
The Seal Design Process

By
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The Delta Rubber Company

This whitepaper describes the tools, methods and techniques used by Delta Engineering for the design of a new seal. While this document will focus on hub bearing seals a similar process is used for other products.



The Thought Leadership Series is a collection of leading edge thinking for members of the Rubber Industry's manufacturing community.

Overview

Delta Rubber Company designs and manufactures seals primarily for the bearing business. Delta is responsible for seal design as well as the tooling used for its manufacture. Delta has been serving this industry for over 50 years. Delta produces over 60 million seals on annual basis with 10 million of those seals used in the automotive hub bearing market.

The typical seal design process would involve taking customer application input, seal performance experience and research and test data to specify an appropriate seal design. Delta design process makes use of past experiences, benchmarking of competitive products, development and functional testing of the seal. Delta will also use analytical techniques such as FEA as a method to help filter design concepts.

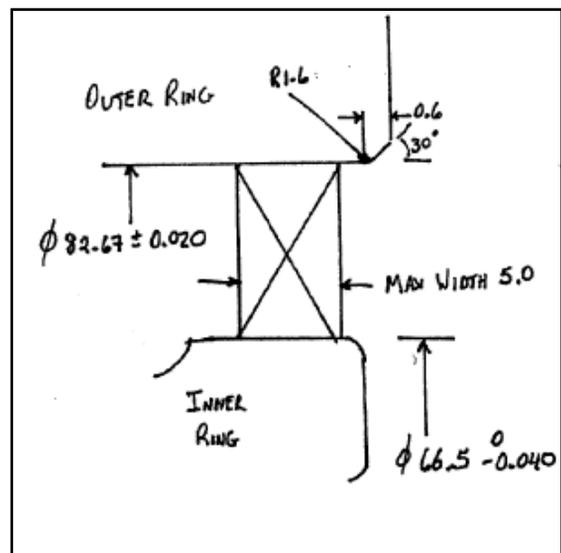
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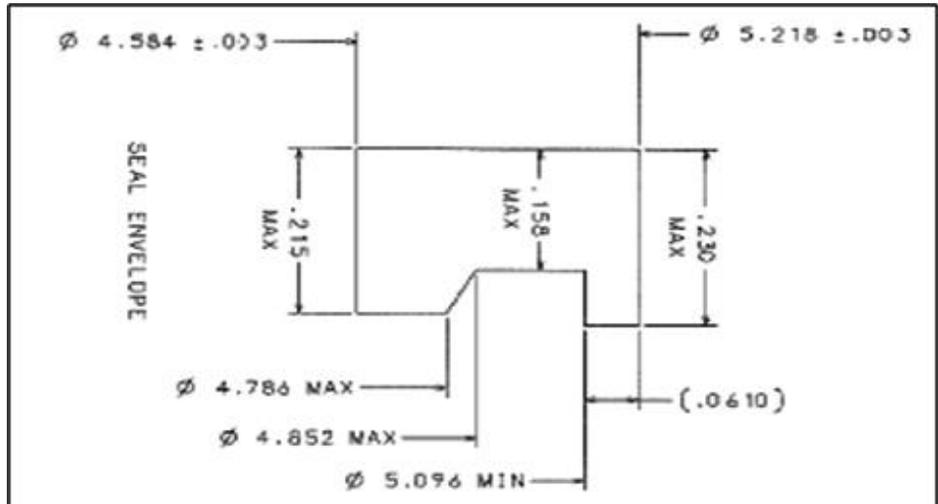
Inputs

Typically the customer will provide a basic envelope size that will be used as the main constraint parameters to construct our seal design. Additional information that the customer provides depends on their level of experience they may have with product, compound and application. The following list shows the most frequently provided inputs we obtain from our customers (Bolded items required for our design process)

- 1. Envelope size**
- 2. Bearing type**
- 3. Environmental parameters**
4. Compound type
5. Test methods
6. Grease Type
7. Pass / Fail Criteria

Typical seal envelope information provided by the customer.





Typical seal envelope information provided by the customer.

Design Personnel

Delta relies heavily on the knowledge and experience of its engineering team during the development of a new seal. This team includes internal personnel to our organization, outside consultants as well as outside services (FEA, special compound tests). The following is a listing of the skill sets available and used during the development of a seal design.

