When Permanent Really Means Permanent

Polyfuze, the New Heat Fused Graphic for Polyethylene, Polypropylene and Other Olefin Resins.

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Abstract

The intent of this paper is to demonstrate the truly permanent nature of a new patent protected heat fusion process for the transfer of graphics to polyethylene, polypropylene and other olefin products. As stated in Wikipedia, “Heat fusion (sometimes called heat welding or simply fusion) is a welding process used to join two different pieces of a thermoplastic. This process involves heating both pieces simultaneously and pressing them together. The two pieces then cool together and form a permanent bond. When done properly, the two pieces become indistinguishable from each other. Dissimilar plastics can result in improper bonding.”

This paper will:

1. Explain the difference between this heat fused graphic, known as Polyfuze, and other labeling processes such as In-Mold Labels (IML), Hot Stamp (Foil), Screen/Pad Printing and adhesive backed stickers.
2. Define the environmental significance of each of these decorating methods vs. heat fused graphics.

Problems with Traditional Labels

For the past 80 years there have been only a handful of ways developed to decorate polyethylene, polypropylene and other olefin resins, most being modified versions intended to decorate other plastics. The most common means of decorating are IML's, hot stamp foils, heat transfers, screen/pad printing or stickers. The problem with all of these decorating methods is they can eventually fail when exposed to outdoor elements, daily uses and physical removal.

Another issue with alternative decorating methods is scrap produced during the decorating process. Scrap rates from 4% to as high as 20% have been reported industry wide, which leaves in its wake a sustainability problem for companies. Labor and reprocessing fees increase overall product costs, while label and product waste take away from the bottom line.

Why the Problems Exist. Incompatibility

Phil Dodge of Equistar Chemicals explains, "Polyethylene, by its nature, does not lend itself to any method of paint adhesion. The polyethylene material is non-porous, it is resistant to attack by solvents useful in paint formulation, and it has a non-polar chemical structure."

Polyethylene, polypropylene and other olefin resins all have an inherent resistance to traditional decorating methods. Pretreatment is often required to have moderate adhesion. This treatment can be costly, time consuming, environmentally non-friendly and inefficient. If one problem is the adhesion qualities of the base material, the other problem becomes the construction of the decorating method.

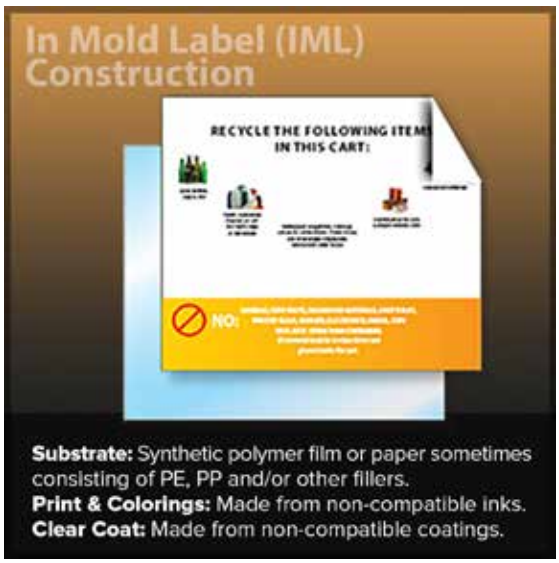

FIGURE 1. In Mold Label Construction

IML's, aka in-mold labels, are commonly constructed of three layers as seen if Figure 1. The only element of an IML that is "compatible" is the synthetic substrate (synthetic polymer film or paper). When an IML is used on polyethylene, polypropylene or other olefin resins, it is the synthetic substrate that bites into the resin, usually by mechanical means and not true bonding. The printed ink and clear coat components of an IML are non-compatible and can eventually fail leaving behind only the substrate.

FIGURE 2. Hot Stamp Foil Construction

Hot Stamp Foils are not compatible with polyethylene, polypropylene or other olefin resins and are commonly constructed of two layers as seen in Figure 2. Even with pretreatment, hot stamp foil begins to chalk and fail with normal use and environmental conditions. They can also be easily removed with everyday solvents and cleaners.

