pipe]	1,350	lbs / lin ft / ft diameter
4	D_{ult} = Ultimate D-Load in lbs/lin ft/ft diameter [based on class of pipe]	2,000	lbs / lin ft / ft diameter
5	R_1 = **Max. Rate from Initial Load to $P_{75\%}$ in lbs/sec** = 7,500 lbs/lin ft/min x 1 min/60 sec x L = 125 lbs/lin ft/sec x L	1,000	**lbs / second maximum**
6	$P_{75\%}$ = **75 % of Design Load in lbs = 0.75 x P**	16,200	lbs
7	R_2 = **Max. Rate from $P_{75\%}$ to Specified acceptance load lbs/sec** = $P_{1/3}$/min x 1 min/60 sec = $P_{1/3}$ / 60 seconds	120	**lbs / second maximum**
8	P = **Design Load in lbs = D_{load} x L x d_{ft}**	21,600	lbs
9	P_{ult} = **Ultimate Load in lbs = D_{ult} x L x d_{ft}**	32,000	lbs



QCast Tools

Please see the letter regarding the updates to the 2022 QCast Manual.

Template Forms

Audits

Audit Checklists

QC Manager Audit

Scale Calibration

Scale Calibration Guide for Independent Agencies

Scale Calibration Calculator & Guide for Plants

Reinforcement

Proper Reinforcement Welding Practices

Reinforcement Calculator

Mix Design

W/C Calculator

Sample Mix Form Calculator

Joint Design

Joint Design Confined Calculator

Joint Design Single Offset Calculator

Joint Design Single Offset Box

3EB Pipe Test

D-Load Rate Calculator

QCast Frequency D-Load Tracker

TEB Tracker

Videos

3EB Instructional Video

Gasketed Box Installation

Gasketed Box External Joint Test Installation

Manual

Updates to 2022 Manual

QCast Appendix forms

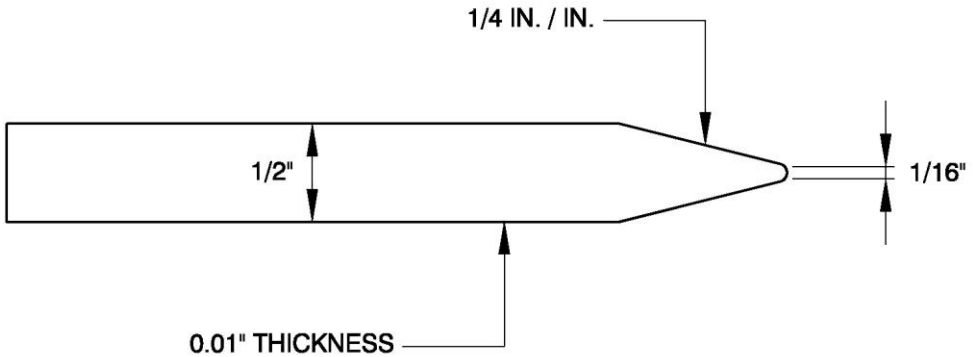
Pipe Reinforcing Inspection Report

Pipe and Manhole Post-Pour Dimension Inspection Form

Three-Edge-Bearing Test Results of Reinforced Concrete Pipe

QUALITY SCHOOL

GAUGE LEAF FOR MEASURING 0.01 - INCH CRACKS

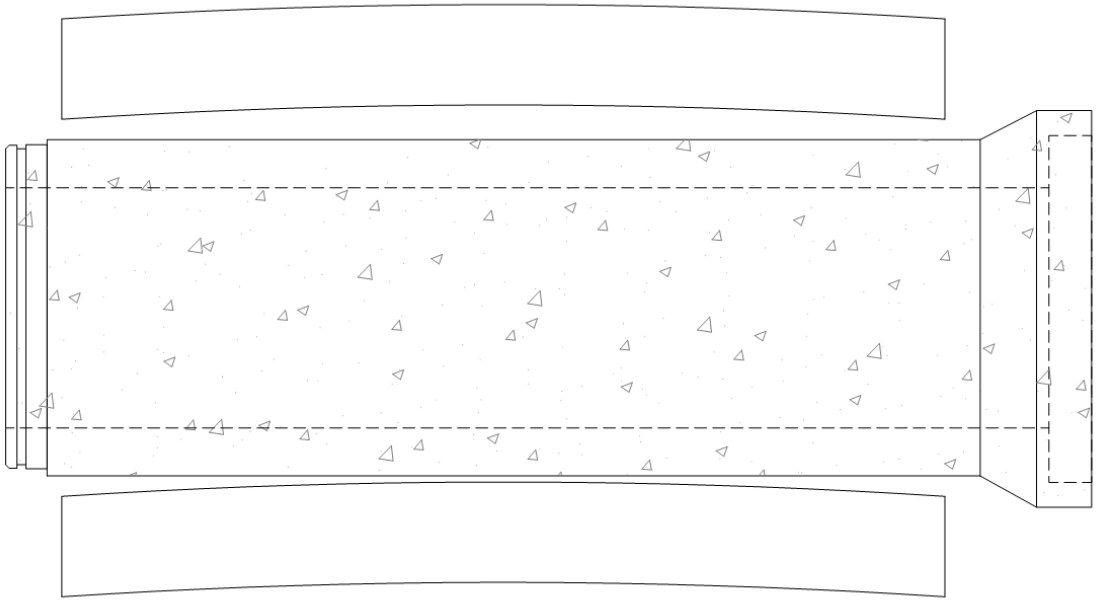


"…when the point of the gage will, without forcing, penetrate 1/16" at 3 in. maximum intervals throughout distance of 1 ft."

SK9919–15

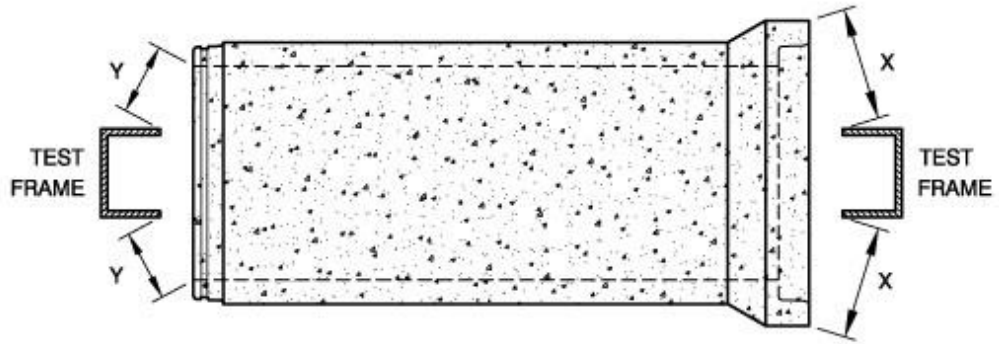
QUALITY SCHOOL

AVOID POINT LOADING



QUALITY SCHOOL

INSTALL SQUARELY IN FRAME



MAINTAIN EQUAL MEASURE TO INSURE SQUARENESS


HYDROTILE

ACPA QCAST MANUAL
T.E.B. TEST FREQUENCIES

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

ACPA T.E.B. TEST FREQUENCIES

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.

