IN THE LAB

Air-channel testing of thermally bonded flexible polypropylene geomembrane seams

By Timothy D. Stark, Richard W. Thomas, and Thomas J. Dehlin

Introduction

For more than a decade, thermal welding has proven to be an efficient and cost-effective procedure for field-seaming geomembranes.

Thermal welding of polyvinyl chloride (PVC) geomembranes has allowed use of air-channel tests in lieu of destructive peel tests to verify field seams meet specified seam peel strength (Thomas and Stark, 2003). These air-channel tests are effective because they take advantage of the natural flexibility of PVC geomembranes that allows the weld to be peeled and visible inspection of the inflated seam (Thomas et al., 2003; Stark et al., 2004; Stark and Pazmino, 2011). These properties resulted in a relationship between geomembrane sheet temperatures and air-channel pressure required to ensure a seam peel strength of 15 ppiw (pounds per inch width).

Because of the inherent flexibility of unreinforced flexible polypropylene (fPP) geomembranes, it was anticipated that a similar correlation between air-channel air pressure, sheet temperature, and seam peel strength would exist for fPP geomembranes as it does for PVC geomembranes. **Figure 1** presents photographs of an inflated fPP geomembrane seam that resembles an inflated bicycle tube and is similar to the inflation of PVC geomembrane seams. This article describes the ongoing research project that is investigating the development of a relationship between geomembrane sheet temperatures and air-channel pressure required to ensure a required seam peel strength for fPP geomembranes.

Project overview

This project is focused on developing a standardized air-channel test procedure for evaluating the quality of field fPP dual-track fusion seams.

Ultimately, this project seeks to determine whether a minimum seam burst pressure can ensure that fPP field seams meet the minimum required peel strength of 25 ppiw as a function of sheet temperature. Therefore, it was necessary to characterize the relationship between the peel strength and burst pressure of fPP seams and how both of these properties change with sheet temperature.

The seam samples were prepared using fPP geomembranes from four different manufacturers and two different thermal welders. The two welders created two different air-channel sizes; 0.4in.-wide and 0.8in.-wide. The thicknesses of the fPP geomembranes varied from 33 to 47 mil.

PROJECT HIGHLIGHTS

PREP, TESTING, WELDING

SEAM SAMPLES PREP
Colorado Lining Intl. Inc.

SEAM PEEL AND BURST TESTS
TRI/Environmental Inc.

WELDER #1
DemTech Services Inc.

WELDER #2
Plastic Welding Technologies Inc.

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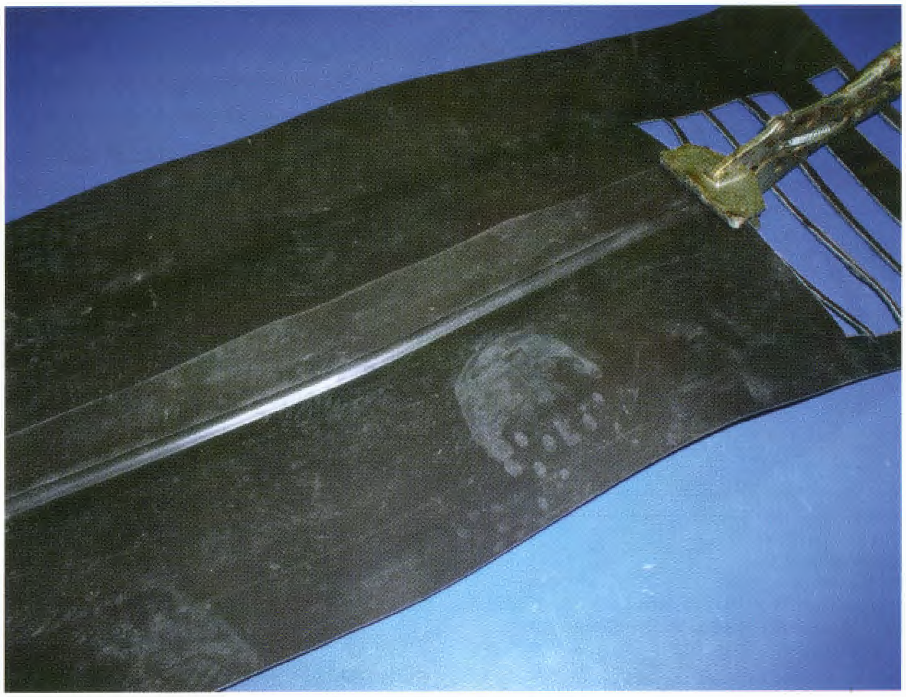

FIGURE 1 Photographs of inflated fPP geomembrane seam prior to air-channel testing.