1. Program Engineers
2. Chemist
3. Seal Test Technician
4. Rubber Lab Technician
5. Dimensional Technician
6. Manufacturing Process Engineer
7. Outside Analytical Lab Rubber Analysis
8. Outside Engineering Consultants for FEA

Design Process:

A. Seal Lip Configuration:

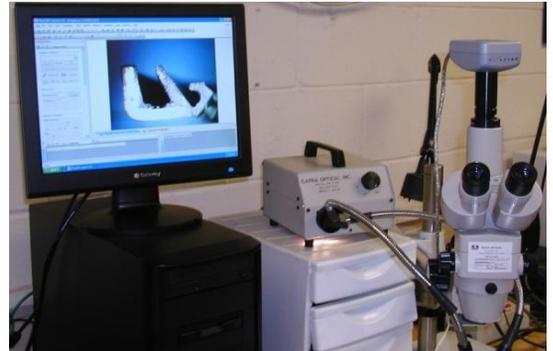
Utilizing the available inputs our program engineers will develop a conceptual seal design for the application. The seal design will incorporate lip configuration to suit the need of the application as well as the bearing type.



Design fixture used to simulate the interference fits while seeing the effects on axial and radial lips. Cross sectional and top views of the seal lips visible.

The following are other parameters that are considered during seal design geometry phase, which is highly dictated by the envelope size.

1. Lip configuration
2. Lip interference
3. Seal retention parameters
4. Rubber shrinkage
5. Manufacturability
6. Method of molding
7. Method of assembly (If required)
8. Rubber compound
9. Benchmarking of competitive products



Magnification of a cross section of a seal. System is capable of 60X magnification and can make measurements of the object. Images can be saved as a file for documentation or transmission to the customer.

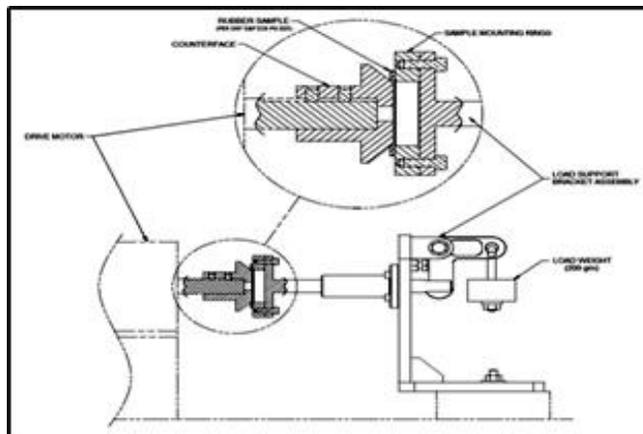
Note: The actual parameters are proprietary to Delta Rubber.

Seal designs are completed on our CAD system and we can submit these for analysis or review utilizing all the most common industry formats.

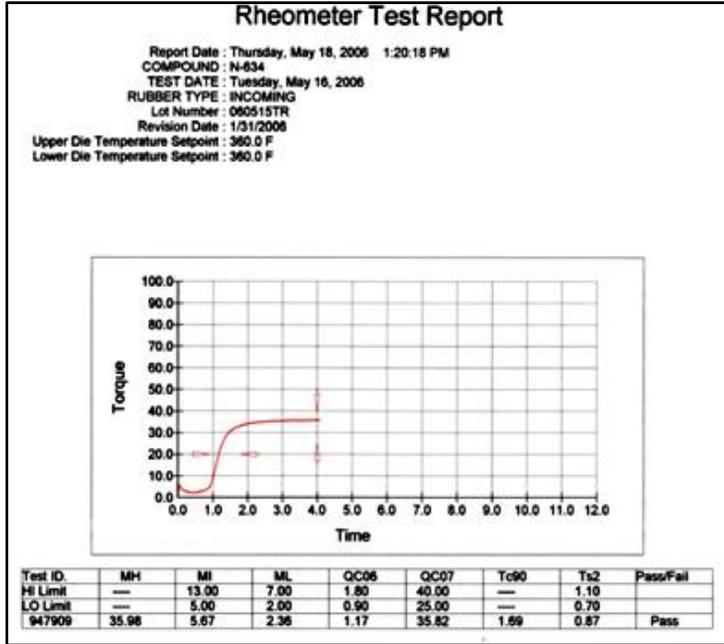
B. Rubber Development

A subset to seal design is compound development. The rubber compound used in our seals is developed by our chemist and is proprietary to Delta. Delta has production seals made in the most common elastomers available in the market. Delta views the compound development to be a very critical phase of the product design and continues to explore new and better formulations. Tools used during compound development include.

1. Physical testing for elongation and tensile
2. Compression set
3. High and low temperature
4. Grease compatibility
5. Rheometer
6. Hardness
7. Wear testing (Bearing surface and taber abrasion)



Delta design test fixture used in the evaluation of rubber compounds for wear. Testing simulates the bearing surface finish as well as a typical axial lip angle.



Tensometer used to determine physical properties of rubber compounds (Tensile, Elongation and Modulus).