FIGURE 3. Heat Transfer Construction

Heat Transfers are not compatible with polyethylene, polypropylene or other olefin resins and are commonly constructed with four layers as seen in Figure 3. They are hot-melt adhesive based labels that require an adhesive bond that sticks to the final product. Even with pretreatment, these labels will not last with long term use and can easily be removed with everyday solvents and cleaners.

FIGURE 4. Pad/Screen Printing Construction

Screen and Pad Printing utilize inks as seen in Figure 4. Inks do not adhere well to polyethylene, polypropylene and other olefin resins, even with pretreatment. With pre-treatment, the color can fail with normal use and environmental conditions. These inks can also be easily removed with everyday solvents and cleaners.

Addressing the Problem. Compatibility

Our goal was to take our existing compatible materials technology, pioneered 32 years ago in the rotational molding industry, and apply its practices and principles within the injection molding industry. We wanted to provide a brand new and truly permanent heat fused graphic for injection molded polyethylene, polypropylene and other olefin resins that would be reusable, economical, recyclable, aesthetically pleasing and environmentally friendly.

FIGURE 5. New Heat Fused Graphic Construction

The Polyfuze graphic, unlike IML's, hot stamp foils, heat transfers or screen/pad printing, is a fully compatible olefin based graphic that literally "fuses/welds" into polyethylene, polypropylene and other olefin resins without using adhesives, bonding layers or synthetic stocks. Polyfuze Graphics™ are constructed of two layers as seen in Figure 5. Polyfuze takes on all the durable qualities of the polyethylene, polypropylene and other olefin resins that it has been fused into. Polyfuze graphics are 100% recyclable.

Polyfuze was created with the consumer, the manufacturer and the environment in mind. The need for companies to be able to apply multi-colored logos, warnings or UPC and QR codes to their products in a manner that doesn't require extra retrofitting or large amounts of scrap. We wanted to create a new heat fused graphic that could be multi-colored, permanent, 100% recyclable, cost competitive and would solve all of the major issues associated with decorating polyethylene, polypropylene and other olefin resins. The Polyfuze graphic is applied with traditional hot stamp machinery, which most molders and manufacturers already have available.

Testing the Theory

To say a product is permanent requires diligent and thorough testing and data to back it up. While many alternative decorating methods available on the market today may meet one or two requirements of permanency, there is no method that can meet each and every requirement. The Polyfuze graphic has not only been proven to not just meet all of these requirements, but has surpassed many of the permanency tests in the laboratory.

Scan with your Smartphone to learn more on our test data at:

www.tattooyourplastic.com/imig-test-data-report/

✓ **Tape Test ASTM D3359-09 Crosshatch:**
100% Passed, no graphic loss

✓ **QUV Accelerated Weatherometer Test:**
100% Passed, no color change

✓ **Heat Test:**
100% Passed

✓ **Low Temperature Impact Resistance Test:**
100% Passed

✓ **Flex Test:**
100% Passed

✓ **Heat Cycle Test:**
100% Passed

✓ **Pressure Wash Test:**
100% Passed

✓ **Various Chemical Tests:**
100% Passed

FIGURE 6. Overall Test Summary

The Polyfuze graphic test summary shown in Figure 6 illustrates the overall set of testing methods and results for permanency and is expounded upon in the following pages.

Testing the Theory (continued)

In Figure 7, the Polyfuze graphic was subjected to the **ASTM D3359-09 Crosshatch Tape Test** after application of the new heat fused graphic to an injection molded piece of polyethylene plastic. ASTM D3359-09 is the standard testing method for measuring adhesion by tape testing over crosshatched cuts made on the heat fused graphic. The Polyfuze graphic scored a 5B. Figure 8 shows the **scoring guidelines** used in the ASTM D3359-09 Test.