The seam peel and burst tests were performed independently of each other. Peel tests were performed in accordance with ASTM D6392 and were conducted at temperatures of 5°C, 25°C, and 60°C. The seam specimens were 1in.-wide strips and were allowed to equilibrate to the test temperature before testing commenced. Each specimen was tested at a cross-head rate of travel of 20in./minute.

Bursts tests were performed primarily at 25°C. An attempt was made to perform these tests at near-freezing temperatures, but the stiffness and strength of the fPP material caused the burst pressure to exceed the available laboratory air pressure (130psi). An air pressure regulator and calibrated pressure gauge delivered the air pressure to the specimens, which were securely clamped with air-channel testing equipment **(Figure 1).**

The burst specimens were approximately 3ft long. After securing a test specimen, approximately 25psi of air pressure was added and the system was monitored for leaks via listening and monitoring of the pressure gauge in the air-channel. If no leaks were present, the air pressure was increased at 5-psi intervals with a brief pause between each interval to ensure no leakage was occurring until the seam burst.

Air-channel testing correlation

The preliminary correlation between seam peel and burst strengths of fPP geomembranes obtained from this project is shown in **Figure 2.**

This relationship shows scatter because of the many variables in the testing process (e.g., four different sheet manufacturers, variable sheet thicknesses and sizes of air channels, and two different thermal welders). Because of the variability in sheet thickness and air channel

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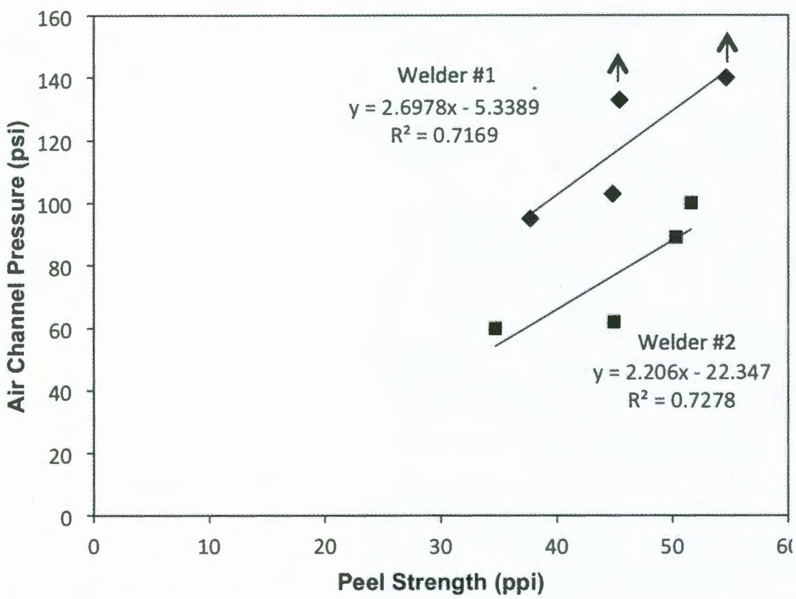

FIGURE 2 Preliminary relationship between seam burst pressure and peel strength.

width, the amount of stress observed in a given burst test varied.

For example, the two data points with arrows in **Figure 2** indicate that air channel pressure required to burst the seam is higher because the seam did not fail. A relationship between the peel stress and the hoop stress may be a better alternative, but calculating the hoop stress requires measuring the width of the air channel in every seam tested, which is probably impractical for a field test.

A correlation between peel strength and burst strength as a function of sheet temperature was also sought. Theoretically, the temperature dependence should be the same for both properties so the two data sets were combined into one graph and the data approximated by one trend line **(Figure 3).**

This graph shows the relative change of both seam peel strength and burst strength with respect to the values of both properties at room temperature. The variability in the results is an indication of the importance of sheet temperature within a geomembrane liner. For example, a single cloud blocking the sun can cause the sheet temperature to decrease quickly and dramatically, making it difficult to know the actual sheet temperature during air pressure testing.

