

Replacing the RTFO



Development of a New Short-Term Aging Apparatus

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Introduction



- We were not satisfied with the RTFO
- Attempts to correct it only added complication
- Time to go back to the drawing board

Problems with RTFO



- Modified binder troubles
- Mass change and associated processes
- Sample size
- Mess/cleanup
- Burn hazards

Research Project 0-1742



- Awarded to TTI in Sept 1999
- Looked at three methodologies
 - Microwave
 - Very thin film
 - Air blowing
- We chose to pursue air blowing

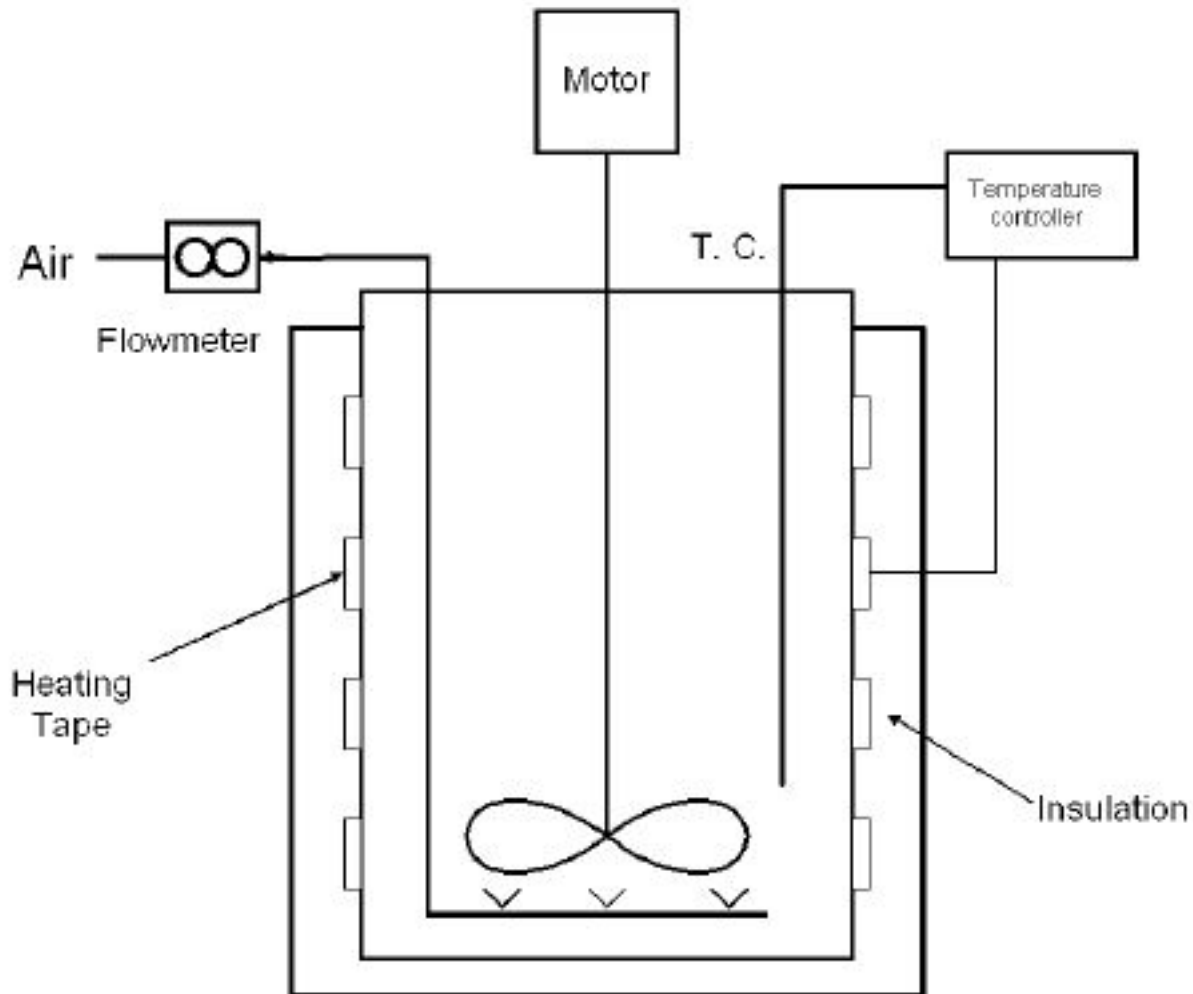


Figure 2-1. Laboratory Unit Used for Air-Blowing Experiments.

Design Aspects



- Sample size
- Sample container
 - Size
 - Type (permanent/removable/disposable)
- Method of air introduction
 - distributed
 - single pipe
- Impeller type

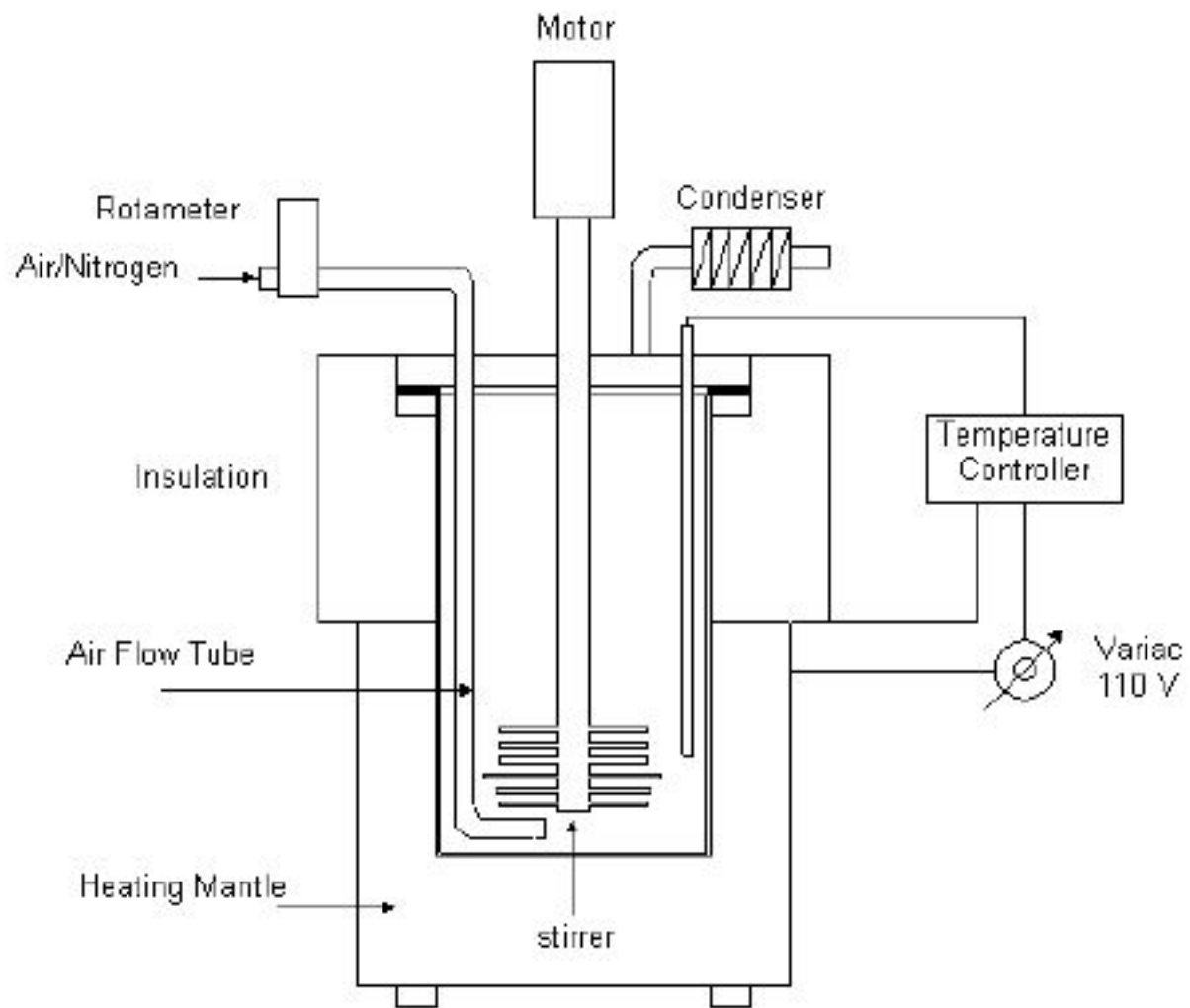


Figure 3-1. SAFT Apparatus.