QUALITY SCHOOL

CERTIFICATION OF THREE-EDGE-BEARING TEST RESULTS OF REINFORCED CONCRETE PIPE

Pipe Information

Pipe Description	Size	Class	Wall	Joint

Test Number: _____
Test Location: _____
Date of Manufacture: _____
Date Tested: _____
Age of Pipe (in days): _____
Method of Fabrication: _____

Pipe Length	Measured	Allowable
Min.		
Max.		
Diff. in Length of Opposite Sides		

Wall Thickness	Measured	Allowable
Min.		
Max.		N/A
Nominal Thickness		

Inside Diameter	Measured	Allowable
Min.		
Max.		

NOTE: Allowable dimensions are specified dimensions either increased or decreased by the specified tolerance. All dimensions are in inches.

Reinforcing

Cage	Reinforcing Description	Area	Specified Area
Inside:			
Outside:			
Elliptical:			

Shear Steel Description and Area: _____

Three-Edge-Bearing Test Results

	Actual Load	Required Load	Actual D-Load**	Required D-Load**
1st Crack				
.01 Crack				
Ultimate				

** D-Load is measured in pounds per linear foot of inside diameter.

If Pipe was not tested to Ultimate:

Load when test was stopped: _____ lbs.

D-Load when test was stopped: _____ lbs/ft

Condition of pipe when test was stopped: _____

_____

_____

_____

Distribution:

I hereby certify that the pipe was three-edge bearing tested in accordance with the provisions of ASTM designation C-497.

Signature: _____

Date: _____

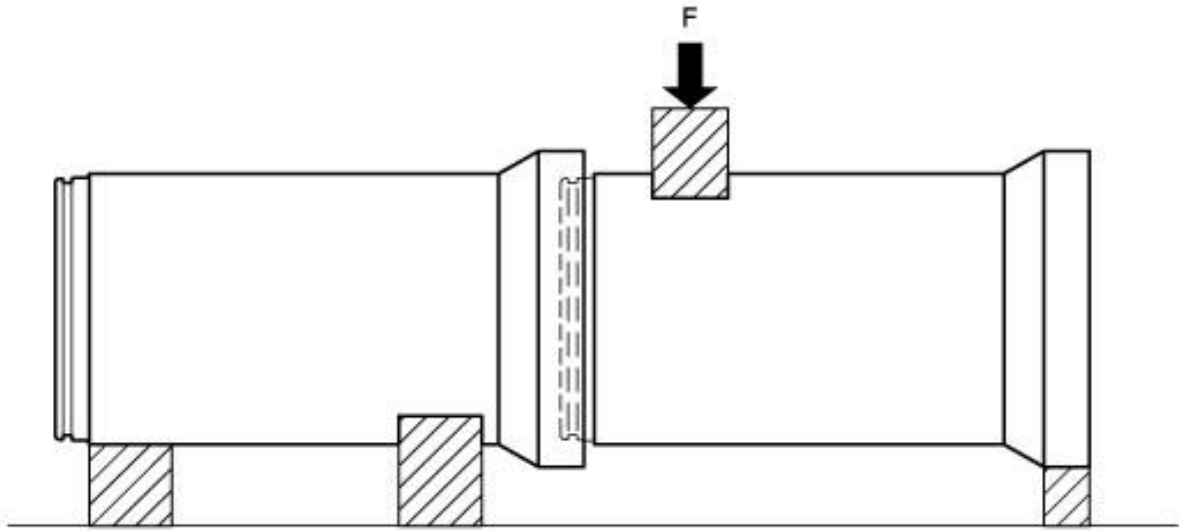
Plant Location: _____

JOINT SHEAR TEST

- SPECIFIED IN ASTM C497

- SANITARY CERTIFICATION ONLY

JOINT SHEAR TEST
SANITARY CERTIFICATION ONLY



JOINT SHEAR TEST SETUP

JOINT SHEAR TEST REQUIREMENTS

4000 lbs/ft of pipe diameter (per ASTM C497)

including the weight of the pipe.

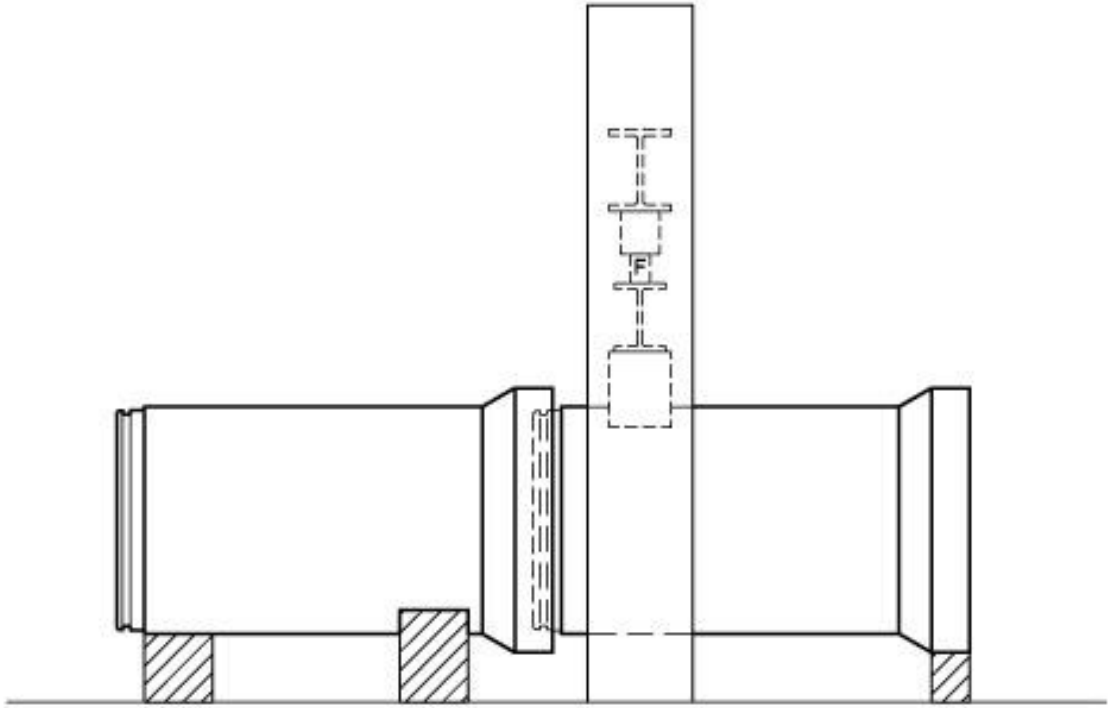
WHAT IS A PASSING TEST- Joint Shear?

