

Integrated One Component Recreational Vehicle Slide-Out Seal: A Systematic Approach to Eliminate Water Leaks

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ABSTRACT

Recreational vehicle slide-out sealing can be significantly improved by using a single integrated, multi-polymeric profile geometry developed with a systematic approach. The design process starts with the selection of highly engineered automotive grade thermoplastic materials. The focus then shifts to design for manufacturing and reducing installation time. As a result, a system can be designed that significantly improves slide-out sealing to eliminate water, dust, and temperature intrusions in recreational vehicles.

This white paper will examine the key steps in utilizing a systematic approach to selecting, designing, producing, and installing highly effective and engineered recreational vehicle slide-out seals. A review of material properties, alternative designs, and assembly methods will allow for a thorough understanding of how slide-out seals can meet the demanding challenges for best-in-class sealing performance. In addition, a review of the application for these polymeric materials will be discussed to allow for greater insight into employing the next generation of slide-out sealing solutions.

INTRODUCTION

Today’s recreational vehicles offer an abundance of features and amenities. Many consumers seek the outdoor camping experience without sacrificing the comforts of home. One of the features, which enable a recreational vehicle to achieve additional living space, is the slide-out.

While the slide-out delivers an outstanding solution to maximize interior RV living space, protecting the interior from the outside elements creates a crucial design engineering challenge. The sealing system plays a significant role in creating a watertight interior, minimizing temperature intrusions, while delivering durability under both static and dynamic loading conditions over a wide range of temperatures.

As a result, the slide-out sealing system requires optimized material selection, part design, and tight tolerance production processes to create a state-of-the-art seal. This whitepaper focuses on the critical features that enable RV design and manufacturing engineers to seal the full industry range of slide-outs utilizing proven engineered automotive grade engineered polymers.

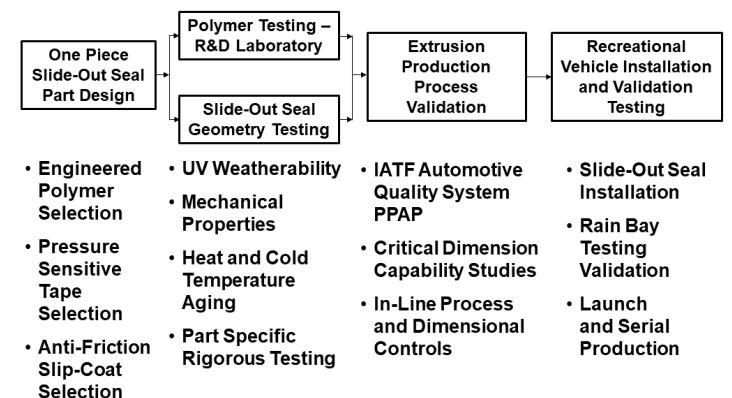
HISTORICAL RV SLIDE-OUT SEALS

A broad range of polymeric slide-out seals have been developed and introduced into the recreational vehicle market over the years. In general, these seals utilize a variety of materials ranging from sponge rubber to general purpose thermoplastic polymers. Historically, the sealing method utilized a two-piece design with an “interference fit” between the components and attached to the RV body via mechanical and/or, adhesive tape applications.

The two-piece RV slide-out seals developed over 15 years ago, utilized both a high modulus (stiff) polymer for the rigid attachment to the RV body and the need for a second component to utilize a low durometer polymer for sealing surface interface. The result was a two-piece design, which required RV manufacturers to stock both components, install the rigid member to the RV body, and then, utilize a bulb seal via an interference fit with the rigid member. These two-piece RV slide-out seals require many cut lengths, increasing the need for RV Manufacturers to utilize more storage area, which creates complex inventory management challenges.

NOVEL INTEGRATED SEAL DEVELOPMENT

A systematic approach for material selection, design, and installation methods can be employed to aid RV manufacturers in achieving best-in-class slide-out room sealing. An overview of this approach is shown below.



ONE-COMPONENT DESIGN & MATERIAL SELECTION

Evaluating and selecting the best automotive grade polymers are critical to ensure long life, durability and application function. The first polymer requirement is to test and evaluate the best material to provide a high modulus (stiffness), combined with elongation characteristics to deliver stability and durability of the portion of the seal, which will be installed to the RV body.

The second low durometer polymer is formulated to provide outstanding sealing properties by delivering the ability to withstand the demands of slide-out cycling through extreme temperature conditions and long-term UV light exposure. The selection of high performance polymers provides RV engineers with the state-of-the-art polymeric sealing technology utilized by the most advanced automotive companies sealing vehicle closures.