Property Comparisons

- Compared key chemical and physical parameters for RTFO and SAFT materials
- Aging was chemically similar to RTFO
- Aging was physically similar, provided time was adjusted

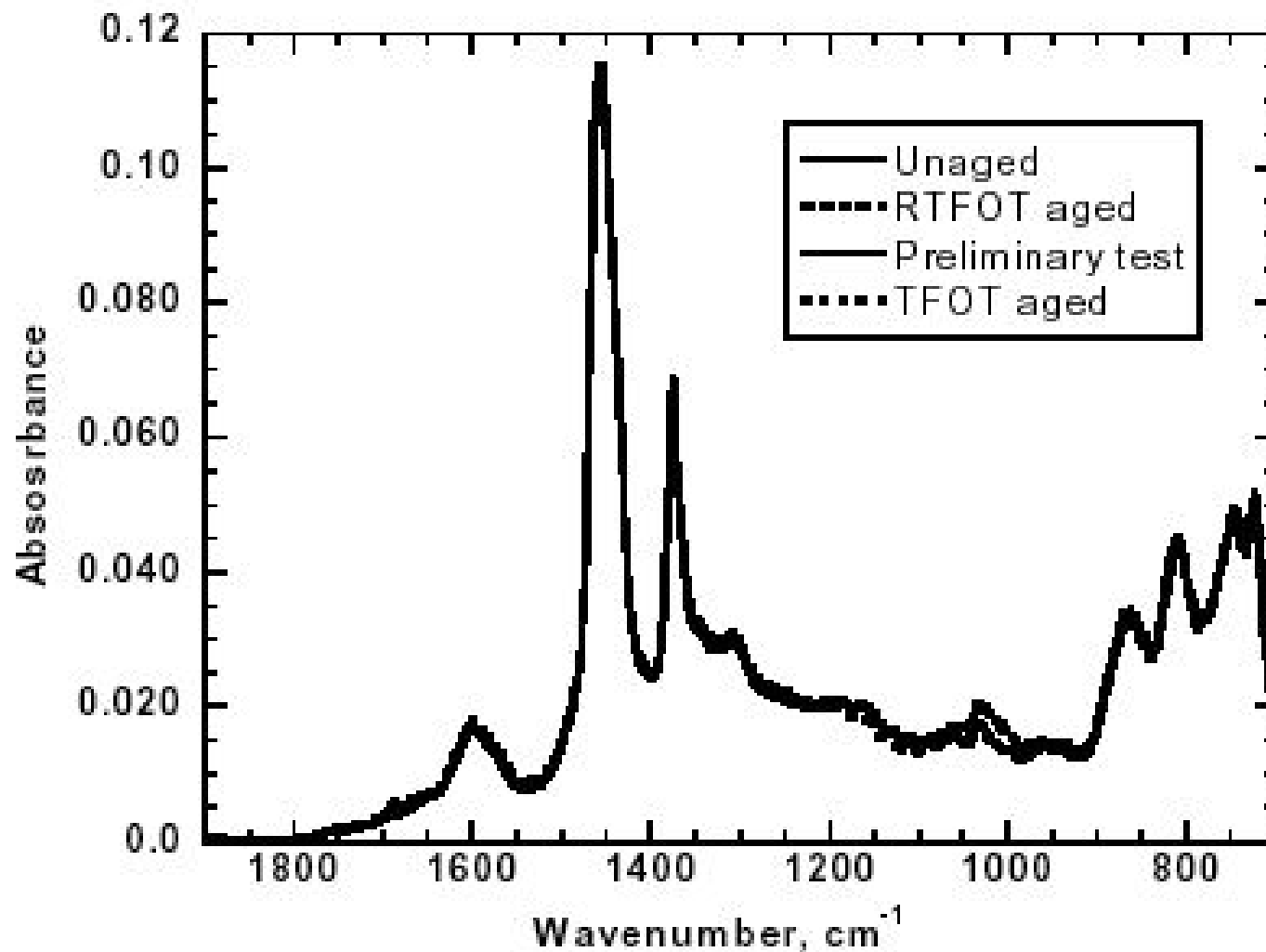


Figure 3-2. IR Spectra of Unaged and Aged A AC-10.

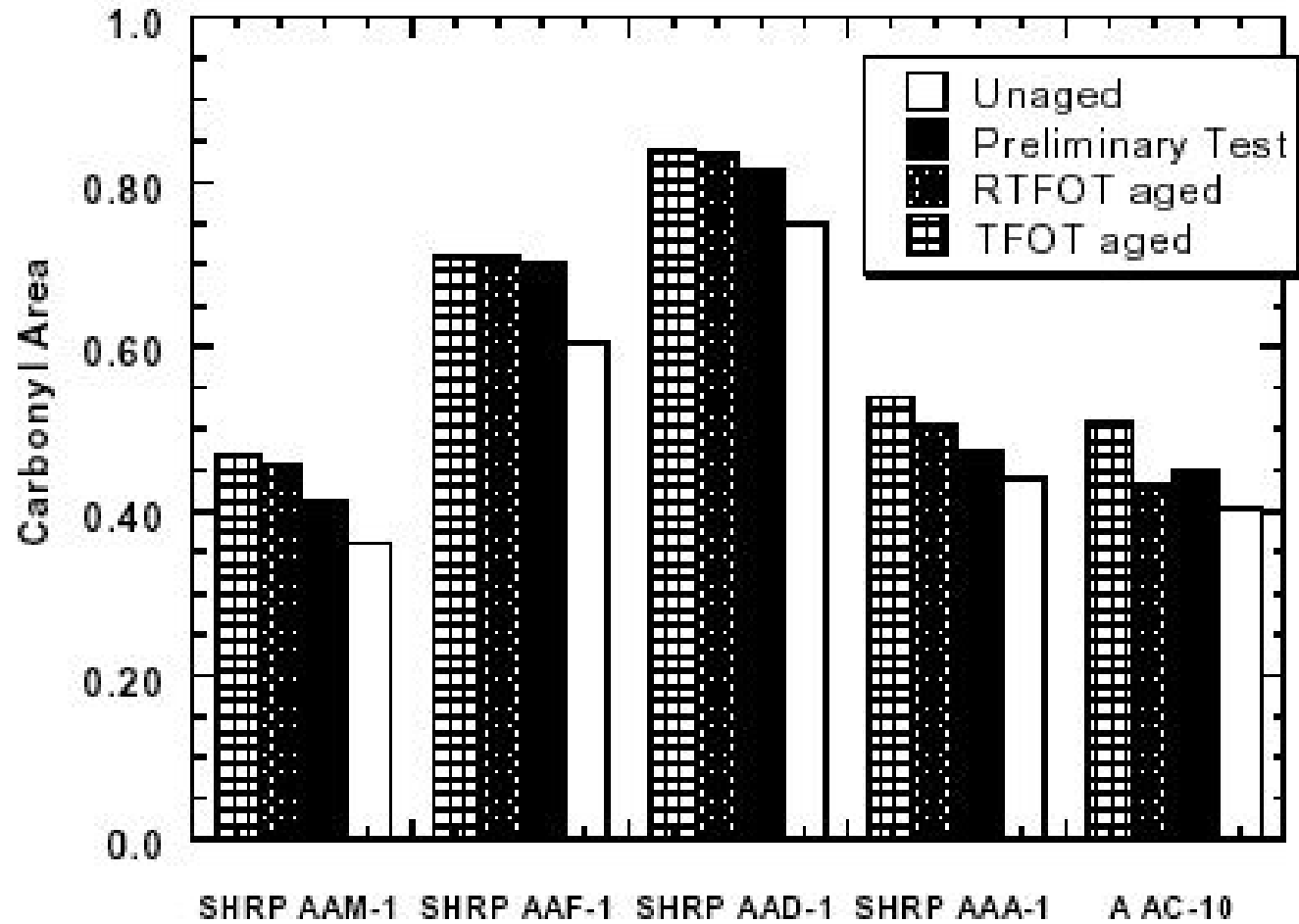


Figure 3-3. Carbonyl Area of Unaged and Aged Asphalts.

