



Analysis of Aquawrap[®] for use in Repairing Pipelines with a Dent / Gouge Defect

Procedure and Evaluation of Cycle Test

Prepared By
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Test Summary

This test is to qualify the Aquawrap® material to be used for repairing dents in piping.

A section of 12.75" OD pipe was dented and a simulated gouge was ground within the dented area. The pipe was pre-pressurized to 900 psi, which was the calculated MAOP of the pipe when factoring in the wall loss from the gouge. The pipe was then wrapped with Air Logistics' Aquawrap® G-05 composite material and subjected to a series of three pressure cycling tests. Each test had a duration of 5,000 cycles. The maximum pressure of each of the tests were as follows: first phase to 1,525 psi (MAOP), second phase to 1,800 psi (85% of SMYS), third phase to 2,118 psi (100% SMYS). This test was considered successful as there were no leaks present during any of the test cycles and there was no evidence of damage to the pipe or the composite repair material.

Pipe and Defect Details

Test End Date: April 19, 2005
Serial # 967594

Test Location: Authorized Testing
2522 Kansas Avenue
Riverside, CA 92507

Pipe Details - 12.75" OD
0.250 wall
ASTM A53 Grade B Pipe
54,000 SMYS (2,118 psi)
72,000 Ultimate (UTS) (2,824 psi)
MAOP 1,525 psi

Defect Details - Dent - 11" long (axial length) x 5" wide (circumferentially)
Deepest point of dent – 0.91" (7.2% of pipe OD)
Created with blunt force object and an abrasive tool
Dent ground smooth before repair application
Gouge - 0.1875" wide
4" long
0.0875" deep (35% of pipe wall thickness)

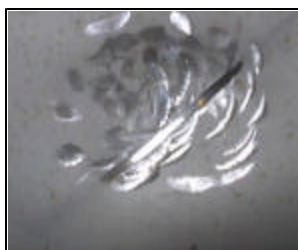


Fig. 1 – Top view of dent with gouge.



Fig. 2 – Angled view of dent with gouge.

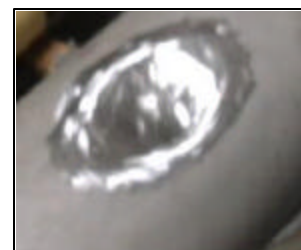


Fig. 3 – Dent ground smooth prior to repair.

Wrap Details - 34 Layers of Aquawrap® G-05, 24" of linear coverage

Fabric weight	24 oz.
Nominal Thickness	27 mils
Tensile Strength	47,500 psi
Tensile Modulus	3.2 e6 psi
Tensile Load Per Ply	1,280 psi
Compressive Strength	25,000 psi
Interlaminar Shear	2,750 psi

Repair Process

Prior to the repair, the pipe specimen was taken to Authorized Testing and pre-conditioned. The pipe was hydrostatically pressurized and taken from 0 psi to 900 psi within 7 minutes, and then was held at that pressure for another 7 minutes. The pressure was then relieved and the pipe drained of water. Very little re-rounding of the dent was observed. Refer to Fig. 4 for before and after measurements. The pressure of 900 psi was calculated by figuring what the MAOP would be, given the depth of the wall loss within the dented area.

