TEST EVALUATION, *DURA-SEAL 6*
for 6" Dia. PVC SERVICE CONNECTIONS

SUMMARY
Blackthorn, Inc.'s *Dura-Seal 6*, as supplied for the connection of 6" dia. PVC pipes to access chambers, complies with the physical test requirements set out in ASTM C 923-96.
This seal provides a watertight and simple to install connection for PVC pipes to pre-cast or in-situ concrete access chambers.

INTRODUCTION
Blackthorn, Inc., which currently has a large range of rubber rings and seals for the concrete industry (& others), has recently developed a new flexible pipe connection seal in sizes to suit 4" and up nominal diameter pipes. Blackthorn, Inc. claims this seal offers superior jointing capability's to those previously available to the industry.

A test exercise was undertaken to evaluate *Dura-Seal 6's* capability. In particular, to verify how the *Dura-Seal 6* performs against specification requirements for pressure, angular installation deflection and simulated lateral earth loads.

Refer Diagram 1, and Photographs for details of Blackthorn's *Dura-Seal 6*

TEST PRESSURES, SHEAR LOADS AND DEFLECTIONS
In order to test the Dura-Seal 6 under the most severe conditions, a number of relevant Standards were consulted per Table 1.

From this data, the following values and approaches were adopted for testing the flexible connection seal:

- Pressure
  Water = 13 PSI Internally applied and maintained for 5 minutes, per reference 1.
  The ASTM standard per reference 3 below, is the basis of using internal pressure. In addition, internal pressure was adopted for the convenience of sequentially carrying out the water and air test (refer below).

  Air = -5 to -13 PSI A minimum pressure of -5 PSI was planned per the ASTM standard and WSA (reference 4, 5, 6 & 8). Air pressure was internally applied and maintained for 3 minutes per Melbourne Water Specification (reference 7). A maximum of -13 PSI vacuum pressure was also planned to test whether an equivalent pressure to water could be successfully applied.

  With the growing environmental and economic concerns, in respect to ingress of ground water into sewerage systems, Authorities and Consultants are increasingly requiring the testing of PCAC and sewer line installations by air (vacuum). Since PCAC service connections will be subjected to air tests in the field, it was decided to include and to evaluate the air test method.

- Deflection = 7 degrees minimum.
  The ASTM standard per reference 3 below was adopted.

- Shear Load = 1012 to 1461 lbf
  The test arrangement and minimum shear load of 1012 lbf is based on the ASTM standard (reference 3 and diagram A in Table 1 attached) for a 6 " pipe diameter. Whilst the exact conversion from imperial equals 4.0 KN, a slightly higher value was adopted.
  The maximum load of 1460 lbf, is the calculated test force to produce the equivalent "shear load" of 730 lbf at the joint/connection per the test load and arrangement in the "Clay Pipe Standard" (AS 1741 reference 2), when applied using the ASTM test arrangement.

METHOD OF TEST

Testing was carried out using the Humes Laverton PCAC testing station, comprising load tester, hydro-static tester and jib crane.

Particular aspects of the set-up of this equipment for trials are as follows:

1 The hydro-test ends were re-located adjacent to the load tester so the load tester jack could be employed to apply shear load to connection pipe. Arrangement per ASTM C 923-96 (Refer diagram A, in Table-1).

2 A standard 43" ID x 3.5" wall x 35" ht PCAC shaft, was randomly selected from factory stock, was installed into the Hydro-test ends.

3 To determine the sealing capability of the seal under minimum rubber compression, the largest "maximum GAP" dimensions for the combination of pipe and cored hole was sought.
After measurement of PVC pipe and preliminary 9-inch nominal cored holes, an oversize cored hole of 9.1" was cut and adopted for tests. Refer Diagram 2 for Test Connection Dimensions.
This +0.1" oversize cored hole dimension gives a "maximum GAP" of 1.77" which allows for the largest cored hole oversize tolerance of +0.1" and PVC pipe undersize tolerance of -0.02".