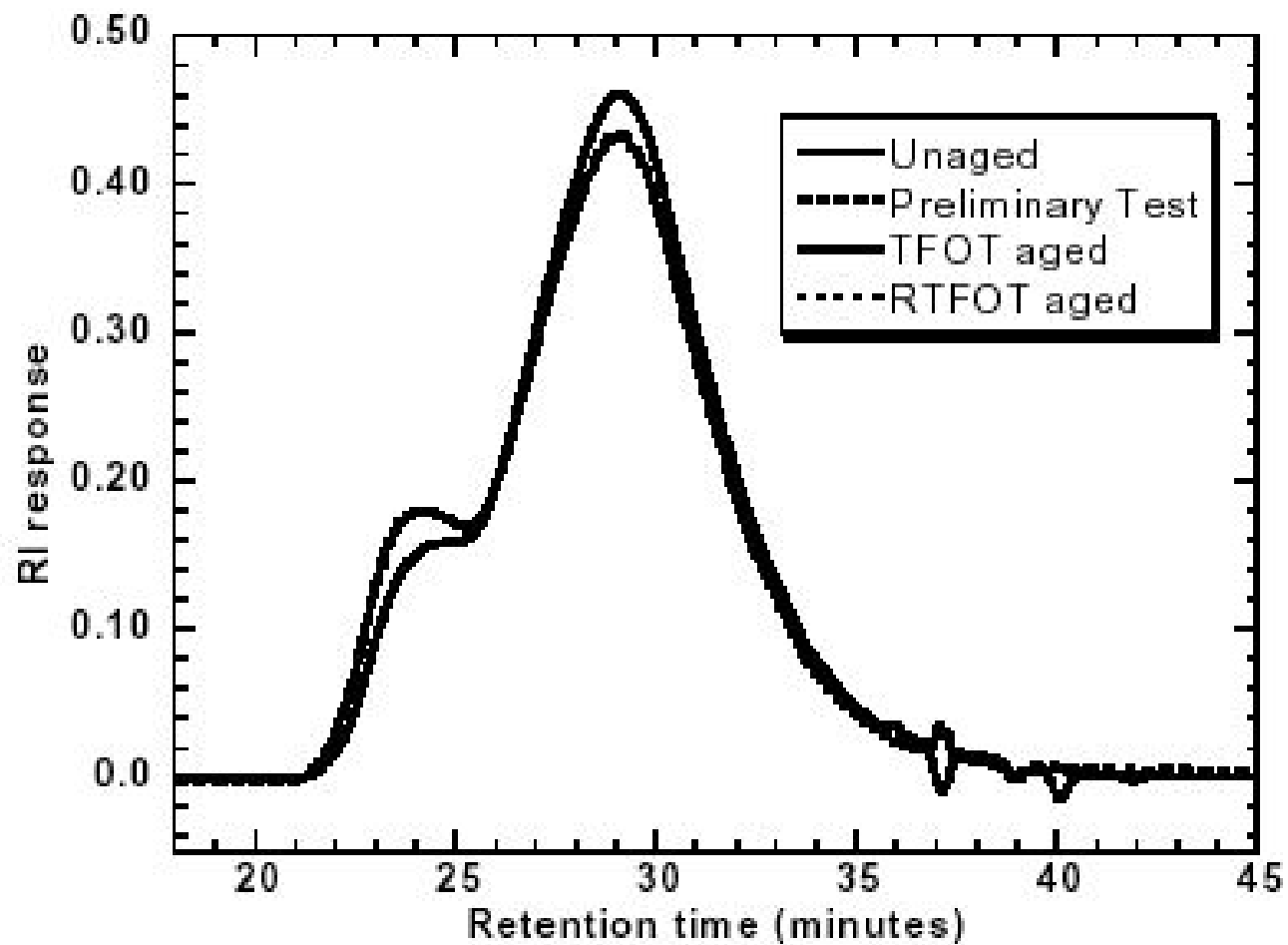


Figure 3-8. GPC Spectra of Unaged and Aged A AC-10.

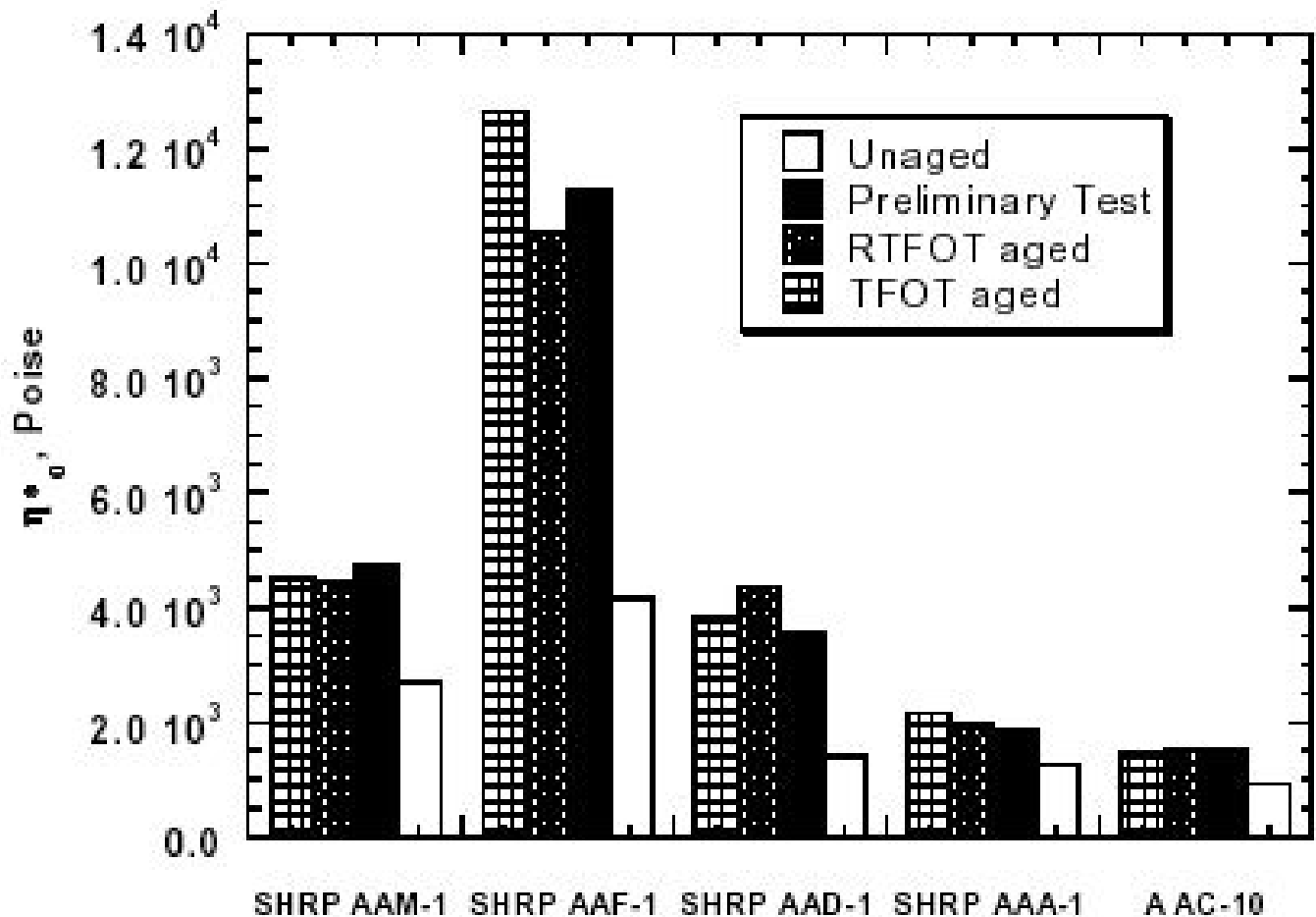


Figure 3-4. Limiting Complex Viscosity at 60 °C and 0.1 rad/sec of Aged and Unaged Asphalts.