Combining the temperature dependence shown in **Figure 3** with the results from the peel and burst tests in **Figure 2** yielded a relationship between the burst pressure required to ensure a peel strength of 25 ppiw as a function of sheet temperature **(Figure 4).** The two trend lines are for the two different thermal

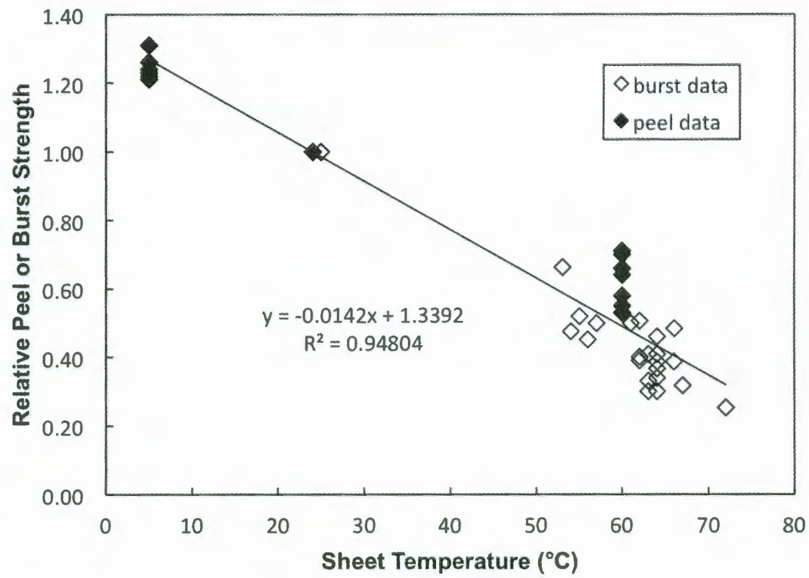

FIGURE 3 Dependence of seam peel and burst strength on sheet temperature.

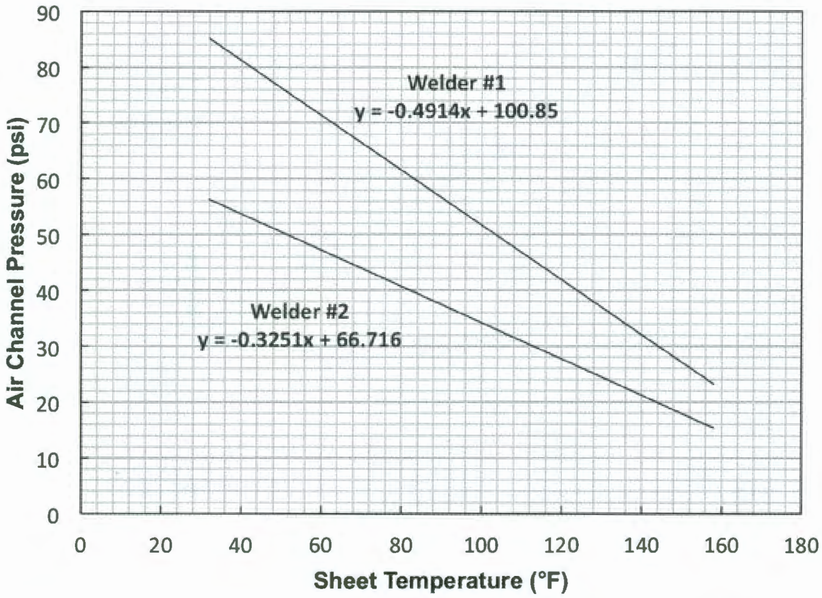

FIGURE 4 Correlation between burst pressure and sheet temperature required to ensure a 25 ppiw seam peel strength.

welders used. Therefore, the preliminary correlation appears welder dependent.

Figure 4 can be used by field personnel to determine the air-channel pressure at a given sheet temperature to ensure that the 25 ppiw minimum peel strength has been achieved for these two types of thermal welders. Additional testing is under way to refine the relationship in **Figure 4**.

Conclusions and future work

Although it is preliminary, **Figure 4** provides the required air-channel pressure required for a 25ppiw minimum peel strength of fPP seams at a given sheet temperature.

This correlation has been established for a burst test sheet temperature of 25°C and future testing is under way to extend the correlation to other burst test temperatures. These future tests will focus on weaker seams and colder temperatures to expand the applicability of the results.

It is anticipated that these future tests will establish the dependence of required air-channel pressure with sheet temperature and standardize air channel testing of field fPP seams as was accomplished for field PVC geomembrane seams (Stark et al., 2004 and Thomas et al., 2003).

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