4 For tests 1,2,3 & 4 the connection seal was initially positioned in wall per Set-up 1A in Diagram 3, and bolts lightly tightened to hold firm in oversize cored hole.
For test 6, the connection seal was initially positioned per above then subsequently deflected per Set-up 2A in Diagram 3, equivalent to a deflection of 10 degrees. At this deflection the edge of the connection seal is flush with the inside & outside of the PCAC shaft wall.

5 After a 10ft length of PVC pipe was positioned in the connection seal and seated on the Shear Test cradle, it was aligned with PCAC shaft centre-line (marked on the inside). All (6) nuts were then fully tightened to provide maximum rubber compression. Ie nuts bottomed out on bolt.

6 For those tests having deflected PVC pipe, the pipe was deflected 7 degree per measurements marked on the Shear test cradle support. (refer Diagram 4 and photographs).
Ie For test 1,2,3 and 5, the PVC pipe was deflected horizontally, whilst for test 4 the pipe was deflected vertically up and pipe cradles packed to suit (refer photographs).

7 To facilitate both internal water and air pressure testing, the PVC pipe ends were sealed using end plates inter-connecting with a threaded rod. In addition, the PVC pipe end was tethered to a bridge piece inside PCAC so neither applied pressure would displace PVC pipe through connection seal.

8 The "shear test load" was applied using the load tester hydraulic jack, via a calibrated load cell and test cradle centrally position between supports.

9 For water pressure testing, the PCAC was filled with water, the air bled off, then pressure increased to 13-14.5 PSI and held for 5 min. Where pressure loss was observed the pump valve was opened to maintain pressure with-in 13-14.5 PSI.
For air testing, (which always followed water testing), water was pumped from PCAC and vacuum pump and gauge connected. Vacuum pressure was increased to a maximum achievable, pump isolated and pressure monitored for nominated duration.

10 Test results were accessed in the following way.
Water Test. The external area of the connection seal was continuous monitored for any visible appearance of water emanating from interface of concrete chamber and seal or seal and PVC pipe as well as through the body of connection seal itself.
Air Test. The loss of vacuum pressure was recorded against time. Where unacceptable loss of pressure occurred, location of air being sucked in was sought by sound and marked.

RESULTS & CONCLUSIONS

Test results are recorded in Table 2 of appendix attached.

The test results show that Blackthorn's *Dura-Seal 6* showed no sign of leakage of water or air when subjected to the 6 test arrangements having specified pressures, deflections and shear loads and at minimum rubber compression.

In addition, Blackthorn's *Dura-Seal 6* was found to be easily installed requiring only a socket for tightening bolts and offers greater flexibility when aligning connecting PVC pipes to access chambers. The Seal design allows some 7-degree of deflection within the seal itself with an additional 10 degrees available within the cored hole.

ACKNOWLEDGMENT

Graeme Cook of "Vac-Tite Services" for the supply of vacuum equipment and assistance performing tests.

NOTE
This investigation forms part of R&D project RD663 - Sealed Pre-cast Access Chambers

KEYWORDS
Manholes, seals, joints

REFERENCES

1. AS 4198-1994, -Precast Concrete Access Chambers for Sewerage Applications.
2. AS 1741-1991, -Vitrified clay pipes & fittings with flexible joints - Sewer quality.
3. ASTM C 923-96, Standard Specification for Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes and Laterals.
4. ASTM C 1244-93, Standard tests Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test.
5. Water Services Association of Australia, - Sewerage Code of Australia WSA 02-1999.
6. Sydney Water Corporation, Supplement Sewerage Code of Australia S0001 Issue:01 Mar-00.
7. Melbourne Water Specification 92 OA 16-8.5
8. Gold Coast City Council, Standard Specification & Drawings for Sewerage Reticulation

ATTACHMENTS
1. TABLE 1, Summary of Specification Requirements for Pressure, Deflection and Shear loads
2. TABLE 2, Test Results
3. Diagram 1, Blackthorn Inc.'s *Dura-Seal 6*
4. Diagram 2, Test Connection Dimensions
5. Diagram 3, Alternative Seal and Pipe connection alignments for testing.
6. Diagram 4, Seal connection angles and deflection measurements
7. Photograph