MATERIAL TESTING

Material testing is a critical requirement to not only select the highest performance polymers, but to also ensure outstanding consumer satisfaction. By evaluating performance over a wide range of environments, RV manufacturers have come to expect the same level of technical support for engineered solutions as automotive manufacturers when it comes to assured slide-out sealing. While a range of testing methods is employed for polymer selection, an overview of some of the critical requirements is shown below:

- Ultraviolet Weatherability
- Compression Set
- Tear Resistance
- Heat Deflection Temperature
- Cold Temperature Aging
- Heat Aging
- Hardness
- Density
- Tensile Strength
- Tensile Elongation
- Elastic Modulus
- Abrasion Resistance
- Chemical Resistance

It is important to note that by conducting extensive long-term performance tests on candidate polymers, RV manufacturers are able to specify highly durable and functional slide-out seals, which are proven to deliver optimal sealing performance. Examples of specific testing which simulate field applications include:

U.V. Weatherability Resistance - By exposing candidate polymers to cycles of ultraviolet light, rain, and dew in an accelerated chamber, mechanical property retention can be measured to

evaluate performance. By measuring properties such as tensile strength, elongation, hardness and other critical functional testing, following U.V. exposure, RV manufacturers can rest assured that long-term sealing performance will be achieved in the slide-out seal. This disciplined approach to material evaluation and specification is identical to the methodology used by leading American, Asian, and European car producers.

Heat and Cold Temperature Aging- By conducting both heat and cold temperature aging, candidate polymers can be analyzed for mechanical property retention to simulate long-term field exposure. Specifically, by exposing the polymer to extremely hot temperatures for property retention for extended periods can be confirmed to ensure reliable sealing performance. Conversely, by exposing the polymer to extremely cold temperatures (-40°C) for extended periods, property retention can be confirmed to ensure robust performance. The result is a best-in-class slide-out seal using decades of experience in polymeric life cycle testing as expected by automotive Original Equipment Manufacturers (OEM's).

PART DESIGN

Due to RV manufacturers desiring a state-of-the-art sealing system, a new one-piece, integrated slide-out seal design was created to consolidate components, improve function, reduce installation time, minimize storage space requirements, and capitalize on the performance of the best automotive sealing polymers (Figure 1).

In Figure 1, the one-component, integrated design incorporates these critical features to enhance function: the locating leg (10), which utilizes the higher modulus polymer for secure mounting to the RV body; the flared wiper tip (50), which specifies the low durometer polymer for effective water management; and the unique bulb design (18), which creates a geometry for enhanced bulb recovery following static and dynamic loading.

