Pressure Testing of PipeMedic™ Laminate

Conducted at:

Link-Pipe
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Prepared by:

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This report summarizes a test of a PipeMedic™ laminate that was conducted at the offices of Link-Pipe in Richmond Hill, ON.

<u>Specimen Preparation</u>

A sample of PipeMedic™ laminate and QuakeBond J201TC were shipped from QuakeWrap, Inc. to Link-Pipe. The PipeMedic™ laminate was 0.026 inches thick and was a special product that was produced from a carbon-glass fabric with a total weight of 17.68 oz/yd^2. The construction of the fabric was 16 ends of 12K carbon the 0 degree and 8 ends of 1800 yield E-glass in the 90 degree. This meant 92 % of the weight was carbon and the balance was glass. No previous coupon test data were available for this product, as this was a special sample.

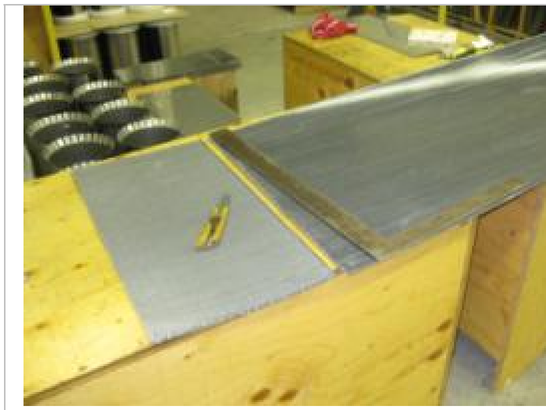

Fig. 1. PipeMedic™ Laminate

The test specimens were prepared by the staff of Link-Pipe under the supervision of Garry Gladstein. Two 30-inch long x 12-inch diameter steel pipes were bolted together such that there was a gap at the connecting ends. Contrary to the common application of PipeMedic™ where the laminates are installed with full backside support provided by the inner surface of the pipe, this sample was prepared as a cylinder supported at its ends. The PipeMedic™ laminate was curved into a 2-ft long x 11 ¼ -inch diameter cylinder. The 14-inch overlap region was bonded together with QuakeBond™ J201TC to form a cylinder. The sample was prepared such that the carbon fibers were in the hoop direction and the much lighter and weaker glass fibers were along the longitudinal axis of the pipe. Figure 2b shows the PipeMedic™ shell with the overlapped region and Figure 2c shows the 2-inch wide x ½-inch thick rings that were bonded to the ends of PipeMedic™.

(a) (b) (c)

Fig. 2 Construction of the specimen; (a) the laminate with approximately 14-inch overlapping region; (b) the support rings at ends; (c) close up of 2-inch wide x ½-inch thick support ring at ends

During the assembly of PipeMedic™, a small bulging (buckling) of the laminate developed at one end when the 2-inch wide end support rings were being bonded (Fig. 3a). This was caused by over-tightening of the hose clamps that were used to affix the end support rings to the PipeMedic™. Attempts to fix this were not successful and the defect remained. Additionally, three small areas where the bumps were intentionally introduced along the PipeMedic™ assembly (Figs. 3b and 3c) to simulate the protrusions that may be present in a damaged pipe or a pipe surface that has not been properly prepared or sandblasted.

(a) (b) (c)

Fig. 3. Defects introduced during the construction of PipeMedic™: (a) buckling near one end, (b) and (c) damage to the resin caused by heat of the grinding wheels

Test Procedure

The PipeMedic™ cylinder was inserted into the pipe. The circular end support rings were lubricated with grease to allow shoving of the PipeMedic™ cylinder into its final position, which was near the midspan of the assembly (Fig. 3a)

(a) (b) (c)

Fig. 3. Sample preparation; (a) PipeMedic™ inside the test assembly; (b) the rubber liner and (c) Link-Pipe end sealers.

A 4-ft long x 12-inch diameter x 1/8-inch thick rubber liner was inserted inside the test assembly (Fig. 3b). At each end of the rubber liner, two strips of a 2-inch wide self-adhesive tape made by butyl compound were placed between the steel pipe and the rubber liner; this provided an adhesive band of nearly 4-inches wide.

Next, 6-inch wide stainless steel Link-Pipe end sealers were inserted into the ends of the rubber liner (Fig. 3c) and were installed using high pressure air (Figs. 4a and 4b). This arrangement ensured that the ends of the rubber liner were perfectly sealed against the steel pipe and no fluid could get behind the liner. Air or water placed in the assembly would cause the rubber liner to expand and that pressure would in turn be applied to the PipeMedic™ laminate.