ATTACHMENTS

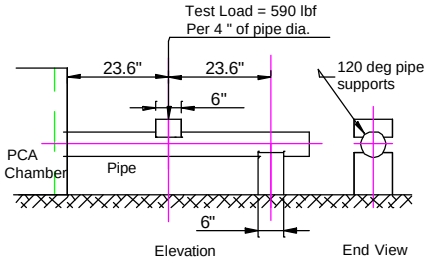
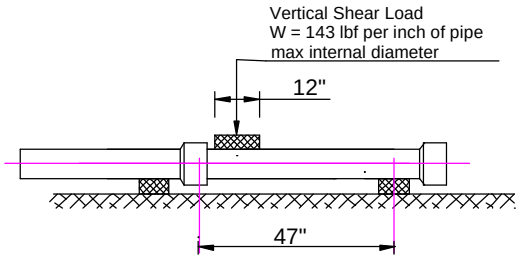
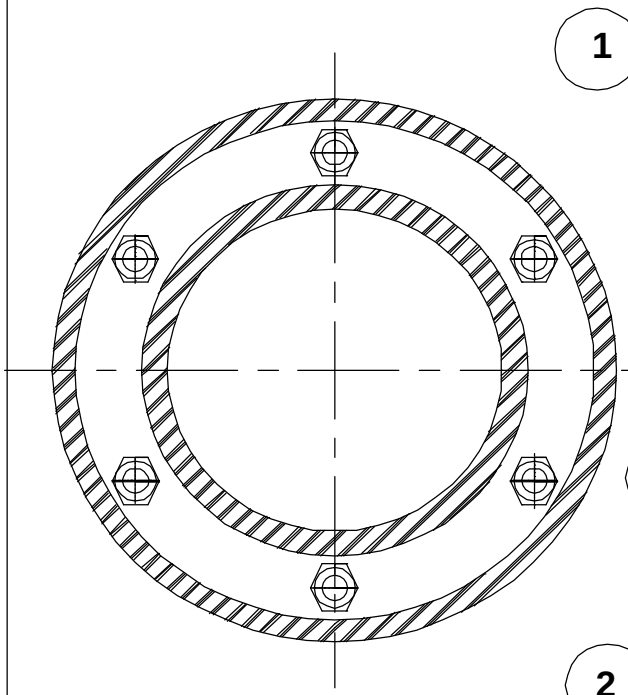
Test	Spec. / Specifier	Requirement
1. Pressure		
Water pressure	AS 4198	13 PSI (externally applied for joint) Maintain pressure for 5 min Pass = no leakage external to the joint/connection
	ASTM C 923-96	10 PSI (internally applied to joint) Maintain pressure for 10 min Pass = no freely dripping water emanating from interface of concrete chamber and seal or seal and lateral pipe nor through the body of seal itself.
	AS 1741	8.7 PSI (internally applied to pipe joint) Maintain pressure for 5 min. Pass = no leakage at joint
Air pressure (vacuum)	WSA & Sydney Water	-5 PSI Pass = Time greater than 82 sec (ie equiv 10m depth) for a maximum vacuum drop of 3.5 KPa
	Melbourne Water Specification	-4 PSI Pass = Time greater than 180 sec for a maximum vacuum drop of 0.7 PSI
	Gold Coast City Council	-5 PSI Pass = Time greater than 82 sec (ie equiv 10m depth) for a maximum vacuum drop of 0.5 PSI
	ASTM C 1244-93	-5 PSI Pass = Time greater than 79 sec (ie equiv 10m depth) for a maximum vacuum drop of 0.5 PSI.
2. Deflection	ASTM C 923-96	Minimum axial deflection in any direction of at least 7 deg.
3. Shear Test Load	ASTM C 923-96	900 PSI load for a 6" dia PVC pipe, to produce a 450 lbf shear load at rubber seal.  Diagram A ASTM Test Arrangement
	AS 1741	840 lbf load for a 6" dia PVC pipe, to produce a 730 lbf shear load at rubber seal.  Diagram B, AS1741 Test arrangement