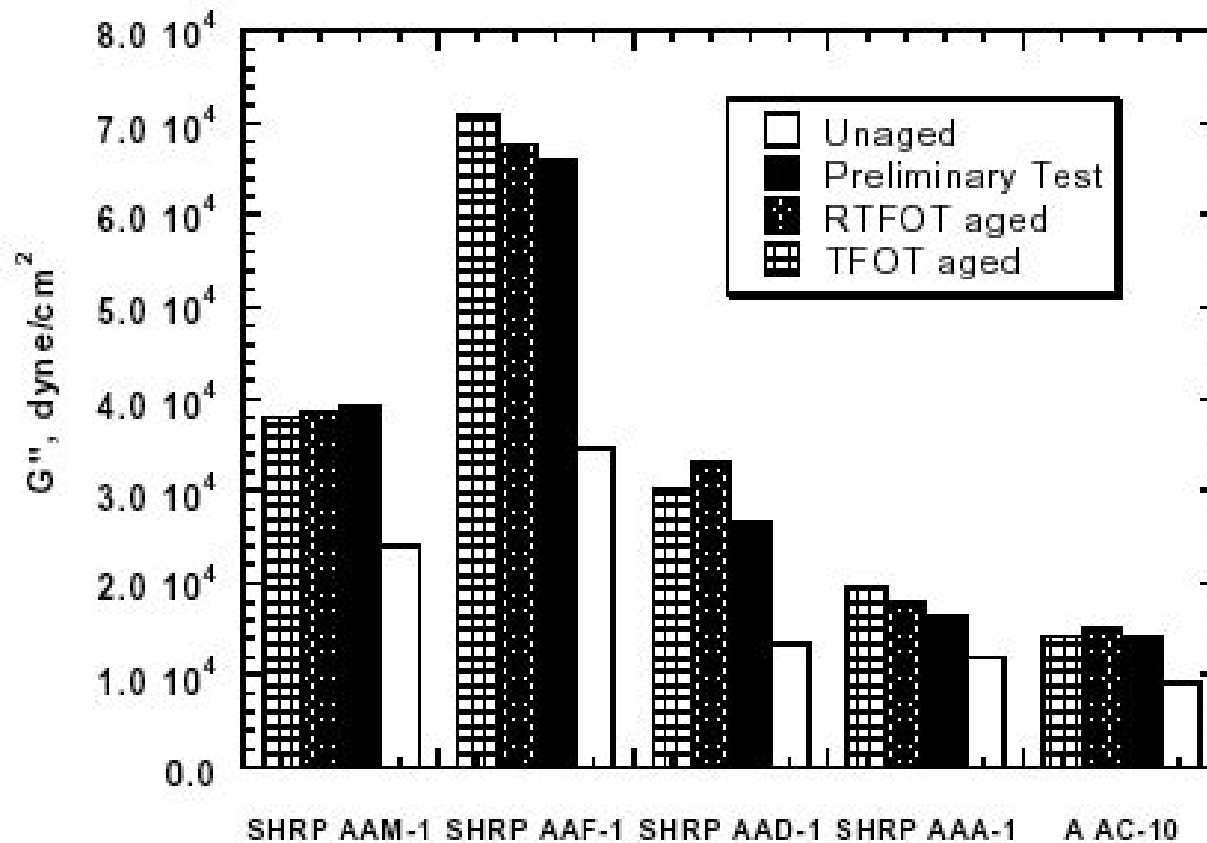


Figure 3-5. Loss Modulus G'' at 60 °C and 10 rad/sec of Aged and Unaged Asphalts.

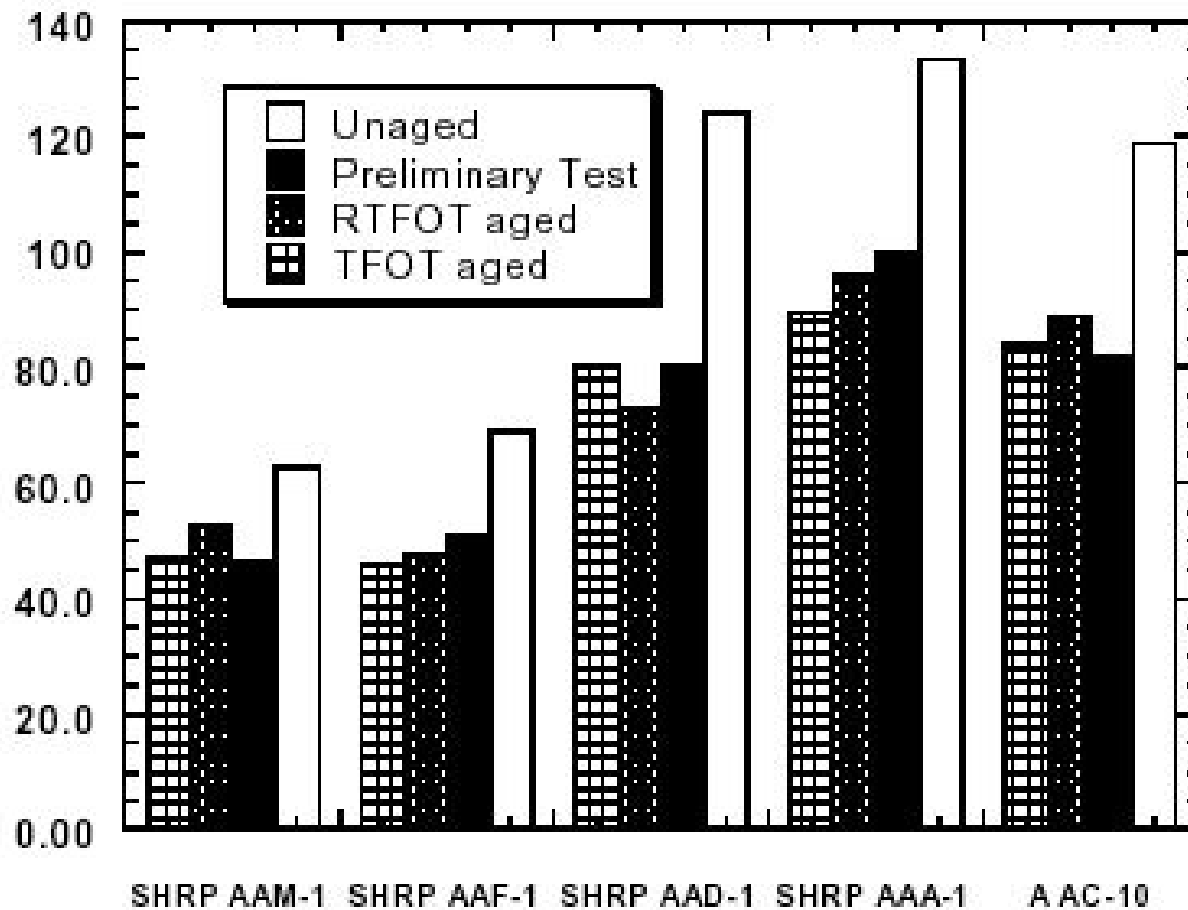


Figure 3-6. Penetration at 25 °C of Aged and Unaged Asphalts.