Next, a 1-inch thick end plates were mounted at each end to cap the test assembly. A single layer of the same butyl tape was applied in a ring at each end to make sure a perfect seal was achieved.

<u>Test Results</u>

On the test day, the assembly was first subjected to an internal air pressure using a 2.5 hp air compressor. The pressure in the assembly was monitored by a pressure gage that was tapped near one end of the pipe (Fig. 4c). The internal pressure was raised to 90 psi which was near the end of the safe limit for the compressor. There was no damage to the specimen at that point. The pressure valve was closed and after about 10 minutes, the pressure was reduced slightly to about 85 psi.

(a) (b) (c)

Fig. 4 pre-test setup: (a) installing the Link-Pipe end sealers with pressurized bladder; (b) installed end sealers; (c) pressure gage mounted near one end of test assembly

At this point, the pressure gage was removed and the specimen was filled with water from the air inlet valve until water started to flow out of the point of attachment of the pressure gage. At that time, the pressure gage was reinstalled on the pipe assembly. Using a 1750 psi pressure washer, the water inside the assembly was pressurized. Some small cracking sound was heard at 150 psi but loading was continued until a pressure of 240 psi (Fig. 5). At that point PipeMedic™ failed, resulting in tearing of the rubber liner and in turn leaking of water from midpoint of the assembly where the two steel pipes were joined together.

The pipe end caps were removed. Around the failure point in the middle point of the test assembly, a bulging of the rubber liner could be seen at the top (Fig. 6). The Link-Pipe end sealers and the rubber liner were taken out (Fig. 7). Inspection of the rubber liner showed a small tearing of about 3/4 inches near the bulged location at midspan. This hole had allowed the water to leak out of the system.

Fig. 5. Testing with pressurized water

Fig. 6. Bulged rubber liner at the conclusion of test

Fig. 7. End sealers removed at the conclusion of test

A view of the PipeMedic™ inside the test assembly showed tension failure in a semi-circular pattern near the midspan that extended over the single-ply region of PipeMedic™ (Fig. 8). Next, the PipeMedic™ assembly was taken out by hammering a wooden block on one end of it to force it move towards the other end of the assembly (Fig. 9). Figure 10 shows the PipeMedic™ assembly taken out of the test assembly.

Fig. 8. PipeMedic™ at conclusion of test inside test assembly

Fig. 9. Removing PipeMedic™ from test assembly

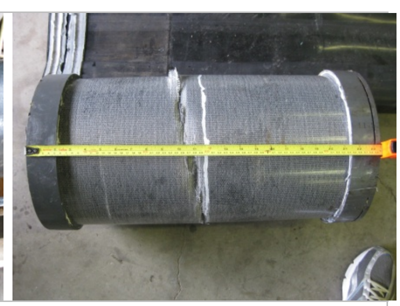

Fig. 10. PipeMedic™ removed from test assembly

As seen in Fig. 11, the damage in PipeMedic™ was in the single-ply zone and the 14-inch region of the circumference where the PipeMedic™ was overlapped (two plies) was not damaged at all. Fig. 12 shows a close-up view of the failure zone and as highlighted in

Fig. 13, the failure of PipeMedic™ at a pressure of 240 psi was due to axial tension failure of the small amount of glass fibers that were present in the longitudinal direction. If the more common PipeMedic™ product PC2.2 , for example, were used this mode of failure could be avoided, resulting in significantly larger failure pressure.

It is interesting to note that the final failure of PipeMedic™ was not due to the defects that were introduced during its assembly, namely the buckled portion at one end and the burnt epoxy shown in Fig. 3.

Fig. 11. Overlap (two-ply) region of PipeMedic™

Fig. 12. Close up view of failure region

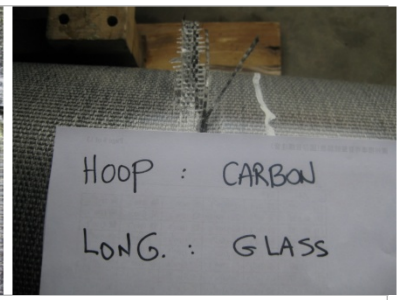

Fig. 13. Close up view of the fibers in PipeMedic™