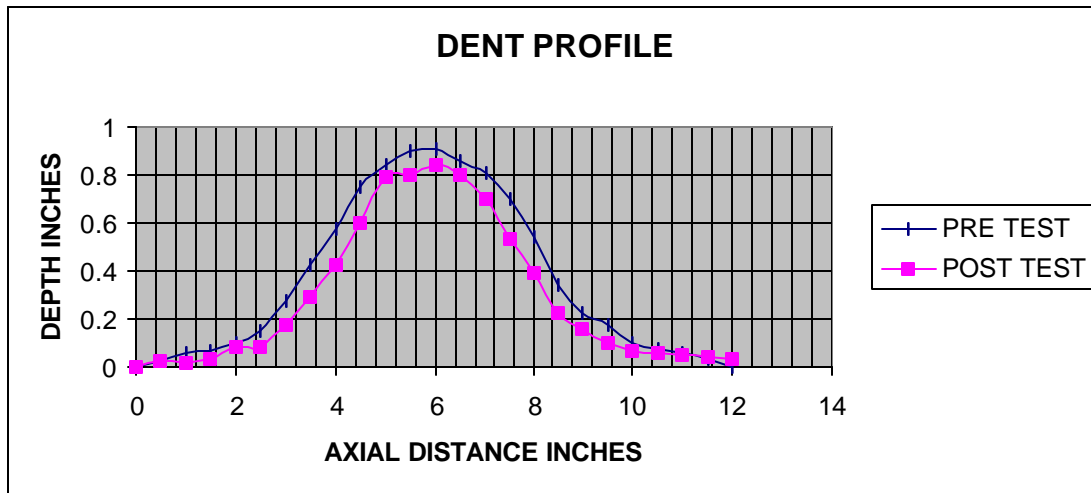


Fig. 4

The pipe was prepared by sandblasting to a NACE II finish and wiped clean with acetone. The dent was filled using TFT Bio-Fix 911 repair epoxy (Fig.5). This high strength filler material will act as the load transfer compound between the composite and the steel. The material was allowed to cure, and then contoured to match the profile of the pipe. Again, the pipe was wiped clean with acetone to remove any loose debris that may have accumulated from the contouring process. BP-1 Primer was applied and allowed to become slightly tacky (Fig. 6). Next, the first lift (courses one and two with a total of 18 layers) of Aquawrap® G-05 was installed circumferentially around the pipe, with the dent centered within the repair area. Stricture Banding™ was applied, and the lay-up was then allowed to cure. The duration from the application of the BP-1 to the end of this initial installation was sixty minutes. After two hours of cure time, BP-2 Interlaminar Adhesive was applied, along with the second and final lift (courses one and two with a total of 16 layers) of G-05 fabric. This lift was again installed circumferentially. The final application of Stricture Banding™ was installed and the lay-up was allowed to completely cure (Fig. 7). The total number of layers of G-05 material applied to the pipe was thirty-four. Refer to the Lay-up Diagram for clarification.



Fig. 5



Fig. 6



Fig. 7

Cycle Test Procedure

The maximum allowable operation pressure (MAOP) of the undamaged 12" pipe is 1,525 psi, using a .72 design factor, per ASME B31.4. The SMYS pressure for this same pipe is 2,118 psi. We have chosen to design this repair so that the repair system can handle at least 100% of the SMYS pressure. The wrap design was based upon no allowance for the steel in the dent area, using the long term (creep-rupture) strength of the wrap, and a .67 design factor for the composite (in accordance with the pending ASME Post Construction Repair Standard for composite repairs).

The initial cycle-test phase consisted of pressurizing the repaired specimen from 200 psi to 1,525 psi (MAOP of pristine pipe) for a minimum of 5,000 cycles. When this was complete, the next phase took the specimen from 200 psi to 1,800 psi (85% of the SMYS) for a minimum of 5,000 cycles. The final phase took the specimen to 2,118.00 psi (100% of the SMYS) for a minimum of 5,000 cycles.

The test was performed using ambient temperature water in a warehouse environment. The minimum dwell time in each of the pressure ranges between 90 and 100 percent of the target pressure was not less than 1.2 seconds.

Cycle Test Results

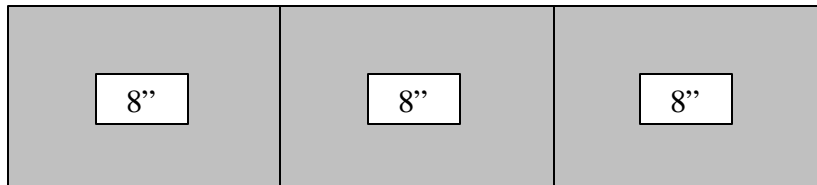
The specimen was inspected after the first phase of cyclical testing, with no visual damage to the pipe or the repair material. The specimen was checked again after the second phase, and again, no visual damage was found on either the pipe or the repair material. After the final test phase, the specimen was removed from the test apparatus and inspected in greater detail. The specimen survived all three 5,000-cycle tests without any signs of leakage or other failure mechanism. This test was deemed a success. A copy of the test report from Authorized Testing is attached.