Load Joint to 4000 lbs/ft diameter

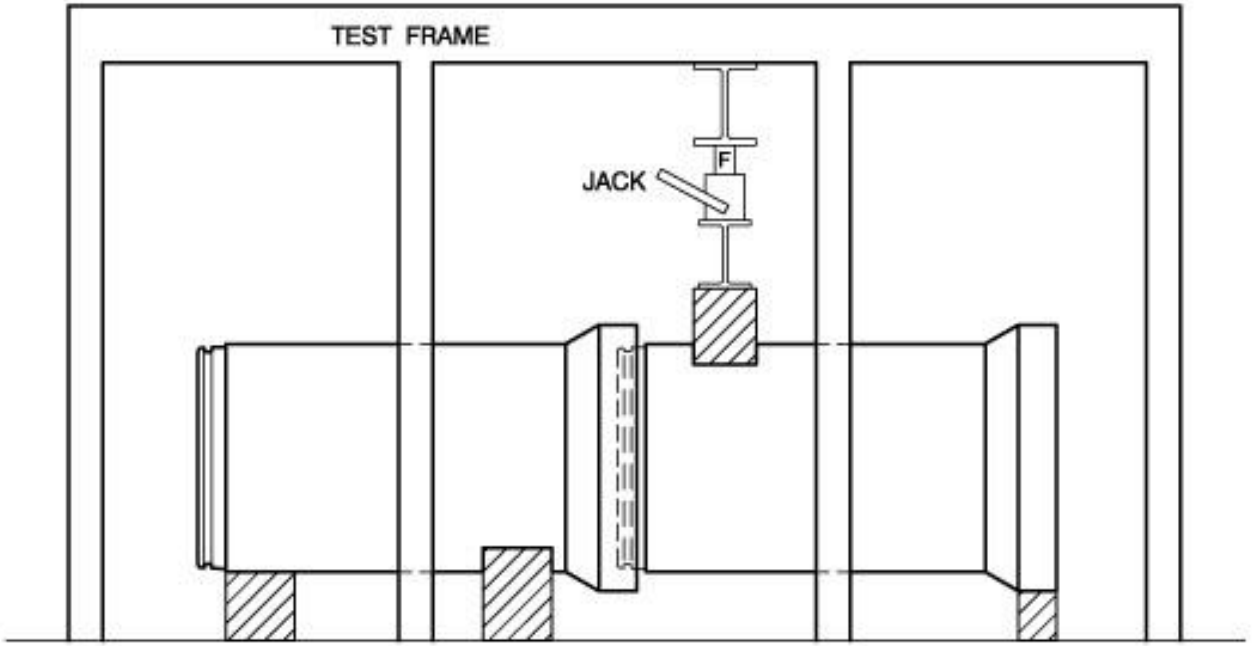
Crack Width less than 0.01” after the load is released.

QUALITY SCHOOL

JOINT SHEAR TEST
w/ THREE - EDGE BEARING TEST FRAME



JOINT SHEAR TEST
w/ EXTERNAL TEST FRAME



SUPPORT BLOCK CONFIGURATION

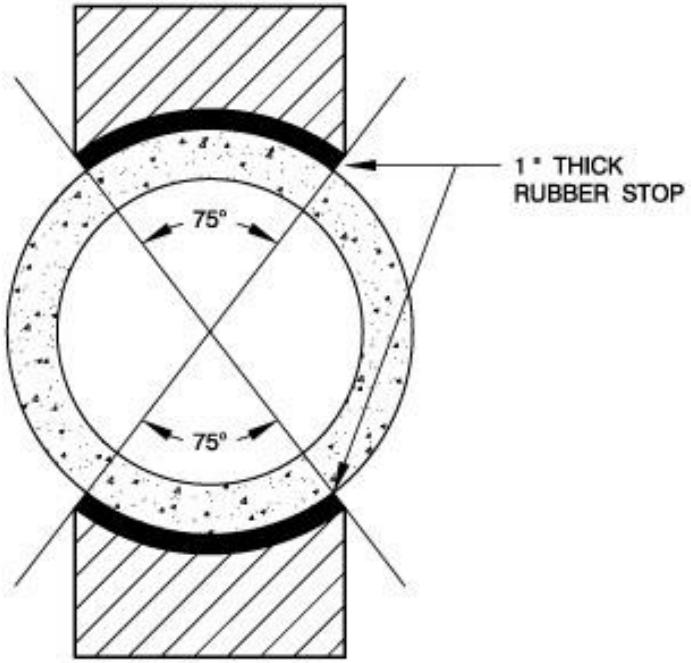


Figure 5
Support Block Configuration

QUALITY SCHOOL

JOINT SHEAR TEST CALCULATIONS

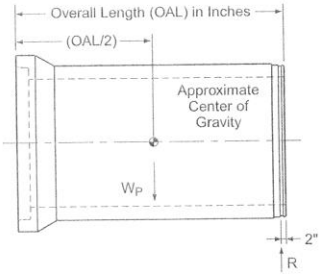
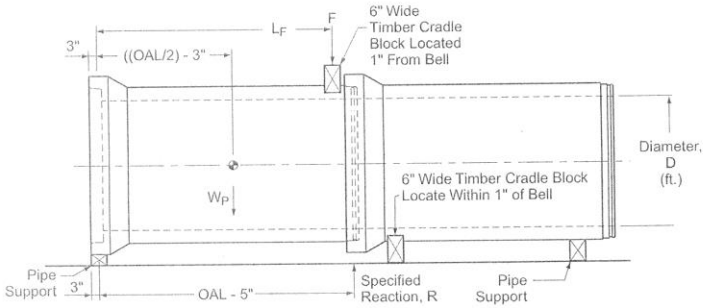


Fig. 4 Simplified Center of Gravity of Pipe



R = Test Requirement
Wp = Nominal Weight of Test Pipe
F = Additional Test Force

$$R = 4000 \text{ lbs. x Internal Diameter in Feet}$$

$$F = \frac{((OAL) - 5")R - ((OAL/2) - 3")W_P}{L_F} \text{ (lbs.)}$$

Fig. 5 Joint Shear Test

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 on same design (must be QCast certified).

OFF CENTER JOINT TEST REQUIREMENTS

- VACUUM or HYDROSTATIC
- Proof of design test on file. All pipe sizes and joint designs
- Sanitary Certification Requirement.

