Selection of Silicone Sealants for Heavy Truck and Off-Road Vehicle Applications

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Applications

Heavy Truck and Off-road Applications are Extremely Harsh

- Extended Use (1KK Miles)
- Severe Engine Wash Procedures
- Aggressive Off-Road Environments (mines, deserts, arctic regions, marine, construction sites, etc.)

Silicones

General Attributes

- Sealant Against Fluids
- Wide Useful Temperature Range (-50 to 200°C)
- Accommodate Large Thermal Motions
- Compatible with Many Substrates

One-Part, Silicone - Overview

- Single Component
- Room Temperature Vulcanizing
- Cured by Reaction with Atmospheric Moisture
- Formulation options in additives, cure chemistry and adhesion promotion create distinctions in supplied resins

Silicone Curing

Cure Reactions

- Silicone Oligomers (liquid state) react with moisture, crosslinking agents and adhesion promoters to produce a crosslinked network that adheres to a substrate
- Diffusion of moisture is a rate determining step
- Factors influencing diffusion include: humidity, temperature and exposed surface area
- The crosslinking agent determines the chemical nature of the cure: **Acid or Neutral cure**
- By-products typically 2-4% sealant weight
- Broad distinction between acid cure chemistry and neutral cure chemistries

Silicone Bond Failure

<u>Factors Influencing Failure - Exposure to...</u>

- High Temperature
- Chemicals (e.g. fuels, oils, cleaning compounds, etc.)
- Corrosive Environments (salt spray, dust, mines, etc.)
- UV Radiation