Lay-up Diagram - Serial #967594
Start Date – March 24, 2005 / End Date – April 19, 2005

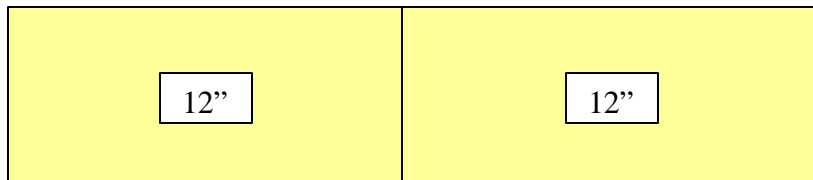


Fig. 8 – Finished repair with 34 layers of Aquawrap® G-05.

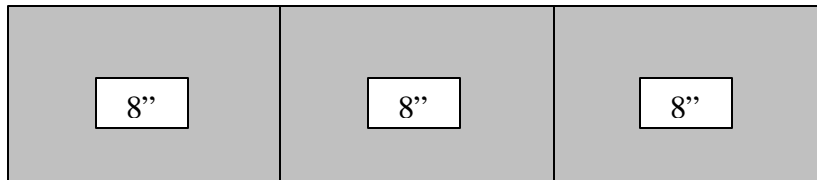
1st Lift – 1st Course - 9 Layers



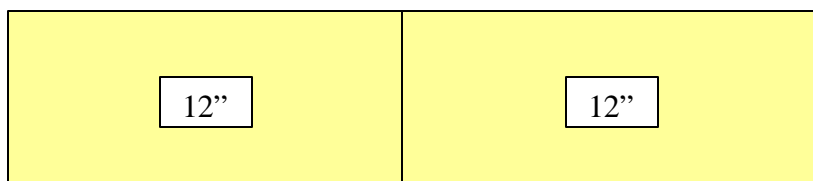
1st Lift – 2nd Course - 9 Layers



2nd Lift – 1st Course - 8 Layers



2nd Lift – 2nd Course - 8 Layers





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TEST REPORT

CUSTOMER: Air Logistics

TEST DATE: 4/19/05

PART NUMBER: Pipe

SUBMITTED BY: A. Schneller

DIAMETER: 12.75"

WALL THICKNESS: .250"

LENGTH: 72"

TEST DESCRIPTION:

PROOF TEST/AMBIENT TEMPERATURE CYCLE TEST

The above listed pipe arrived at the ATI test lab with an 11" wide, .91" deep dent that was not repaired prior to any testing.

The pipe was subjected to a proof test at 900 psi for a duration of seven minutes. During this time the pipe was inspected for any leaks or deformation of which none was noted.

Upon successful completion of the proof test the pipe was then subjected to 5,000 pressure reversal cycles from between not greater than 200 psi and 1,525 psi. The minimum dwell time in the pressure range between 90 and 100 percent was not less than 1.2 seconds. The cycle rate did not exceed 4.6 cycles a minute.

The pipe was then subjected to 5,000 pressure reversal cycles from between not greater than 200 psi and 1,800 psi. The minimum dwell time in the pressure range between 90 and 100 percent was not less than 1.2 seconds. The cycle rate did not exceed 4.6 cycles a minute.

The pipe was then subjected to a third phase of cycle testing, 5,000 pressure reversal cycles from between not greater than 200 psi and 2,118 psi. The minimum dwell time in the pressure range between 90 and 100 percent was not less than 1.2 seconds. The cycle rate did not exceed 4.6 cycles a minute.

Subsequent to each phase of cycle testing the pipe was visually inspected for any leaks or deformation of which none was noted.

The pipe was returned to the manufacturer for further evaluation.

I certify the above information to be true and correct.

Signed: _____

Date: April 20, 2005

Frank Jensen, Vice-President, Special Programs
Authorized Testing, Inc.