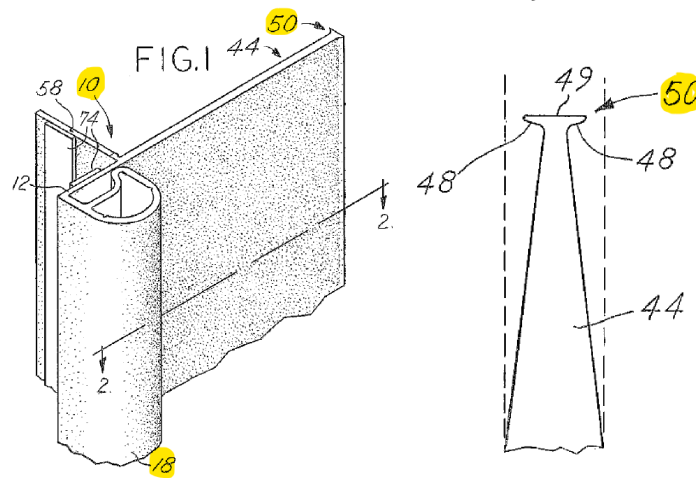


Figure 1 - Jaeger-Unitek Patent US 9,045,027 B2

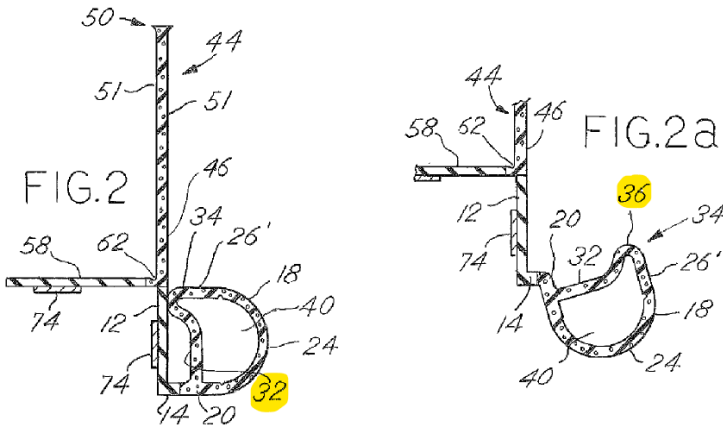


Figure 2 - Jaeger-Unitek Patent US 9,045,027 B2

A closer look into Figure 2 and 2a provides insight into the advantages of creating the “flipping” function of the seal to provide RV slide-out installers with an easy method to “wet-out” the pressure sensitive adhesive tape, while applying fasteners for a secure and robust mounting and sealing function. By incorporating the “duck-bill” shaped bulb (36) and modifying the nominal wall section (32), the stiffness is increased, resulting in the improved ability of the bulb to recover following extended loading conditions. Specifically, an improved resistance to a compression load during slide-out cycling, and the subsequent recovery of the original geometry, is achieved. Ultimately, the design delivers the ability to “coil” the slide-out seal, eliminates the historical use of two-component seals, and achieves reduced storage space requirements.

MATERIAL SELECTION

Following extensive testing of the selected engineered automotive grade polymers, the best in class materials can be specified for use in the integrated, one component RV slide-out seal for optimized sealing performance. Ultimately, four critical materials are selected to aid RV manufacturers in storage, installation, and performance in demanding slide-out applications in any environment (Figure 3).

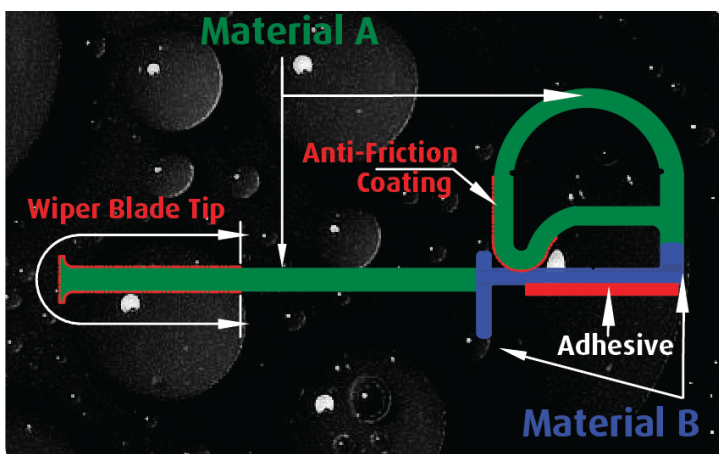


Figure 3 - Flip 'N Seal® Material Technology

Material A - This low durometer polymer provides outstanding sealing performance under a wide range of temperatures following extensive slide-out room cycling. By selecting the best performance polymer and increasing the nominal wall thickness, impressive compression set values are achieved to deliver watertight sealing under very demanding environmental conditions.

Material B - This higher modulus polymer provides both the rigidity to maintain dimensions over wide temperature ranges and the tensile and impact strength to withstand installation and vibrational loads during RV transport and slide-out cycling. It is important to specify the Material B polymer, which provides the highest resistance to crack propagation, which can occur with lower performing materials.

Anti-Friction Coating - The use of anti-friction coatings on slide-out seals to reduce the coefficient of friction, serves two functions. First, minimal ergonomic force is required to install the seals. Installation tools can easily slide across the surface with minimal drag. Second, the anti-friction coating reduces surface abrasion and resistance, protecting a highly critical sealing surface on the bulb geometry.

Pressure Sensitive Adhesive Tape - By evaluating, testing, and specifying the highest performance heat activated tape, RV manufacturers can take advantage of proven automotive technology. The results include: outstanding adhesion to both the RV body and to the integrated one component RV slide-out seal, high performance in operating temperatures up to 90°C (194°F), resistance to weather and UV exposure.

RV INSTALLATION AND VALIDATION TESTING

Due to the intrinsic time required to install the historical two component seals, RV manufactures desired an integrated one-component, slide-out seal for both installation and sealing improvements. As a result, a new invention was created to provide enhanced sealing.