OFF CENTER HYDROSTATIC JOINT TEST

SANITARY CERTIFICATE ONLY

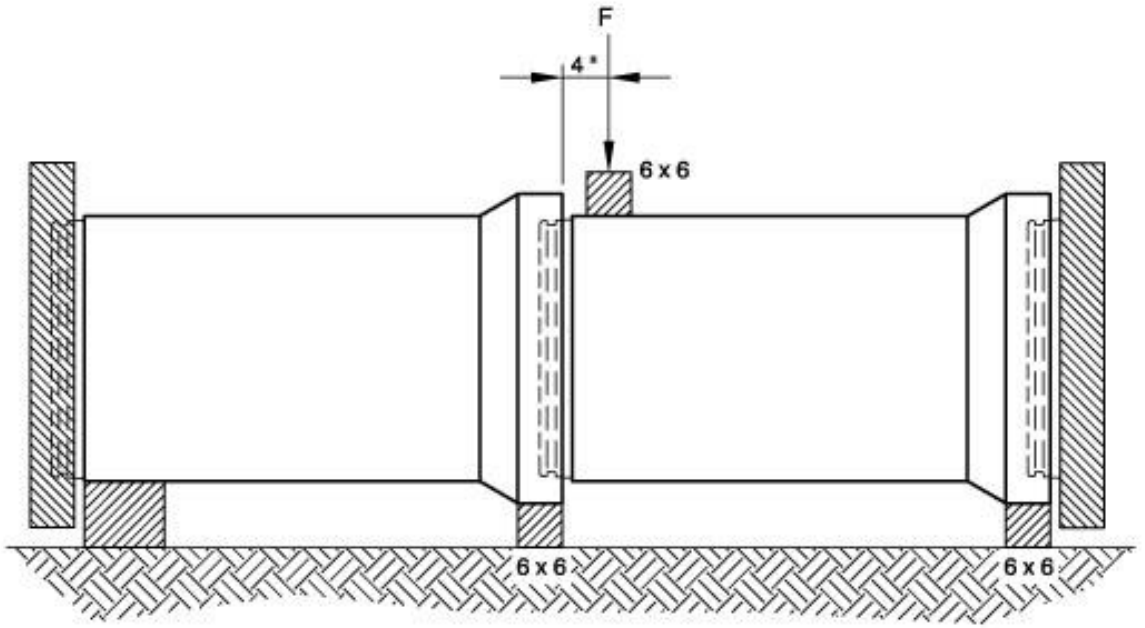
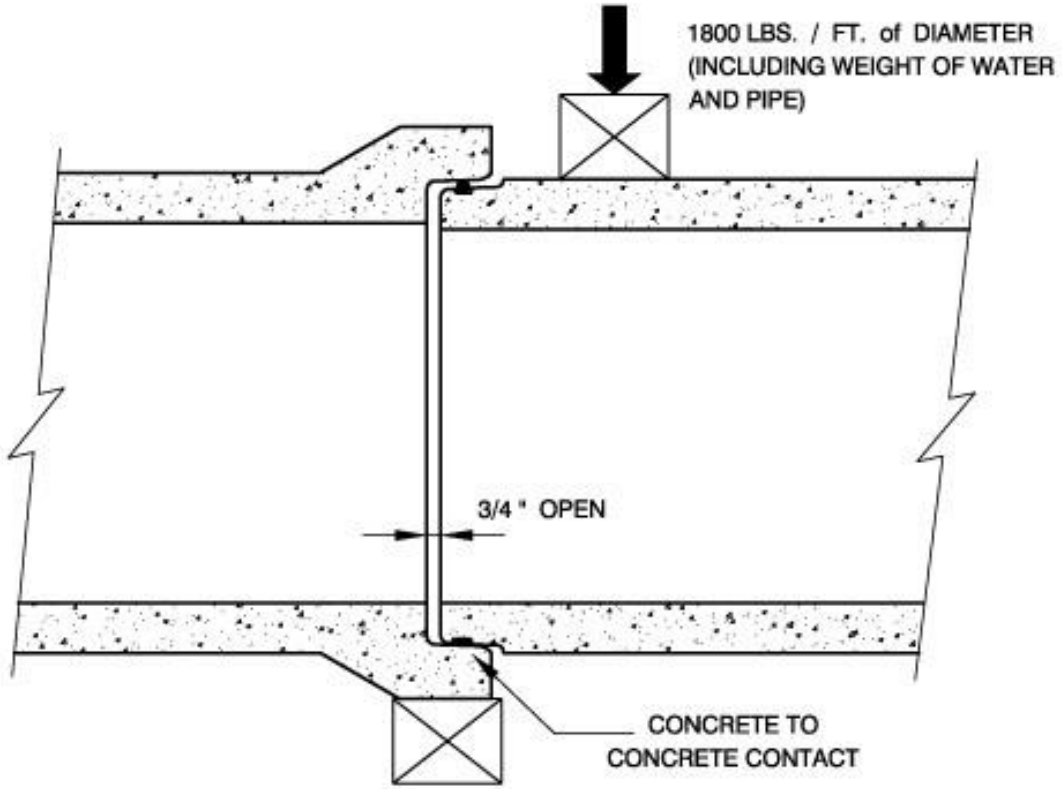


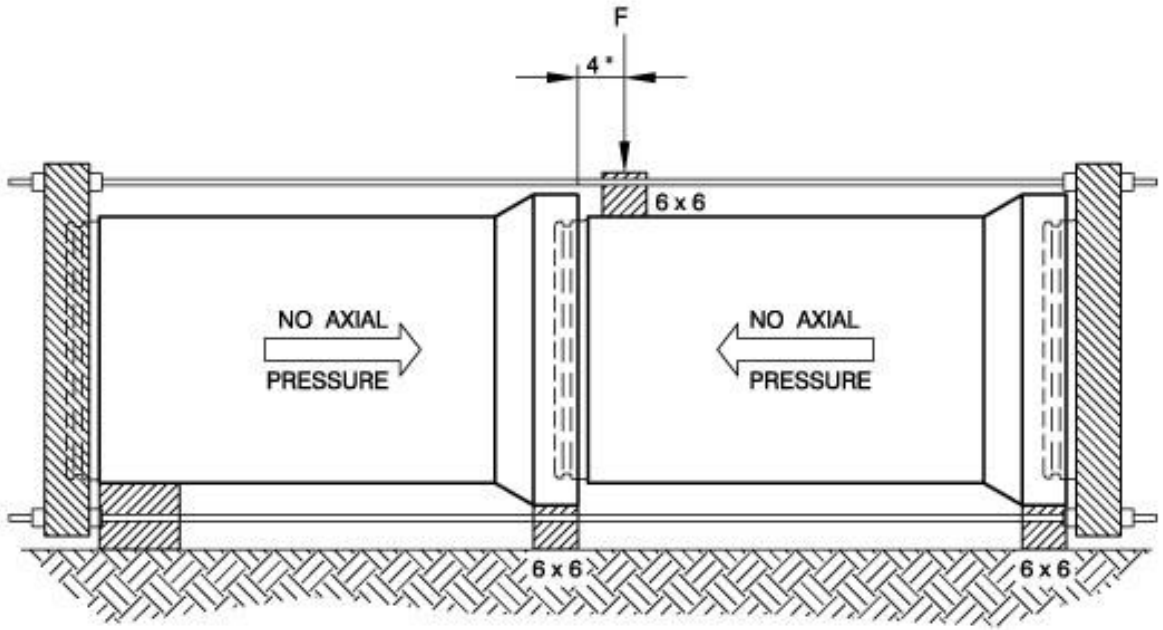
Figure 1
Off Center Hydrostatic Joint Test Setup

JOINTS HOLD WATER UNDER PRESSURE w/ CONCRETE TO CONCRETE CONTACT



QUALITY SCHOOL

OFF CENTER HYDROSTATIC JOINT TEST



BULKHEADS CANNOT PUT AXIAL
PRESSURE ON PIPES BEING TESTED

WHAT IS A PASSING TEST – Off-Center? (QCast)

- Vacuum test: Less than 0.108” drop from 7 inches of mercury over set time period
- Hydrostatic test: Maintain 13 psi for 2-1/2 minutes with no visible leakage (drips)
  - [Can condition the pipes up to 24 hours.]