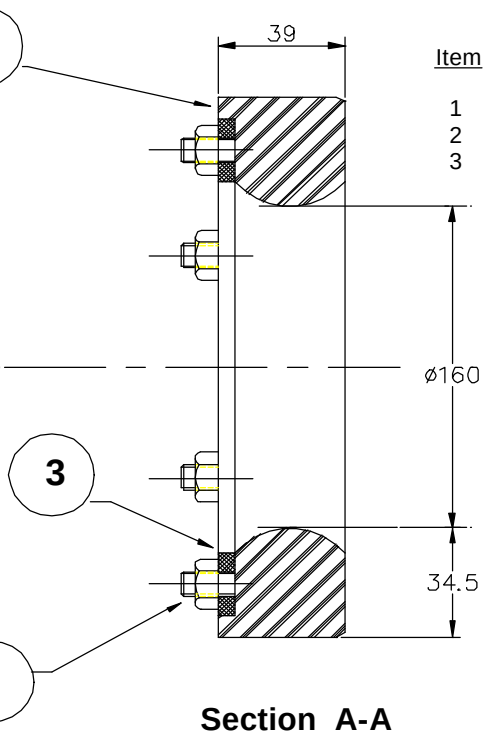
TABLE 1, Summary of Specification Requirements for Pressure, Deflection and Shear loads

TEST No	Date	Test Details	Deflection	Shear Load lbf	Test Time Hr:min	Pressure	Comments / Result
1	17-Aug	**Water**	Nil	1011	11:19-11:24	13-14.5 PSI	Water beads forming at 8 location in shaft. None at connector.
		Refer Diag. 3				13-14.5 PSI	Water beads in shaft running. None at connector
		Set-up 1A		1461	11:25-11:30		**PASS**
2	17-Aug	**Air**	Nil	1034	11:47-11:50	0 to -5.2 PSI	
		Refer Diag. 3		1034	11:50-11:55	-5.2 PSI	No loss of vacuum pressure
		Set-up 1A		1484	11:55-12:00	-5.2 PSI	No loss of vacuum pressure
							PASS
3	17-Aug	**Air**	Nil	1056	12:02-12:25	-5.2 to -10.4 PSI	Max. vacuum achievable with equipment
		Refer Diag. 3		1056	12:25-12:39	-10.4 PSI	No loss of vacuum pressure
		Set-up 1A		1461	12:45-01:00	0 to -10 PSI	Max. vacuum achievable with equipment
				1461	01:00-01:07	-10 PSI	No loss of vacuum pressure
							PASS
4	17-Aug	**Air**	**7 deg.**	1056	01:54-02:15	0 to -10 PSI	Max. vacuum achievable with equipment
		Refer Diag. 3	HORIZONTAL	1056	02:15-02:20	-10 PSI	No loss of vacuum pressure
		Set-up 1B		1461	02:20-02:25	-10 PSI	No loss of vacuum pressure
							PASS
5	17-Aug	**Water**	**7 deg.**	1011	02:46-02:51	13-14.5 PSI	Water beads various shaft locations. None at connector.
		Refer Diag. 3	VERTICAL	1461	02:53-02:58	13-14.5 PSI	Water beads various shaft locations. None at connector
		per Set-up 1B					**PASS**
6	22-Sep	**Water**	**17 deg. Total**		03:02-03:07	13-14.5 PSI	Water beads various shaft locations. None at connector
		Refer Diag. 3	HORIZONTAL	1034	03:20-03:25	13-15.2 PSI	Water beads various shaft locations. None at connector.
		Set-up 2B		1484	03:30-03:35	13-14.8 PSI	Water beads various shaft locations. None at connector
							PASS