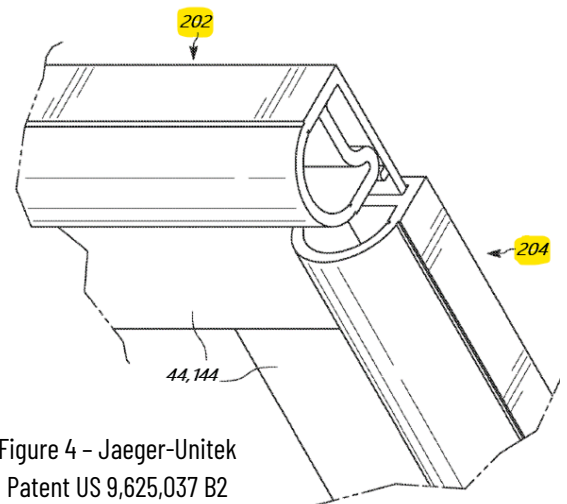


Figure 4 - Jaeger-Unitek Patent US 9,625,037 B2

By looking closely at Figure 4, we can see how the two integrated one-component RV slide-out seals create a novel method of installation. By “flipping,” the sealing bulb on the side seal (202) and inserting the wiper seal of the top seal (204) under the bulb and fastening as a result a watertight sealing system is fully achieved without any additional mechanical or gluing requirements.

Following installation, RV manufacturers validate the sealing effectiveness by conducting extensive pre-delivery inspections including rain bay testing to validate repeatable performance and consumer satisfaction.

SERIAL PRODUCTION AND IATF QUALITY SYSTEMS

Serial production using a disciplined Production Part Approval Process (PPAP) for new slide-out seals under an automotive IATF Quality System provides a seamless transition to serial production. Similar to designing and launching automotive sealing systems, the IATF 16949 quality management system provides a culture and process for continuous improvement, prevention of defects, and the reduction of variations and waste. The objectives of the quality system include a focus on control processes and quality to increase customer satisfaction, identify and eliminate risks in the supply chain, and ultimately, provide repeatable slide-out seals, which comply with demanding specifications and requirements.

CONCLUSION

By employing a systematic development process to improve recreational vehicle slide-out sealing, recreational vehicles can eliminate water, dust, and temperature intrusions to enhance consumer satisfaction. Specifically, by capitalizing on proven automotive grade, highly engineered polymers, the historical approach of a two-piece slide-out seal can be consolidated into a single, integrated, multi-polymeric profile. As a result, RV manufacturers can achieve a reduction of unique part numbers and storage space, improve installation processes, and utilize engineered materials, which have been extensively tested in harsh ultraviolet and temperature cycling environments, while delivering all of the comforts of home for a growing camping population.

AUTHOR BIO'S

Leon Bogucki - Lead Plastic Product/Process Engineer

Leon has a Bachelor's Degree in Mechanical Engineering Technology and an Associate's Degree in Computer Integrated Manufacturing Technology from Purdue University. He has over 24 years of project and product development engineering experience from Bosch, Hitachi, Honeywell, CTS, Whitley Products, and AMSAFE prior to Jaeger-Unitek. Leon also holds one patent.

Jason Cackley - Lead Application Engineer

Jason holds a Bachelor's Degree in Mechanical Engineering from Purdue University and a Master's Degree in Business Administration from Bethel University. He brings 15 years of Engineering and Project Management experience from Whirlpool Corporation and Hoosier Racing Tire Corp prior to joining Jaeger in 2019.

Colton Phelan - Sales Manager

Colton earned his Bachelor's Degree in Business Administration from Trine University. He brings 8 years of Sales and Project Management experience from NRP-Jones and Jaeger-Unitek. Bridging on his success in the Automotive market, Colton played a key role in Jaeger's entrance to the RV industry.

Makoto Sato - Product Engineering Manager

Mac has over 30 years of Plastic Extrusion Engineering and Sales experience in the Automotive and Industrial markets for manufacturers in Tokyo, Japan. Mac brought his veteran engineering expertise to Jaeger-Unitek and for the past 20 years has contributed to Jaegers success as a leading plastic extrusion manufacturer. In his 50-year career, Mac has co-authored several patents within the Automotive, Industrial, and RV industries.

Ray Young - V.P. Engineering

Ray holds a Bachelor's Degree in Mechanical Engineering from Purdue University and a Master's Degree in Business Administration from Indiana Wesleyan University. Ray has over 25 years of Engineering and Quality Management experience within the Automotive, RV, and Industrial markets. Ray has co-authored several patents within the RV sealing industry.

To learn more about Jaeger's sealing solutions and product capabilities, please contact us:



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