Scan with your Smartphone to learn more on our test data at:

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FIGURE 7. ASTM D3359-09 Crosshatch Tape Test

Score Guide: D3359 - 09

Classification	% of Area Removed	Surface of Cross-cut Area From Which Flaking has Occured for 6 parrallel Cuts & Adhesion range by %
5B	0% None	
4B	Less Than 5%	
3B	5 - 15%	
2B	15 - 35%	
1B	35 - 65%	
0B	Greater Than 65%	

FIGURE 8. ASTM D3359-09 Scoring Guideline

Testing the Theory (continued)

Additional weather testing was conducted by Polyfuze Graphics™ Corporation between its Polyfuze graphic and an IML. Below is a summary of the test results:

QUV Accelerated Weatherometer Test: 8 hour UV cycle 70°C (158°F) with irradiance of 1 (UVA bulb). 4 hours condensation cycle at 50°C (122°F)

Test was evaluated at 2,000 hours and at intervals of 500 hours after. Total completed time on the test 4,000 hours.

Evaluation: Crosshatch adhesion ASTM D3359-09

Graphic	Hours	Results
Polyfuze	2,000	5B
Polyfuze	2,500	5B
Polyfuze	3,000	5B
Polyfuze	3,500	5B
Polyfuze	4,000	5B

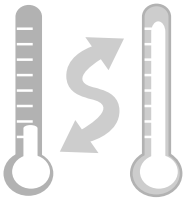
Graphic	Hours	Results
IML	2,000	3B
IML	2,500	1B
Not Evaluated after this point		

QUV Accelerated Weather Testing was also conducted by Polyfuze Graphics™ Corporation and Otto Environmental Systems on the new heat fused graphic to simulate the damaging effects of sunlight and environmental conditions through alternating cycles of intense elevated UV light and moisture in a controlled environment. An ASTM D4329 Condition B Test was conducted on the Polyfuze graphic for a 2,000 hour cycle. The result was a 100% pass with no color loss or degradation, as well as, no graphic delamination or diminishing.

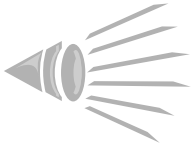
HEAT TESTING

IMPACT RESISTANCE TESTING

CONTINUOUS FLEX TEST



HEAT CYCLE TEST



PRESSURE WASHING TEST

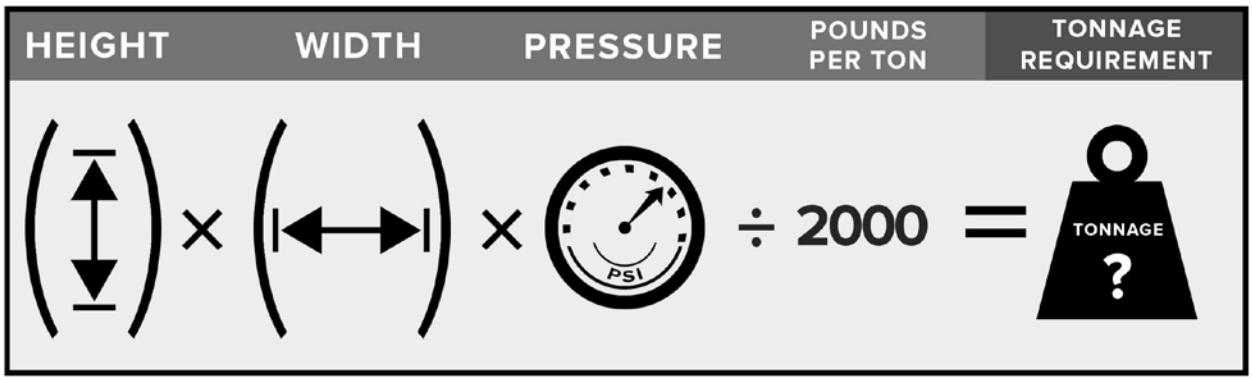
VARIOUS CHEMICAL TESTS

Testing the Theory (continued)