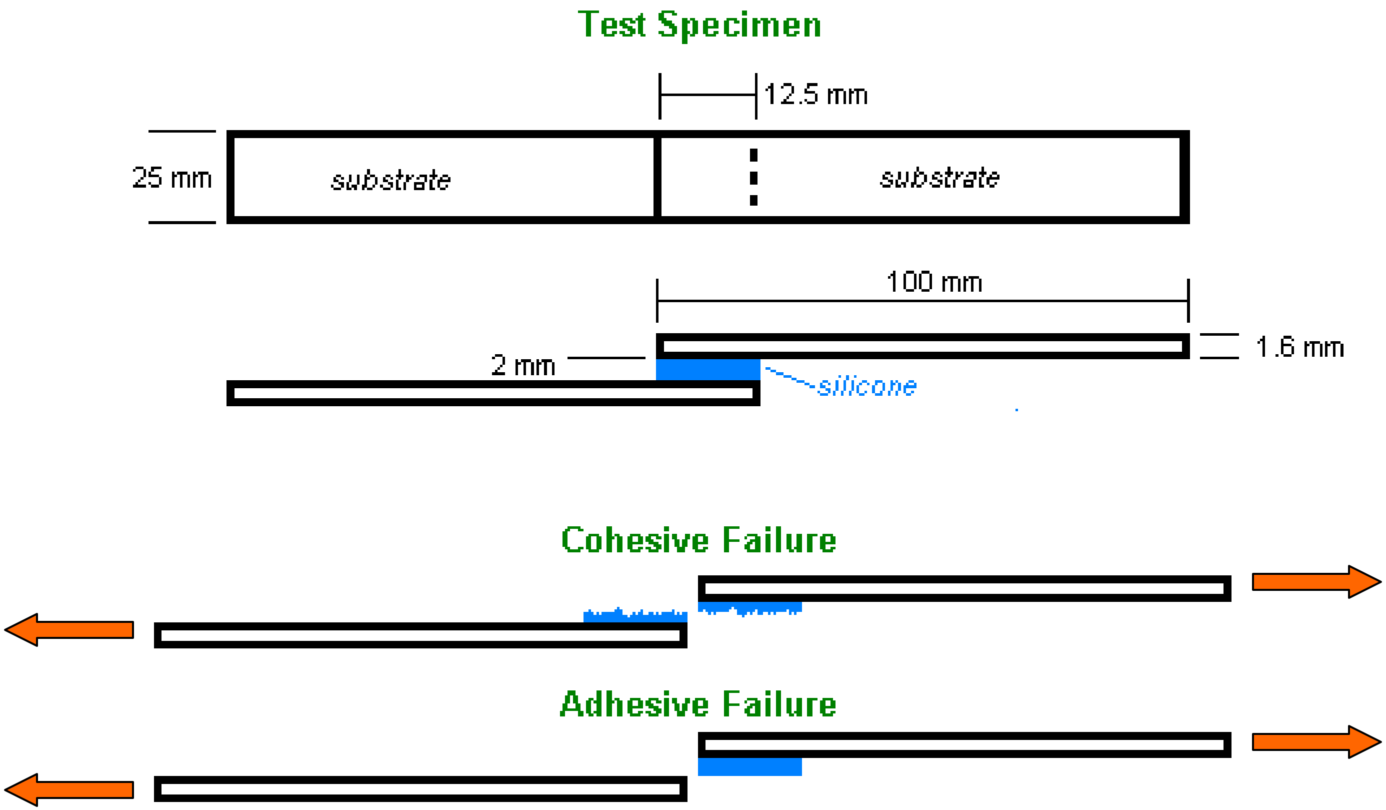
Project Goals

- Establish an efficient method to screen silicones for application testing
  - Lap Shear Test per ASTM D1002
- Select silicone materials for further application testing
- Focus of experimentation:
  - Cure time
  - Strength and adhesion characteristics on substrates
  - Resistance to vehicle fluids