- Test must be run during a (sanitary) audit unless testing performed at another company plant that is QCast certified.

QUALITY SCHOOL

OFF CENTER JOINT TEST CALCULATIONS

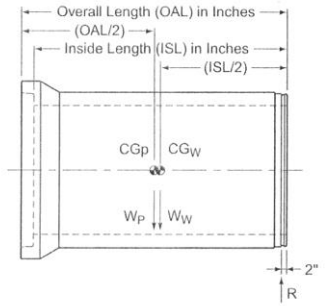
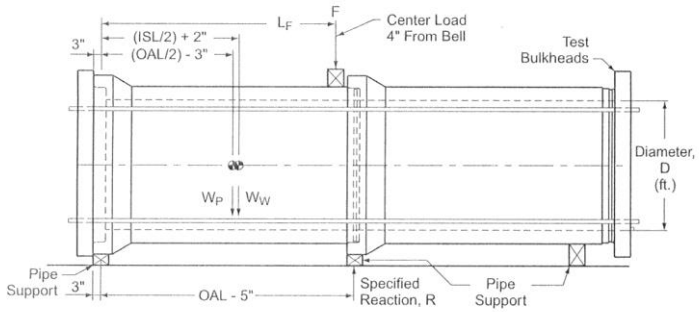


Fig. 1 Simplified Center of Gravity of Pipe Filled With/Without Water



R = Test Requirement
Wp = Nominal Weight of Test Pipe
Ww = Nominal Weight of Water in Test Pipe
Fh = Additional Test Force for Hydrostatic Test
F = Additional Test Force for Vacuum and Low Pressure Air Test

R = 1800 lbs. x Internal Diameter in Feet

$$Fh = \frac{((OAL) - 5")R - ((OAL/2) - 3")W_P - ((ISL/2) + 2")W_W}{L_F} \text{ (lbs.)}$$

$$F = \frac{((OAL) - 5")R - ((OAL/2) - 3")W_P}{L_F}$$

Fig. 2 Off Center Hydrostatic Joint Test

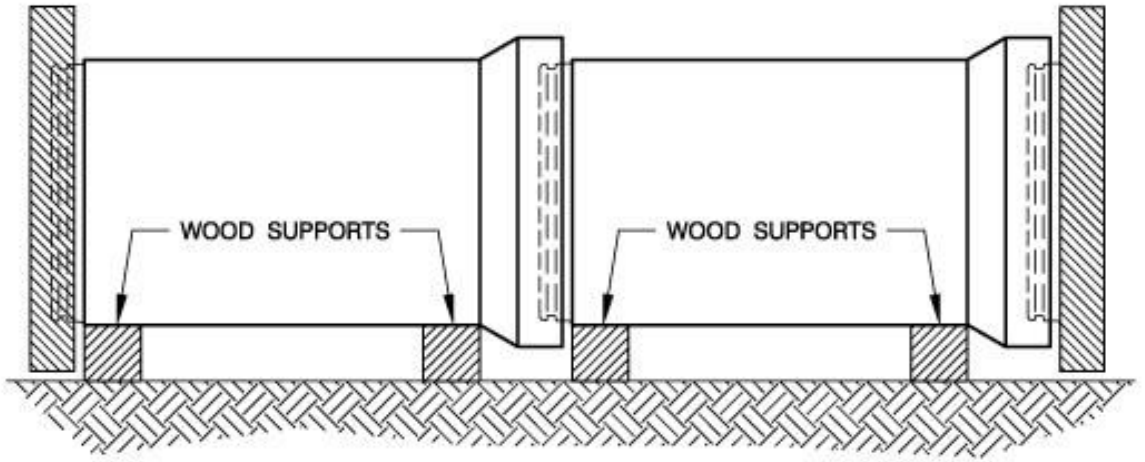
STORM SEWER AND CULVERT JOINT TEST REQUIREMENTS

- Gasketed Storm Pipe Joints
- VACUUM or HYDROSTATIC

- Proof of Design for all Gasketed Pipe Sizes and Joint Designs

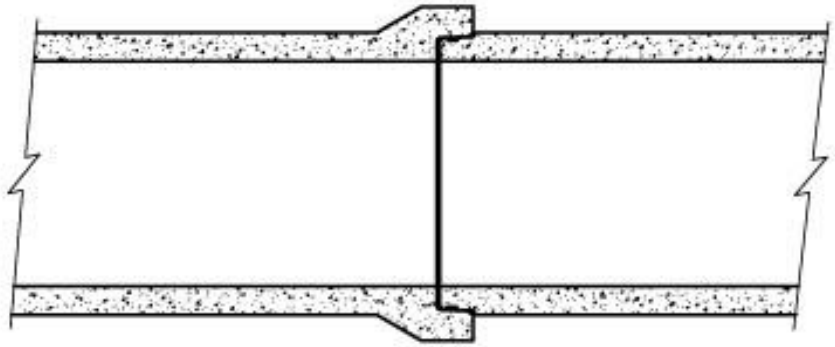
QUALITY SCHOOL

STORM SEWER AND CULVERT JOINT TEST

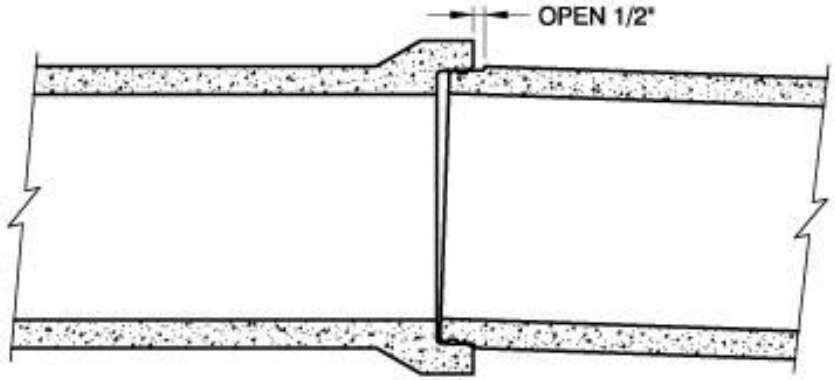


QUALITY SCHOOL

STORM SEWER & CULVERT JOINT TEST



STRAIGHT ALIGNMENT



MAXIMUM DEFLECTION POSITION

WHAT IS A PASSING TEST –Gasketed Storm Joint Test (QCast)?