Rheometer used in the evaluation of rubber compounds. Determines the rate of cure and how the compound will process. Useful in setting up new manufacturing cycles.

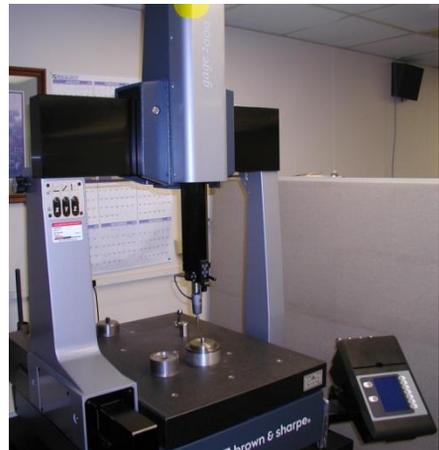


Lab ovens used for grease compatibility trials, heat aging, post cure of test slabs, compression set trials. These trials can last up to 42 days at elevated temperature. Ovens capable of 500 F.

Design Validation

Once a design has been determined to be suitable, we will build a single production cavity for manufacture of sample parts. Delta's prototype cavities are production capable and are used as such when the program is launched. The samples are molded, measured and then sent to the customer for testing or tested in house. Typically the customer would provide the bearing to Delta for testing in our lab. Delta has and can perform validation tests without the actual bearing by developing fixtures that simulate the interference fits on the seal. The following is a sample of the various trials we perform during validation phase.

1. Dimensional Analysis
2. Torque tests
3. Water immersion
4. Water spray
5. Mud slurry submersion
6. Mud slurry spray
7. High temperature
8. Low temperature
9. Longevity (Life Test)
10. Radial lip force
11. Insert retention forces
12. Dust



Brown and Sharpe CMM used for contact measurement of product. Used in measuring bearing components for interference fits.



Smart Scope used in non-contact measurement of seal geometry. Typical measurements of radial and axial lip heights and diameters are gathered here.

Delta Rubber Seal test lab. Showing eight test heads available for controlled testing of seals in a bearing or other type of fixture. Typical tests performed on these rigs include water spray, elevated temperature, dust, and life test. Test rigs control RPM and measure temperature and torque during the cycle. Computer controls the environment on / off cycles.



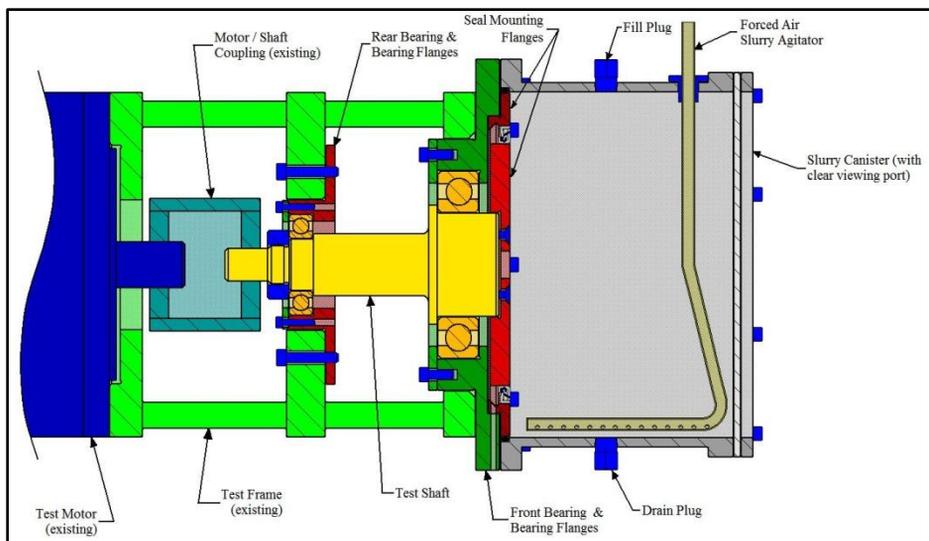
Additional test rigs for seal testing. These are specifically designed for mud spray and submersion tests. These rigs are used with the bearing to conduct the test. Similar controls and measurements performed on these rigs.



Test heads used for seal only testing. Seals are tested until failure.



Temperature test chamber capable of -100 F to +350 F. Rotation of a shaft is performed by a side mounted motor for seal testing.



Above is a cut away of a Delta designed fixture to be used for mud submersion

Summary

As automotive and industrial companies put a greater emphasis on continuous improvement in their manufacturing processes for precision rubber components, they are increasingly drawing on the design expertise of key suppliers, like Delta Rubber. Doing so helps them focus on reducing inefficiencies designed into new products early in the design process when revisions are least expensive and easiest to make.

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