TABLE 2, TEST RESULTS

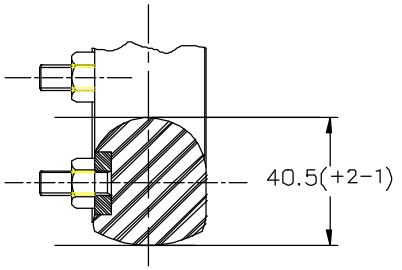


End View



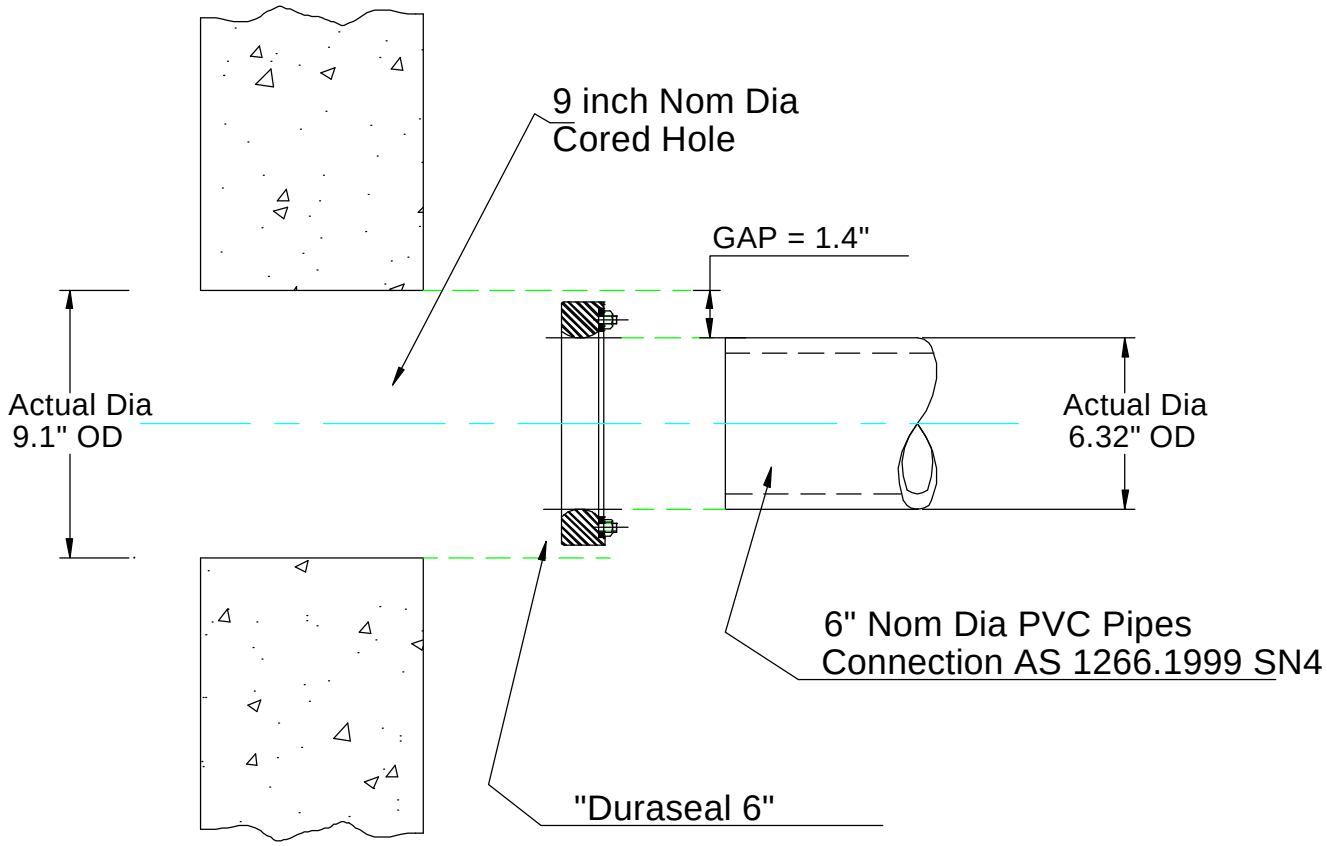
Section A-A

Item	Component	Material
1	Rubber	AS1646, Hardness 42-48 duro
2	6No Bolt/Nuts	304 SS
3	Compression Plate	Bayer Durathan EKV 30 or equivalent