Other tests conducted by the Polyfuze Graphics™ Corporation laboratory included a **heat test.** This test was performed at 77°C (170°F) for a total of 120 hours of exposure, in which the Polyfuze graphic showed no visual change, no sign of delamination and passed the ASTM D3359-09 Tape Test upon completion. A **low temperature impact resistance test** was also conducted on a sample of the Polyfuze graphic that had been stamped into HDPE. This sample was set to a temperature of -40°C and struck with a 40lb. falling dart from a distance of 4 feet. The Polyfuze graphic showed no visual change, no signs of delamination and passed the ASTM D3359-09 Tape Test upon completion. A 240 hour continuous **flex test** at 21°C (70°F) was also conducted in which the Polyfuze graphic showed no visual change, no signs of delamination and passed the ASTM D3359-09 Tape Test upon completion. A **heat cycle test** for 2 hours at -40°C then 2 hours at 77°C (170°F) was conducted. This test showed no visual change, no signs of delamination and passed the ASTM D3359-09 Tape Test upon completion. A **pressure wash test** was also conducted for 3 minutes at 1200psi and 49°C (120°F) with a 90° nozzle angle and 6 inch distance in which the Polyfuze graphic showed no visual change, no signs of delamination, flaking or removal and passed the ASTM D3359-09 Tape Test upon completion. Numerous **chemical and solvent soak tests** were also performed. These chemical/solvents included gasoline, diesel fuel, 2 cycle engine oil, lacquer thinner, brake fluid, turpentine, kerosene, muriatic acid 20 Baume 31.45%, alkali solution (ph 13). All tests had a complete soak time of 168 hours at 21°C (70°F) with the results showing no visual change, delamination or removal and all samples passed the ASTM D3359-09 Tape Test upon completion. An additional soak in both water and salt water for 720 hours also resulted in no visual change, delamination or removal and passed the ASTM D3359-09 Tape Test upon completion.

Additional Manufacturing Benefit

Beyond its notable durability improvements the Polyfuze graphic offers the **additional benefit of application with just a 75psi requirement**. In comparison, hot stamp foil requires 400psi while standard heat transfers require 500 psi. The formula used to calculate tonnage required for application is (w X h X psi/2,000). Using this formula below required tonnage is revealed.



Required Tonnage for Application:

Polyfuze 4” X 6” graphic = .9 tons
Hot Stamp Foil = 4.8 tons
Heat Transfer = 6 tons

Simply stated, a lower tonnage requirement will allow manufactures to apply a larger size Polyfuze graphic with the same tonnage machine.

Summing It Up

Companies today are looking for business solutions and methods that are environmental friendly, all while providing for growth and profit in the future. Decorating polyethylene, polypropylene and other olefin resins is an important part of the plastics industry for very specific reasons. These include warning labels that thwart theft and instruct of dangers. Logos that give brand identity and define quality and differentiation. Instructional labels which direct a consumer on the proper use of a product. UPC and QR Codes which provide tracking and stocking information. But the only way these types of labels have the ability to do their job, is if they remain intact for the life of the product.

Alternative decorating methods referenced throughout this paper are commonly removed by various outdoor elements, such as, extreme cold or heat, over exposure to sunlight and weather conditions such as wind and rain. They also are removed by daily uses including rubbing or abrasion, daily wear and tear to the product and daily contact with necessary cleaning solutions. Physical removal such as pressure washing or heavy solvents and chemicals are also factors in the durability and life of these labels. These label failures account for a considerable loss of money, time and valuable resources. This also means loss of vital information and identification that affects traceability and asset management. In the case of warning and informative labels, this can lead to litigation.

Polyfuze Graphics address all of the above listed issues, simultaneously providing exponential benefits over and above any other alternative decorating methods currently used on polyethylene, polypropylene and other olefins.

It's not just a "new and improved adhesive" or a "special clear coat". It's not "improved inks" or "added UV stabilizers". This Polyfuze graphic is not a reformulation of old technology. It is new technology with an innovative and permanent solution in the decorating process of olefin products.

References
1. "Heat Fusion." Wikipedia. Wikipedia Foundation, Inc. 20 Dec. 2012. Web. 3 Dec. 2013.
2. Figure 8. Diagram recreated from page 4, FIG.1 Classification of Adhesion Test Results of the ASTM D3359-09 Standard Paper.