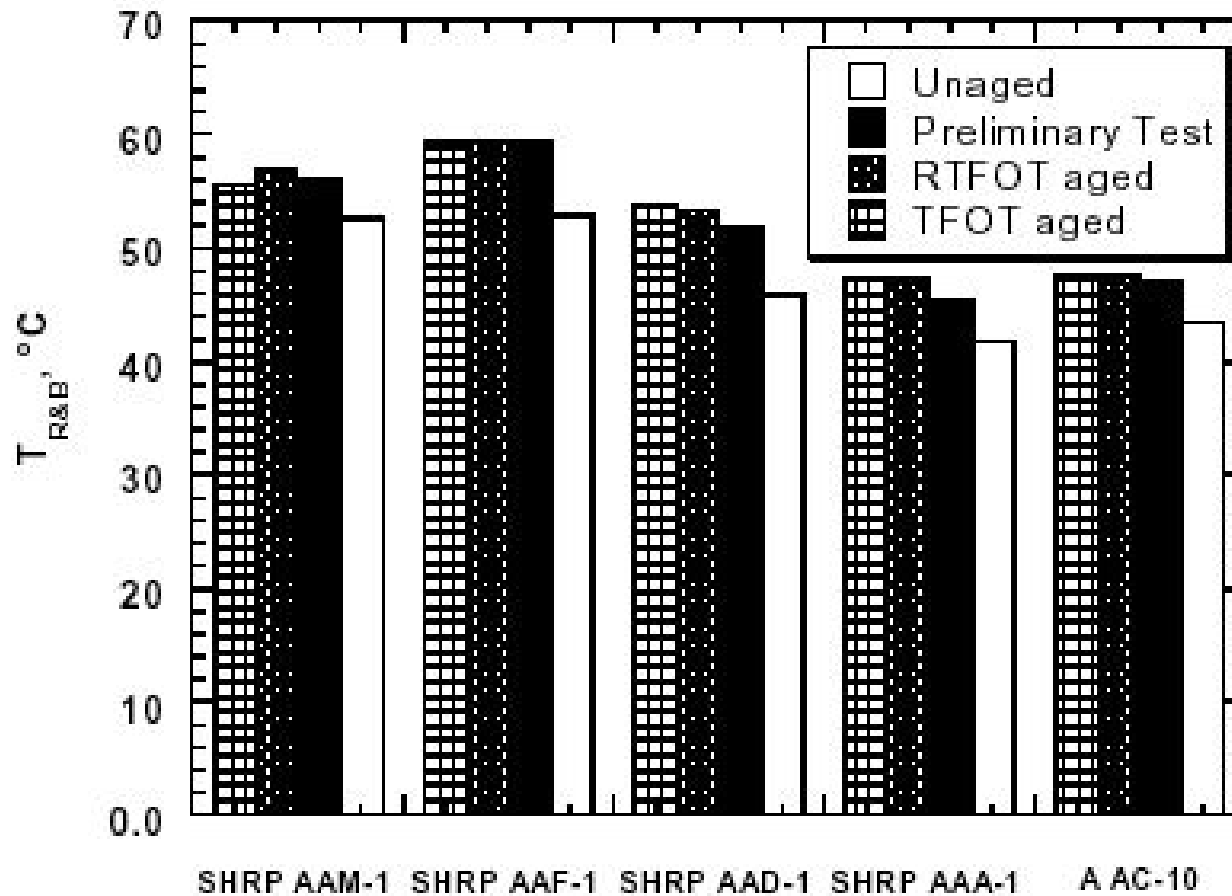


Figure 3-7. Softening Point ($T_{R\&B}$) of Aged and Unaged Asphalts.

Test Parameters



- Test temperature = 325°F
- Stirring rate
- Air flow rate
- Aging time - to be determined by properties
- Use of nitrogen

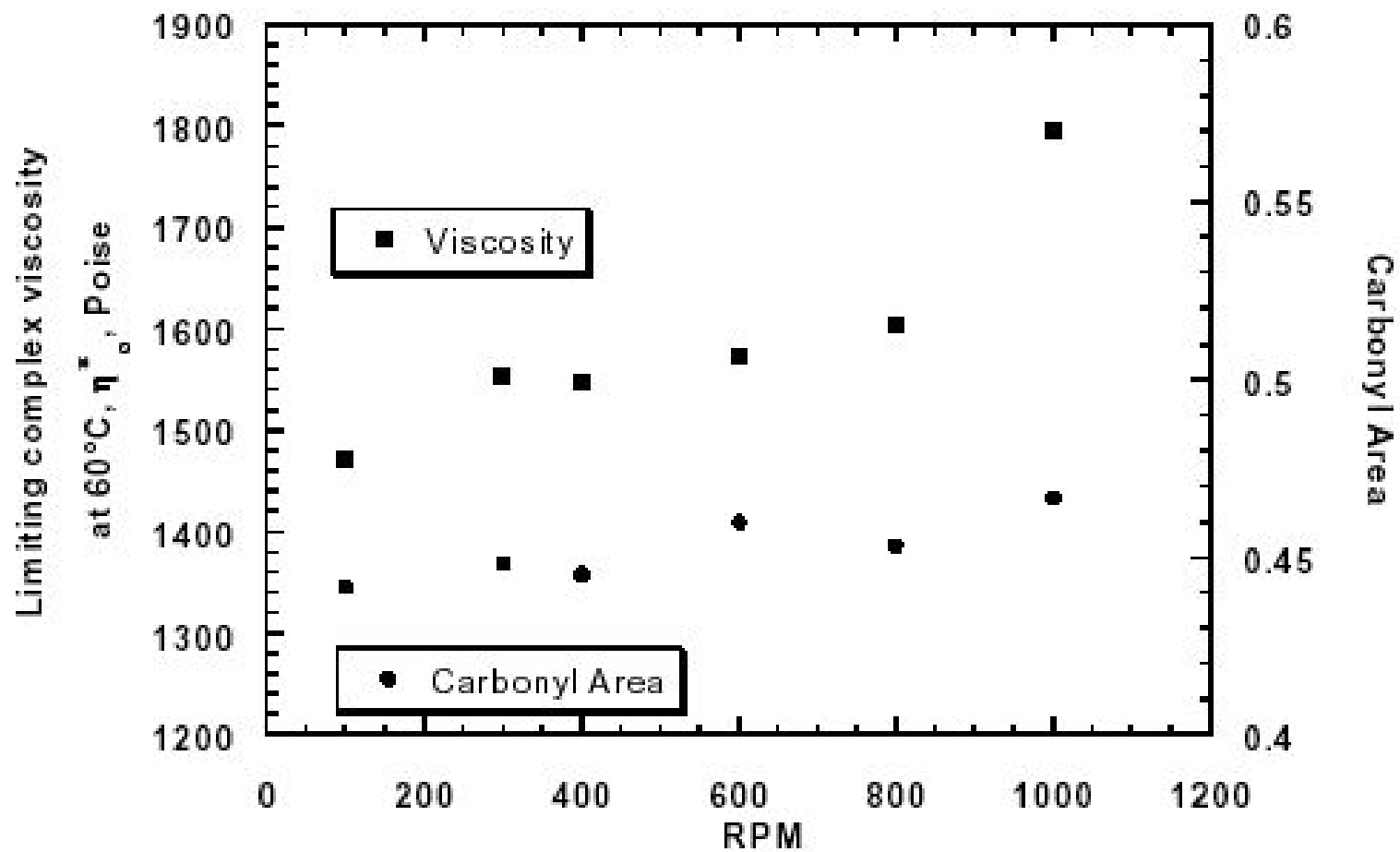


Figure 3-11. Effect of RPM on Limiting Complex Viscosity and Carbonyl Area, Prototype Apparatus.