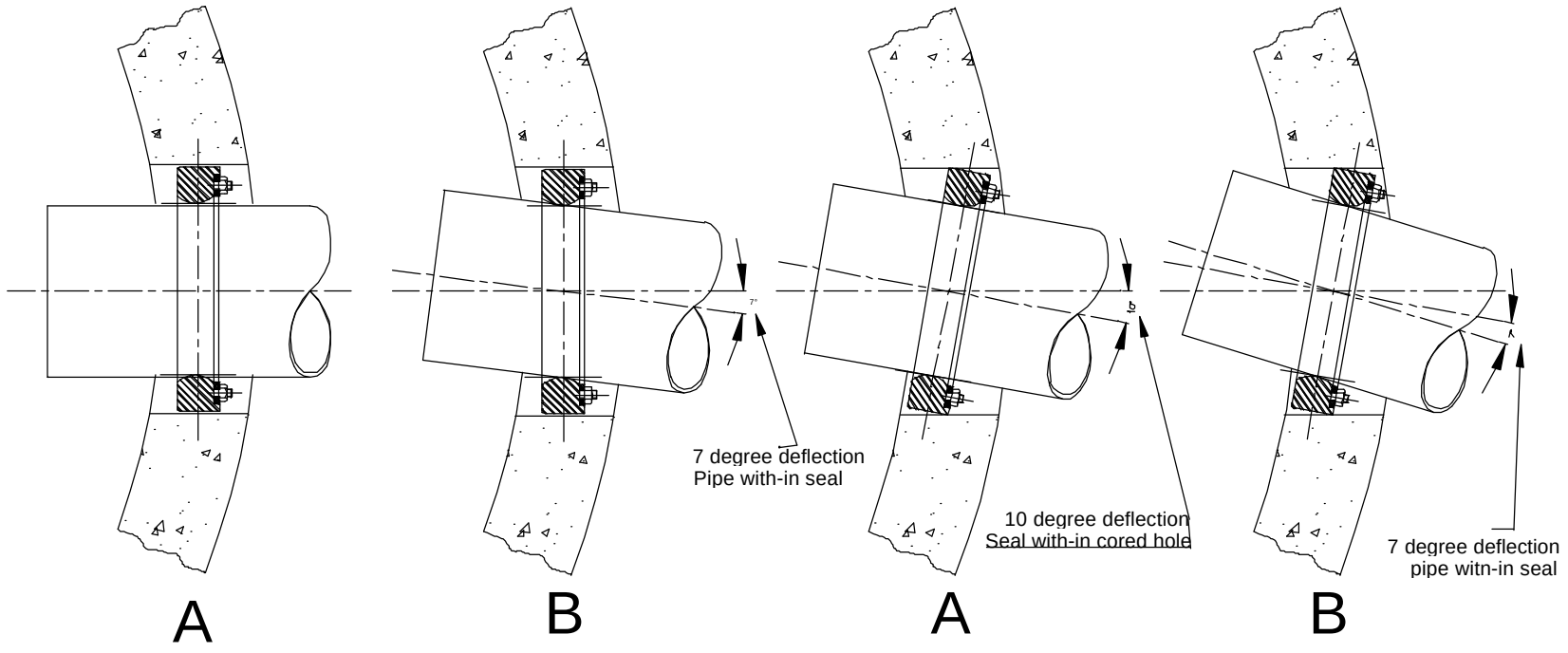


Section
Showing full width of seal when bolts tightened -Un-installed

Diag. 1, Duraseal 6



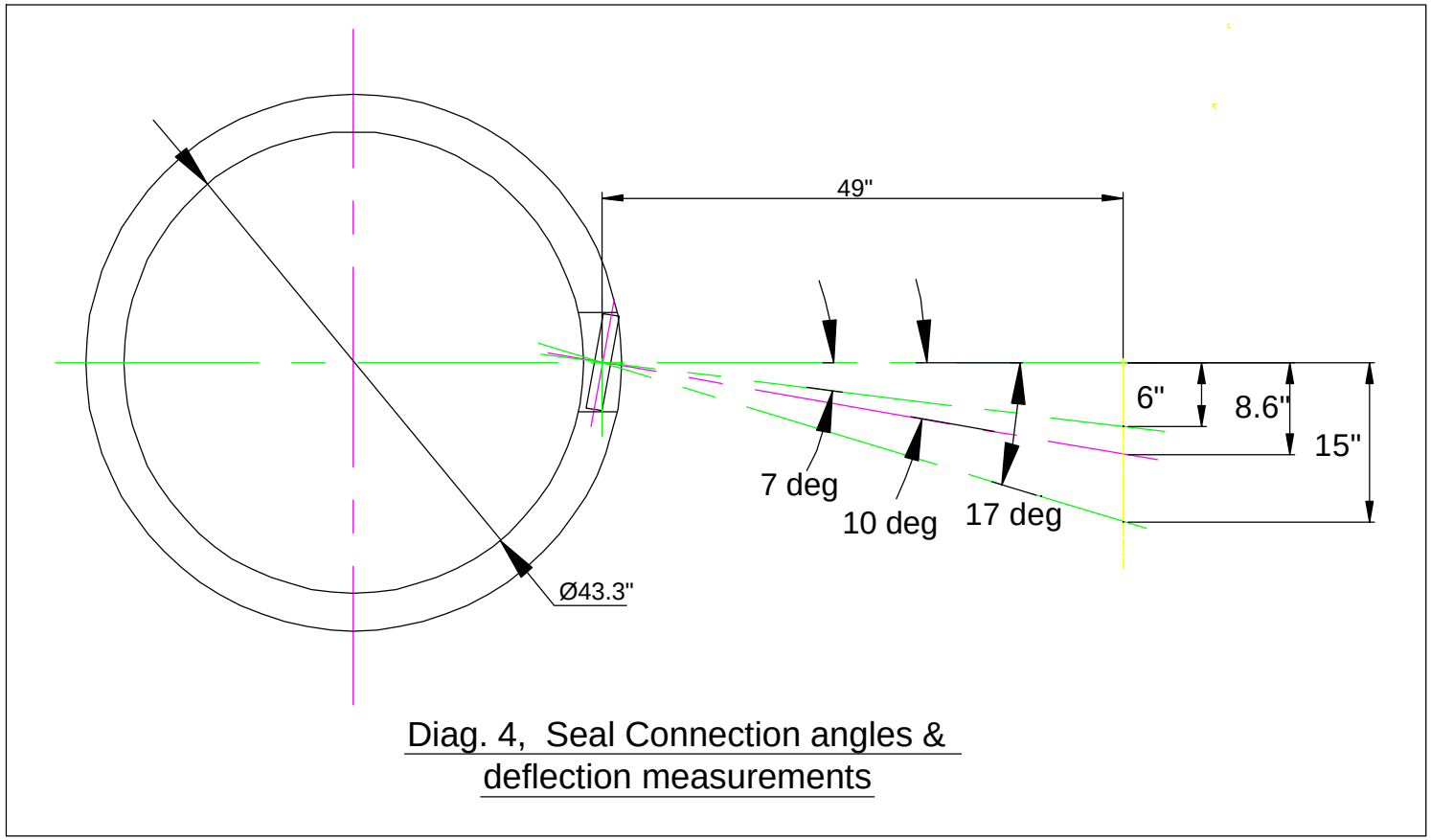
Diag. 2 - Test Connection Dimensions (NTS)



Setup -1

Setup - 2

Diag. 3, Alternative Seal & Pipe Connection Alignments for Testing



Diag. 4, Seal Connection angles & deflection measurements