- Vacuum test: Less than 0.108” drop from 7 inches of mercury over set time period
- Hydrostatic test: Maintain 3 psi for 10 minutes with leakage rate less than 200 gallons/inch diameter/mile of pipe/24 hours

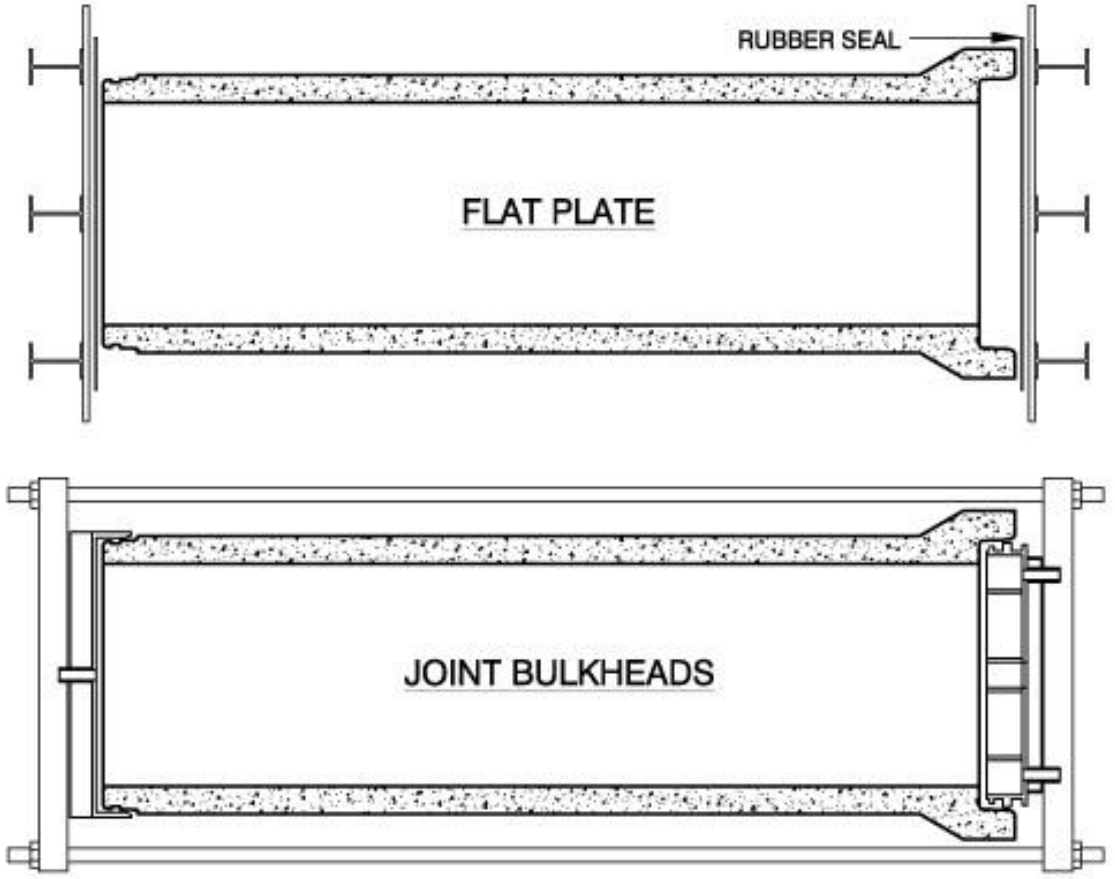
WATER TIGHTNESS TESTS
Sanitary Certification Requirement

In-plant quality control tests for pipe barrels

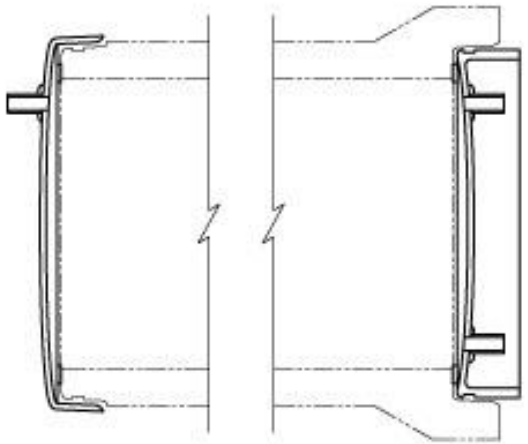
- 12”-36” pipe Vacuum or Hydrostatic (test 100%)
- 42” & larger pipe and manhole Vacuum or Hydrostatic
  - (1/100, min. of 2 pieces)

QUALITY SCHOOL

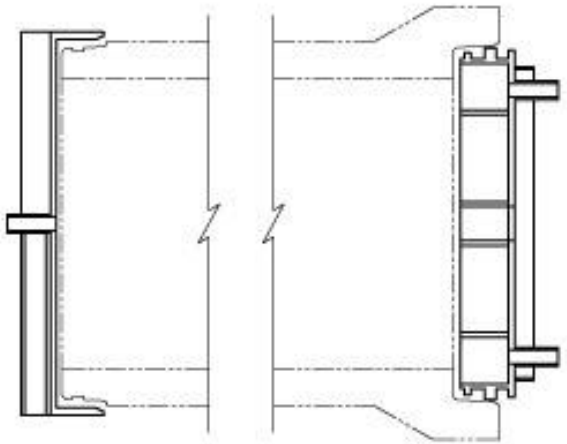
BULKHEAD STYLES



JOINT BULKHEAD OPTIONS



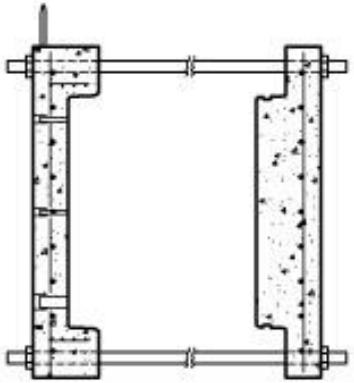
FIBERGLASS (VACUUM ONLY)