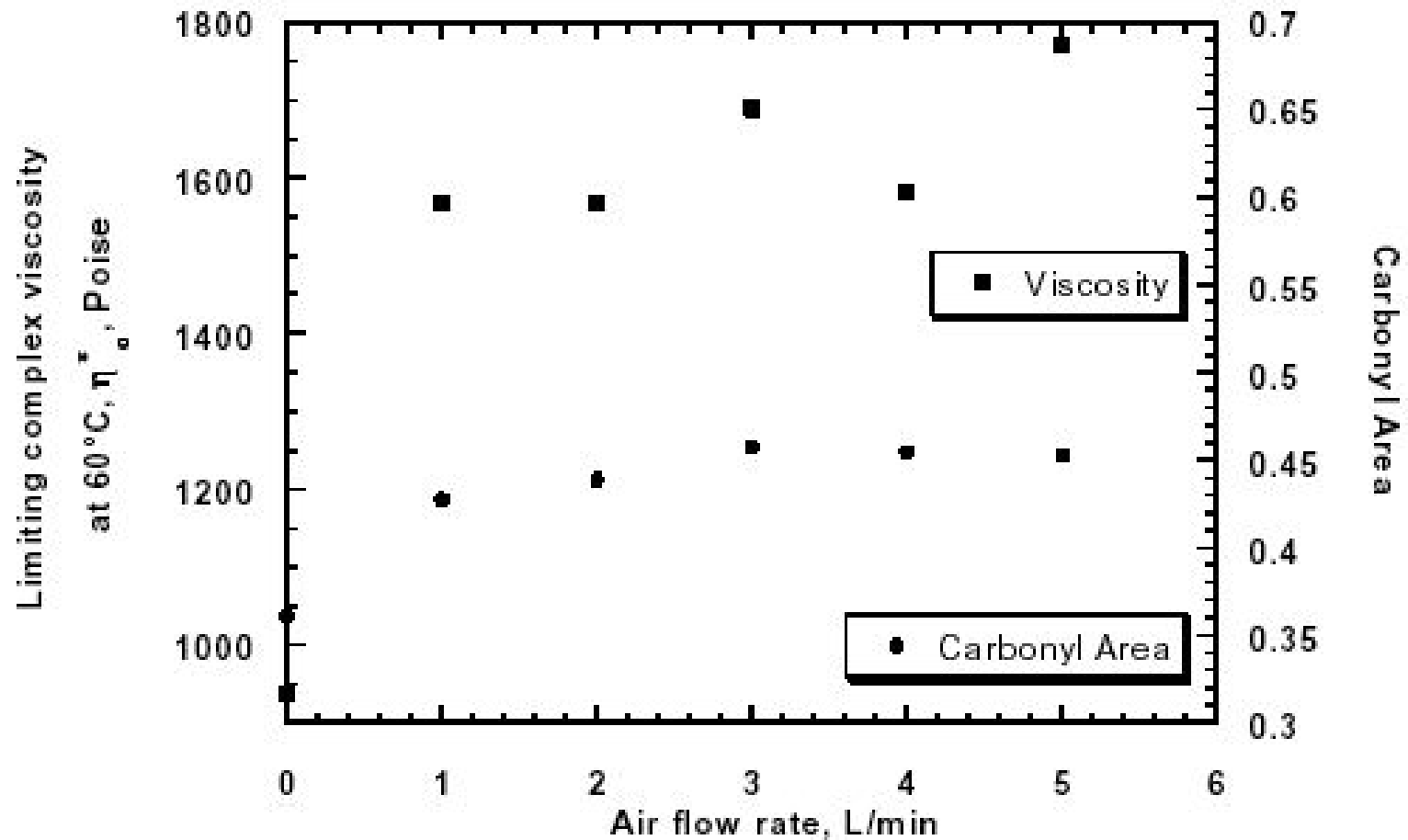


Figure 3-10. Effect of Air Flow Rate on Limiting Complex Viscosity and Carbonyl Area, Prototype Apparatus.

Final Test Parameters



- Temperature - 325°F
- Air Flow Rate - 2 L/min
- Stirring Rate - 700 RPM
- Sample Size - 250 g
- Aging Time - 30 min
- Nitrogen flow before and after aging

Volatiles Loss



- A condenser was added
- Could be rinsed with solvent to recover and weigh volatiles
- Produced encouraging results

Table 3-2. Condensed Volatiles and RTFOT Mass Change, Prototype Apparatus.

| Asphalt | Condensed volatiles, wt.% | RTFO/Reference Library, wt.% |
|------------|---------------------------|------------------------------|
| A AC-10 | 0.013 | +0.057 |
| A AC-20 | 0.043 | N/A |
| SHRP AAA-1 | 0.027 | -0.312 |
| SHRP AAF-1 | 0.045 | -0.092 |
| SHRP AAM-1 | 0.014 | +0.052 |
| SHRP AAS-1 | 0.031 | -0.039 |
| SHRP AAD-1 | 0.051 | -0.810 |
| SHRP ABM-1 | 0.035 | -0.248 |
| SHRP AAG-1 | 0.051 | -0.180 |
| C AC-20 | 0.032 | -0.400 |
| B AC-20 | 0.018 | +0.057 |

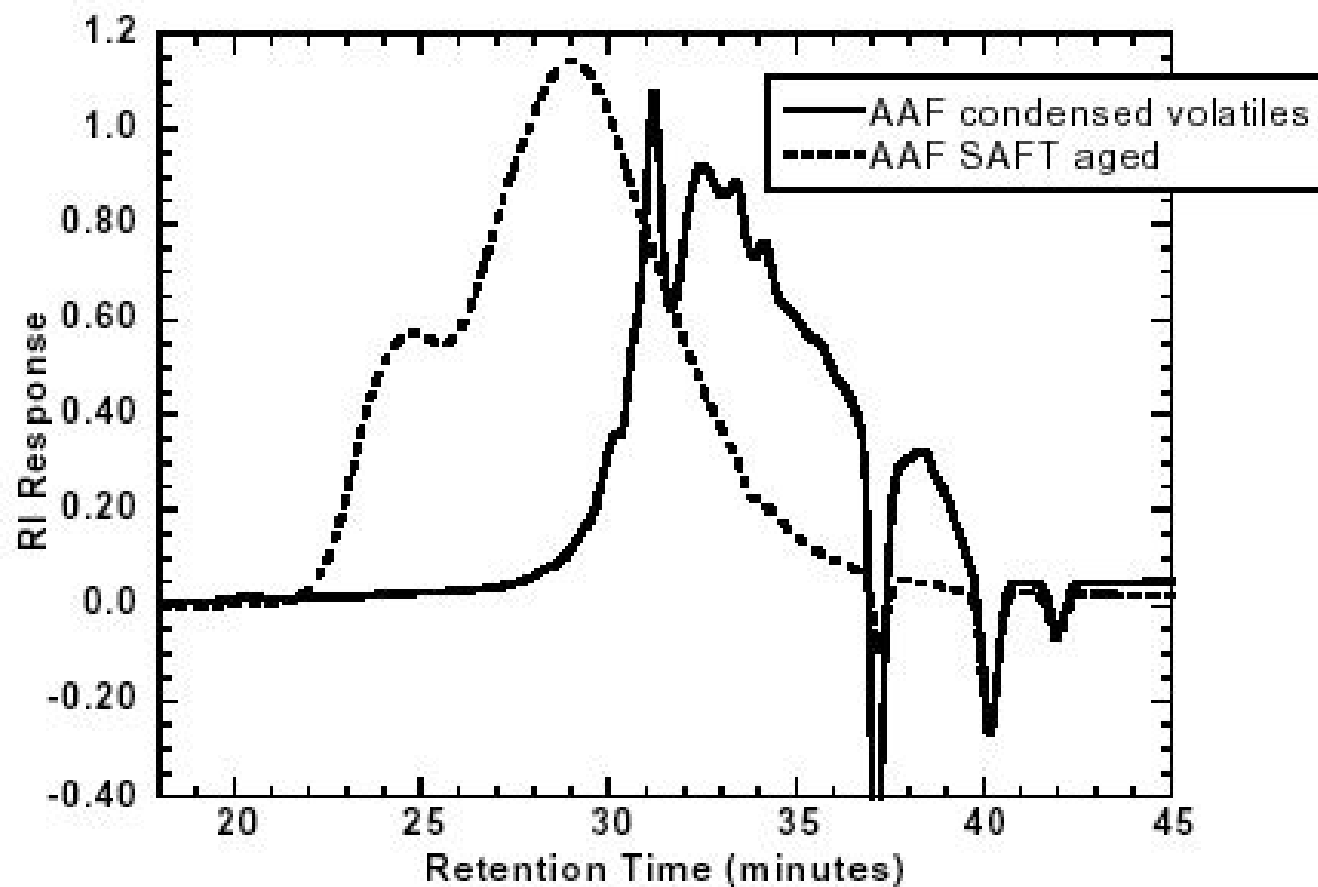


Figure 3-12. GPC Spectra of Aged SHRP AAF-1 and Condensed Volatiles, Prototype Apparatus.