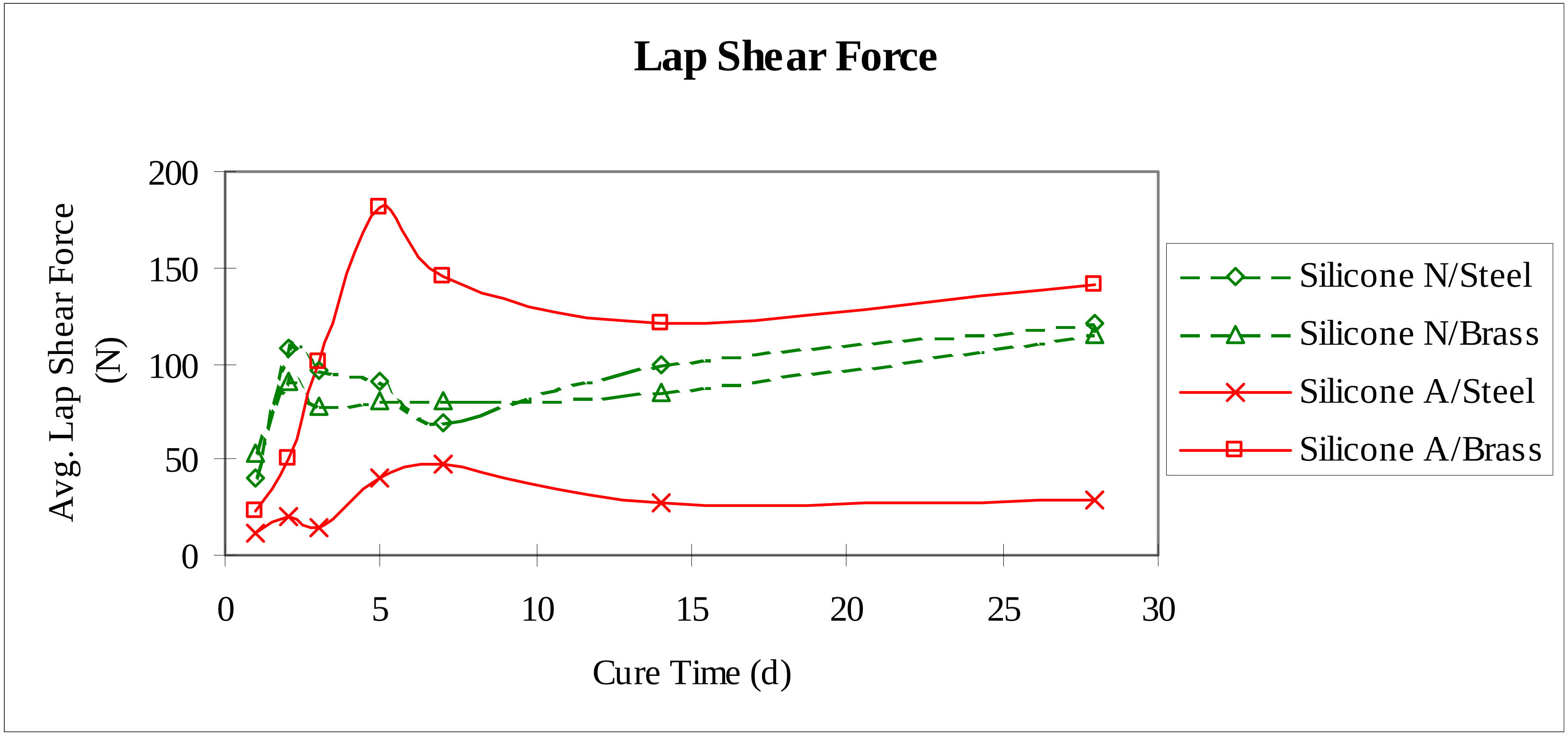
Cure Time Experiment

- Bonded silicones to brass & chromate plated steel
- Cured for up to 28 days
- Measured lap shear strength at different cure times

Lap Shear Test



Cure Time Results



Silicone A/7 & 28 d Cure

Brass tarnished

Adhesive/Cohesive Failure

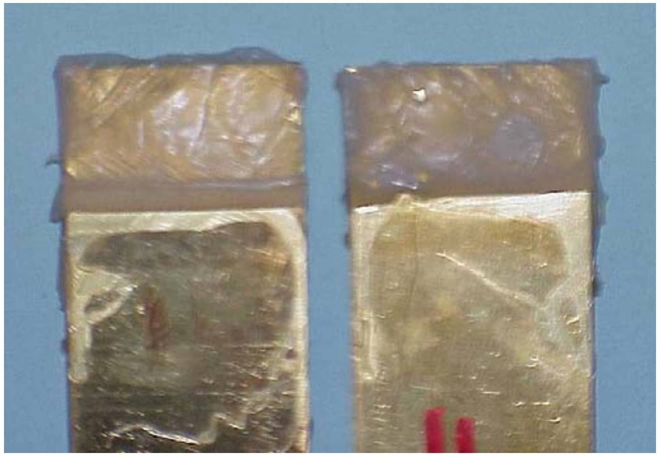
Cohesive Failure

28d Cure 7d Cure

Fluid Exposure Experiment

- Bonded silicones to brass & chromate plated steel
- Cured for 14 days only
- Immersed in fluids for 2 or 8 weeks:
  - water
  - antifreeze
  - engine wash fluid
  - ATF
  - motor oil
  - brake fluid

Water Exposure Results

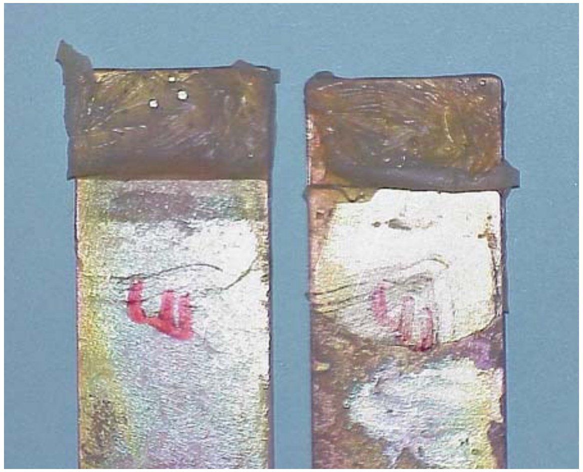


Silicone N

Brass

Plated steel

14d cure
14d exposure
cohesive failure



Silicone A

Brass

14d cure
14d exposure
adhesive failure

Fluid Exposure Results

Silicone A

- Immersed for 2 weeks; brass substrates only
- Bonds are stable in:
  - ATF
  - Motor oil
- Bonds deteriorate in:
  - Antifreeze
  - Engine wash fluid
  - Brake fluid

Fluid Exposure Results

Silicone N

- Immersed for 8 weeks; brass & plated steel substrates
- Antifreeze, ATF & Motor Oil:
  - Bonds are stable, no effect of substrate
- Brake Fluid:
  - Stable on brass
  - Slight deterioration on steel; cohesive nature retained
- Engine Wash Fluid:
  - Moderate deterioration on brass; mixed failure modes
  - Deterioration on steel; adhesive failures

Summary

- Acid cure silicone on plated steel substrates
  - Unsuitable performance
- Acid cure silicone on brass
  - Bond deteriorates over time & during fluid immersions
  - Unsuitable performance
- Neutral cure silicone
  - Adheres well on brass & plated steel
  - Retains good adhesion through most fluid immersions
- Lap shear method was a good test for selection

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