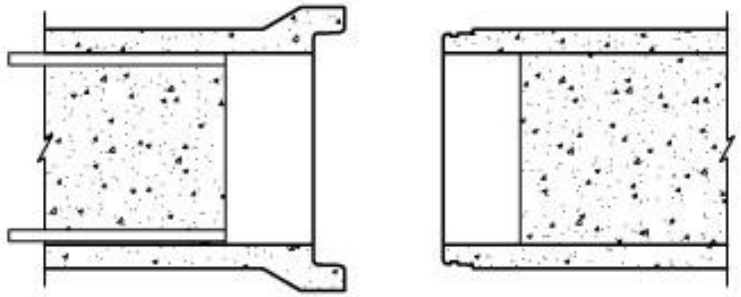
FABRICATED STEEL

QUALITY SCHOOL

JOINT BULKHEAD OPTIONS



REINFORCED CONCRETE

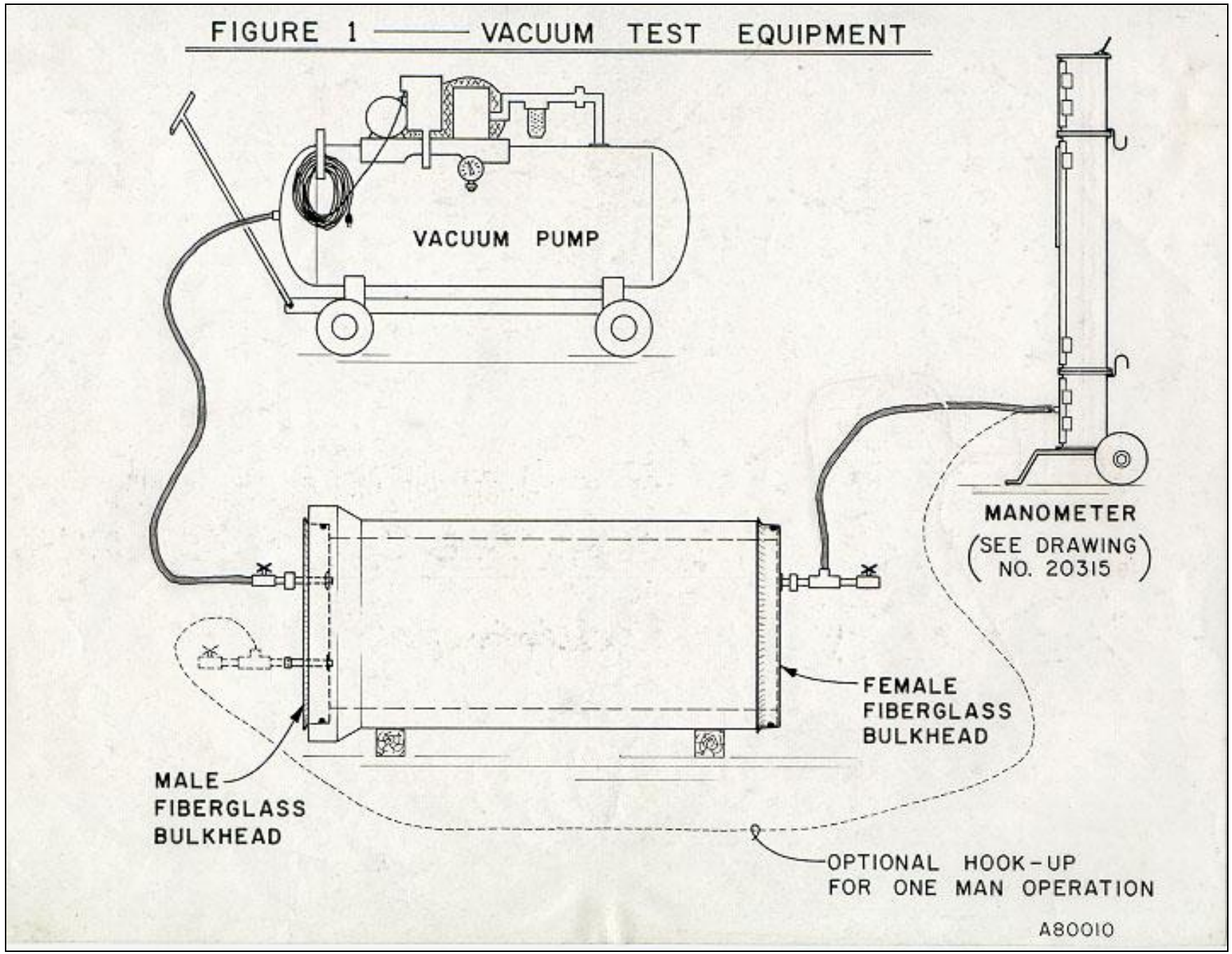


FILLED PIPE BULKHEADS

ACPA PIPE PLANT CERTIFICATION
Requires 100% plant testing
12”-36” Sanitary Sewer Pipe

- 12”-36” Vacuum Test
  - Starting vacuum is 7” Hg
- 12”-36” Hydrostatic Test
  - 13 psi for 2 1/2 minutes
- Found in Appendix A of QCAST Certification Manual