Round-Robin Study

- Researchers provided 5 instruments
- Participants
 - TxDOT M&P (us)
 - Fort Worth District Lab
 - Odessa District Lab
 - Gulf States Asphalt
 - Asphalt Institute
 - TTI

Round-Robin Study

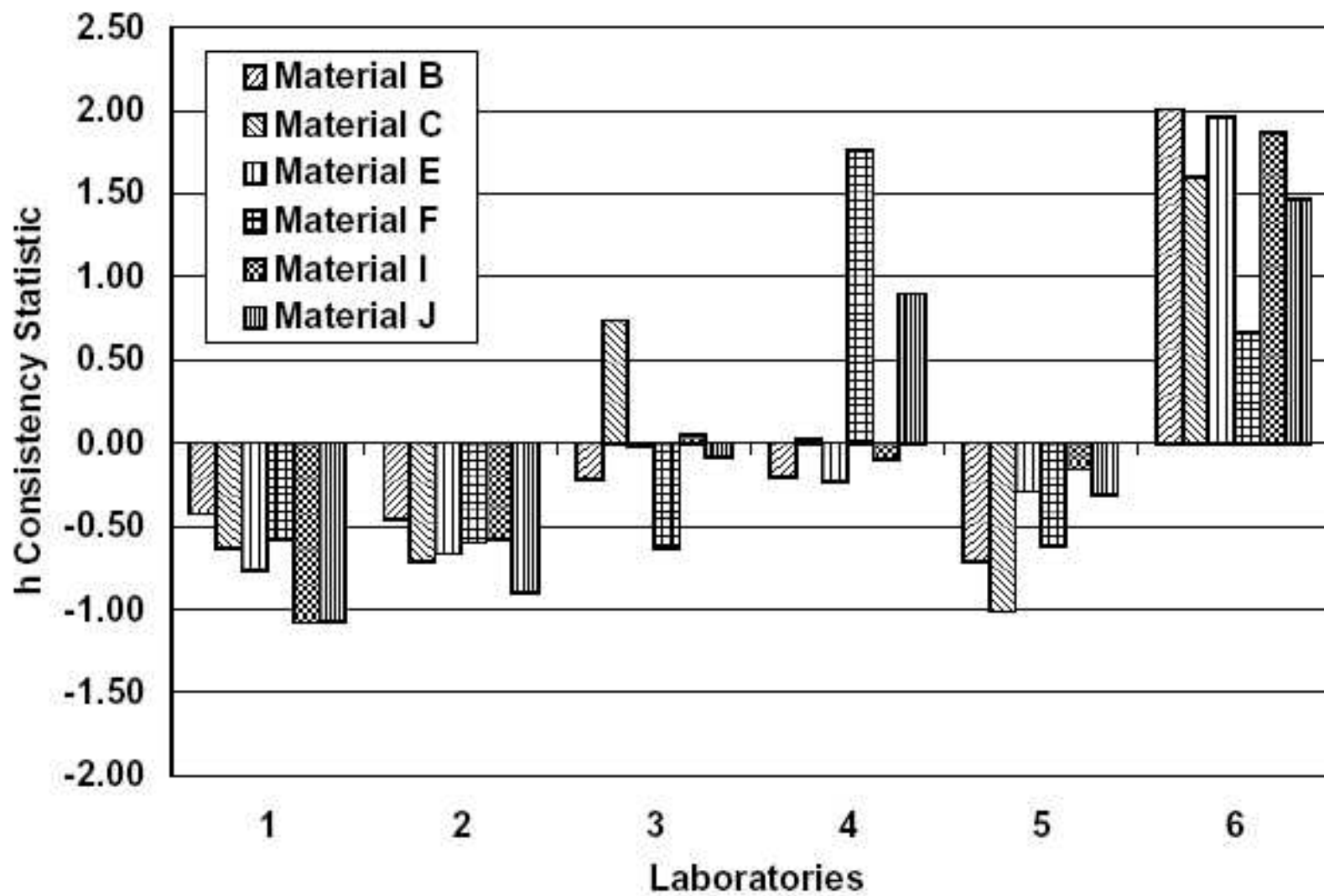


- Designed in accordance with ASTM E-691
- 6 labs and 6 materials
- RTFO and SAFT tests were run
- Results analyzed for consistency, repeatability, and reproducibility

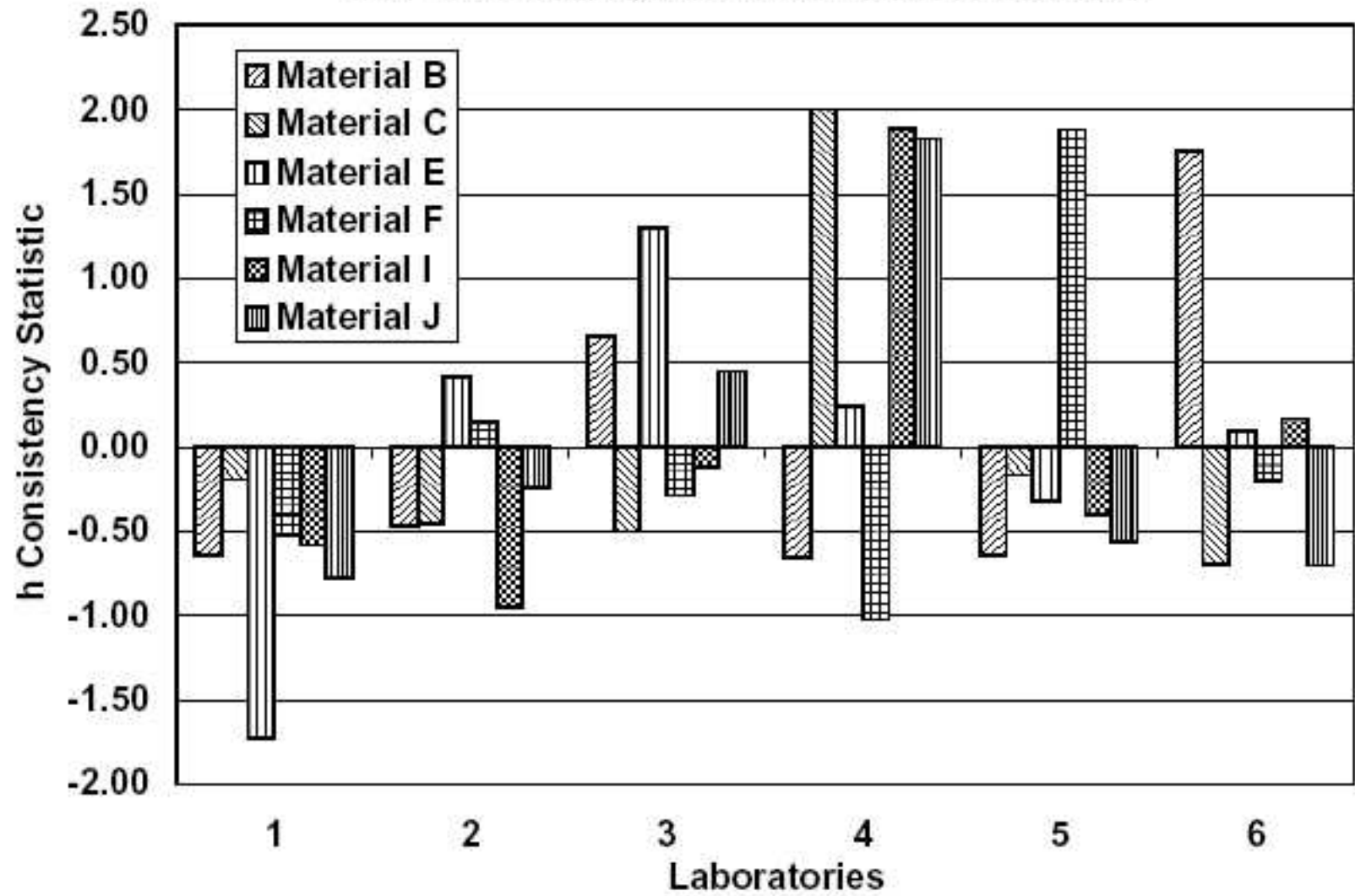
Table 3. Precision Statistics for the Round-Robin Test.