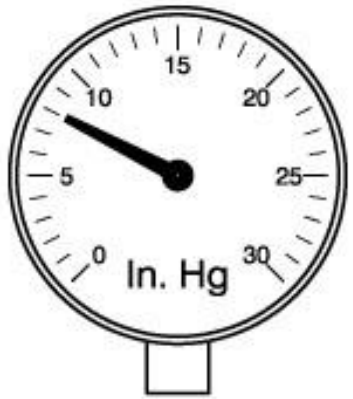
FIGURE 1 —— VACUUM TEST EQUIPMENT



PRESSURE MEASURING DEVICES

PRESSURE GAGE

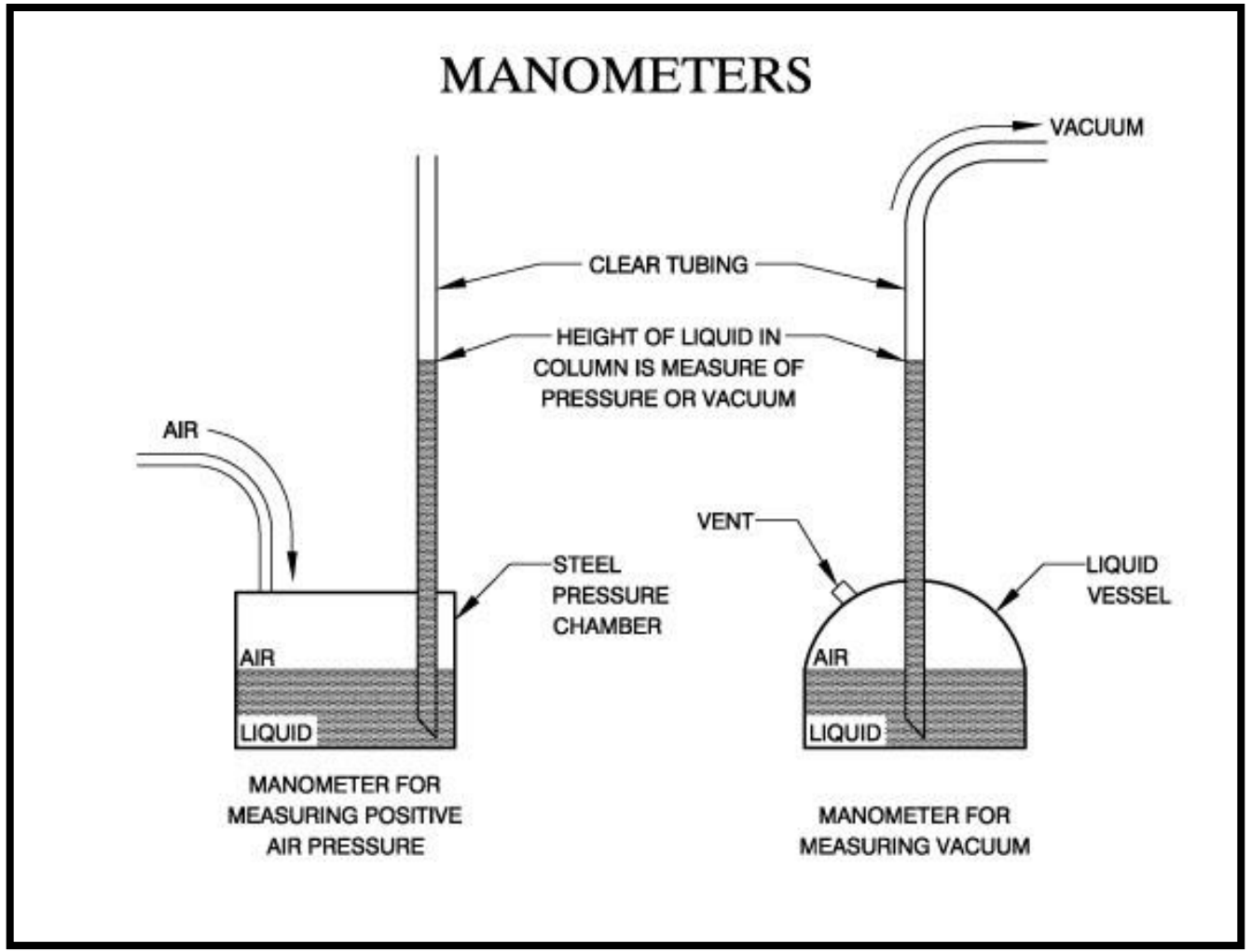
0-25 PSI

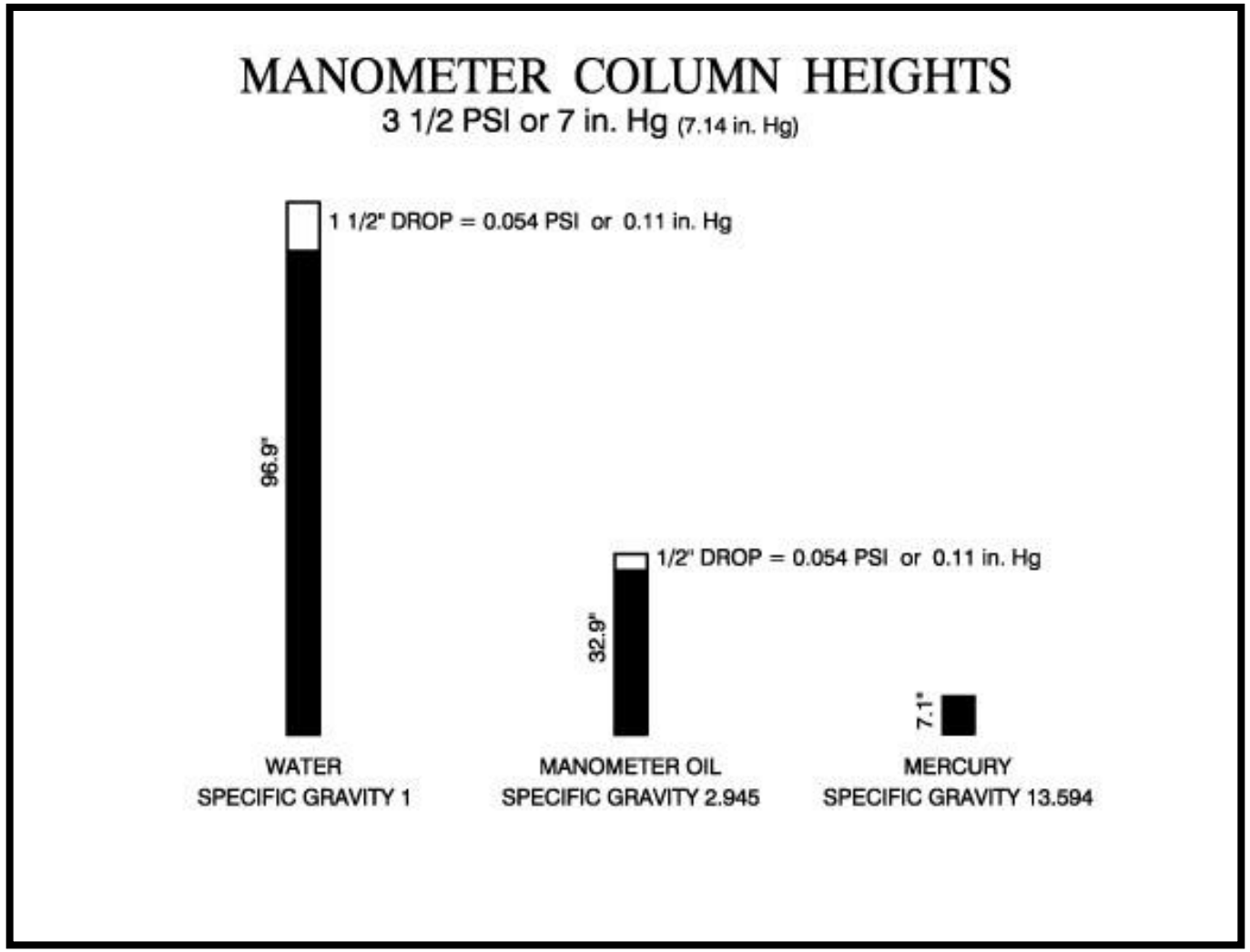


VACUUM GAGE

0-30 In. Hg

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


MANOMETERS
VACUUM
CLEAR TUBING
HEIGHT OF LIQUID IN COLUMN IS MEASURE OF PRESSURE OR VACUUM
AIR
STEEL PRESSURE CHAMBER
AIR
LIQUID
MANOMETER FOR MEASURING POSITIVE AIR PRESSURE
VENT
LIQUID VESSEL
AIR
LIQUID
MANOMETER FOR MEASURING VACUUM


MANOMETER COLUMN HEIGHTS
3 1/2 PSI or 7 in. Hg (7.14 in. Hg)
1 1/2" DROP = 0.054 PSI or 0.11 in. Hg
96.9"
1/2" DROP = 0.054 PSI or 0.11 in. Hg
32.9"
7.1"
WATER
SPECIFIC GRAVITY 1
MANOMETER OIL
SPECIFIC GRAVITY 2.945
MERCURY
SPECIFIC GRAVITY 13.594

QUALITY SCHOOL

VACUUM TEST TABLE

Test Time, Seconds (2)

Pipe Size	0.0017 CFM/ft² (3)	0.003 CFM/ft² (3)
12"	32	18
15"	41	23
18"	49	28
21"	57	32
24"	64	36
27"	73	41
30"	81	46
33"	90	51
36"	97	55
42"	114	64
48"	128	72
54"	146	82
60"	162	92
66"	180	102
72"	194	110
78"	209	118
84"	226	128
90"	243	138
96"	256	144

(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.

QUALITY SCHOOL

OK to use modified Vacuum Test Pressures and Time,
see QCast Appendix

- Digital Manometer

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 2minutes 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 <u>as soon as</u> the gauge drops to 250.**
8. **Ending test pressure is 246. Stop the stopwatch <u>as soon as</u> 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.**

DIAMETER	Digital Manometer Test Times FAIL SECONDS
12”	Less than 35
15”	Less than 44
18”	Less than 52
21”	Less than 61
24”	Less than 70
27”	Less than 79
30”	Less than 87
33”	Less than 96
36”	Less than 105
48” Manhole	Less than 78*

*** Based on leakage rate of 0.0017 cfm/ft^2 except for 48” manholes which are 0.003 cfm/ft^2**

12” - 36” HYDROSTATIC (Water)

- 100% OF SANITARY PIPE
- 13 psi for 2 1/2 minutes
- NO VISIBLE LEAKAGE THAT RESULTS IN A DRIP

42” AND LARGER HYDROSTATIC or VACUUM TEST

- Hydrostatic test - 13 psi for 2-1/2 minutes with no visible leakage (drip)
- Vacuum test per table
- 1/100 - minimum of two per lot

QUESTIONS?