| Precision Statistic | | Material | | | | | | Mean |
|------------------------|--------|----------|-----|-----|-----|-----|-----|------|
| | | B | C | E | F | I | J | |
| s_r | Unaged | 96 | 40 | 32 | 29 | 54 | 66 | 58 |
| | RTFOT | 48 | 129 | 92 | 80 | 86 | 57 | 86 |
| | SAFT | 290 | 61 | 191 | 114 | 59 | 64 | 155 |
| s_R | Unaged | 330 | 162 | 195 | 533 | 194 | 97 | 290 |
| | RTFOT | 201 | 253 | 167 | 183 | 182 | 198 | 199 |
| | SAFT | 335 | 456 | 262 | 254 | 179 | 125 | 289 |

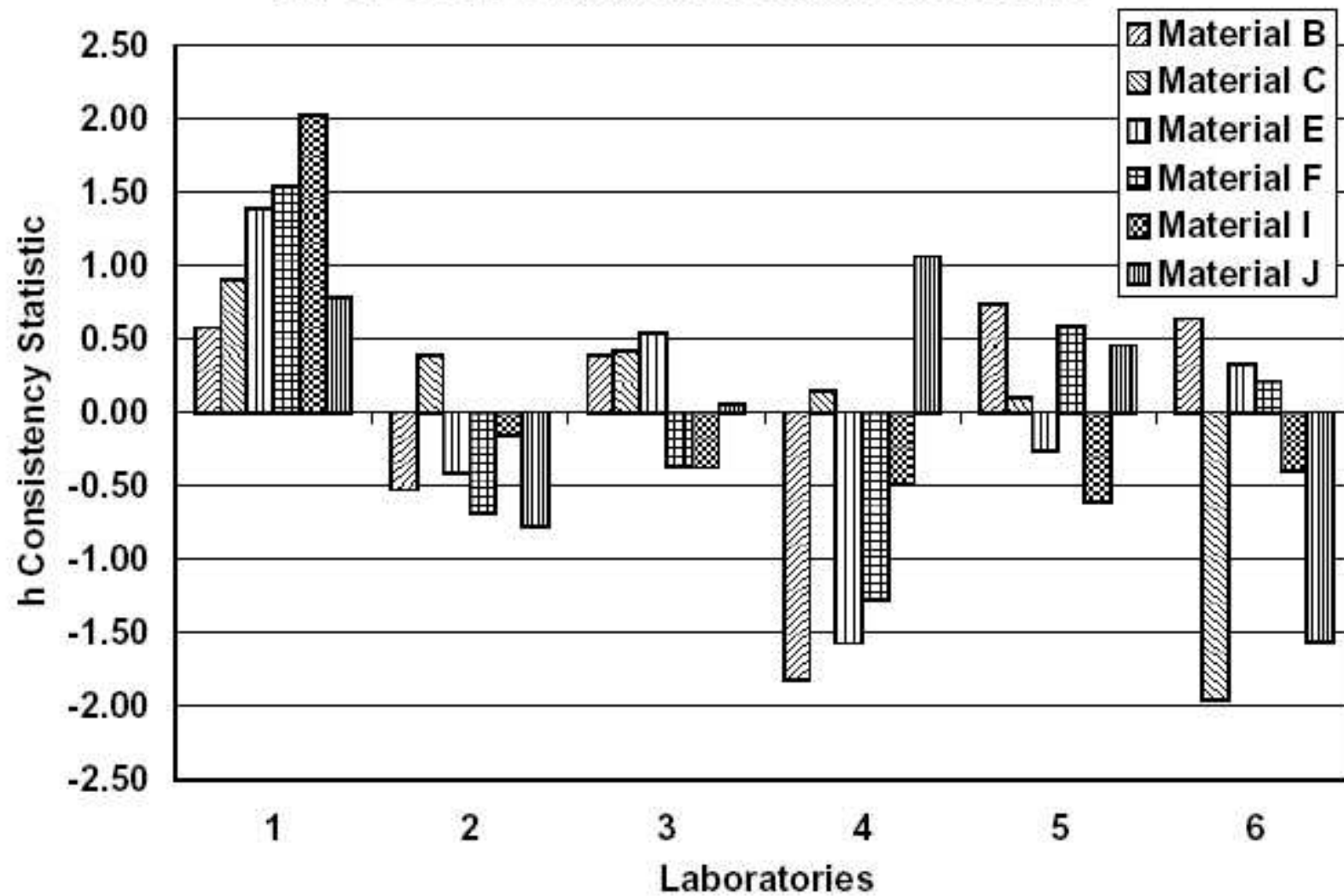
Unaged $G^*/\sin \delta$: h, Materials within Laboratories



SAFT $G^*/\sin \delta$: h, Materials within Laboratories



RTFOT $G^*/\text{Sin } \delta$: h, Materials within Laboratories



Round-Robin Findings

- Reproducibility and repeatability
 - RTFO was slightly better than SAFT
 - SAFT numbers were not bad
 - Expected, since all of the operators were new to the test
 - Generally in good shape

Round-Robin Findings



- Precision
 - No inter-laboratory biases were detected
 - Consistency with labs was also acceptable
- Volatiles Collection
 - 2 labs did not run; one had a systematic error
 - Statistics for the remaining three labs were good

Round-Robin Findings

- RTFO/SAFT comparison
 - $G^*/\sin(\delta)$ was consistently lower for SAFT
 - Suggest increasing test time to 35 minutes
- No problems with modified binders were observed

Round-Robin Findings



- Problems
 - Consistent stirring rate was impeded by shaft alignment and motor power
 - Suggest a redesign of the bearing/bushing and a stronger motor with a speed controller

Round-Robin Findings



- Problems
 - Some temperature control problems
 - Suggest better tuning on the controller and matching nitrogen flow to air flow

Round-Robin Findings



- Other suggestions
 - Use RTD rather than thermocouple
 - Provide easier-to-handle insulation
 - Use switching valves to change gas flow
 - Panel mount controls

Current Status



- About to start 2nd phase of IPR
 - Redesign the instrument
 - Approach potential manufacturers
 - Purchase the instrument for interested TxDOT districts
- Still planning to use the SAFT in place of the RTFO

In Closing



- Advantages of the SAFT
 - Shorter aging time
 - Better sample size
 - Mechanical agitation less sensitive to binder stiffness
 - Less mess and easier cleanup
 - Safer - no direct handling of hot equipment

In Closing



- Advantages of the SAFT
 - More representative measurement of volatility
 - Smaller
 - Cheaper
 - Most parts are off-the-shelf; the ones that are not are very durable
 - Simple, familiar methodology

For Detailed Reports:

- Contact TxDOT's Research and Technology Implementation Office (RTI)
 - Projects 0-1742 and 5-1742
 - Library services phone: (512) 232-3126
 - e-mail: ctrlib@uts.cc.utexas.edu