Durability Evaluation of Urea SCR Catalysts for Heavy Duty Diesel Engines

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OUTLINE

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Project Objective

✦ **Assess the potential long-term durability of various SCR catalyst formulations for mobile heavy duty diesel application.**

➢ Identify and evaluate deactivation mechanism

- *1) Thermal aging*
- *2) Poisoning (coking)*

➢ Develop simple aging tests to "stress" the catalysts

- *1) Lab evaluation: furnace aging + reactor bench test*
- *2) On-engine evaluation: extended low temp. cyclic test*

➢ Use tests to evaluate commercial SCR catalyst formulations

- *Supplier participation*

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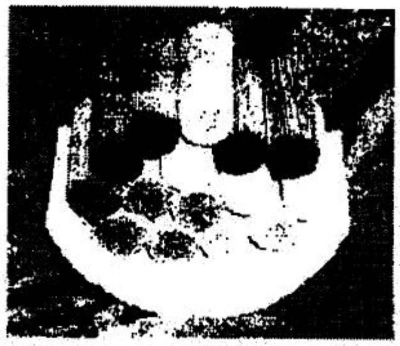
Thermal Deactivation Evaluation

✦ **Aging Conditions:**

- ➢ **6 SCR catalyst formulations (A - F)**
- ➢ **3 aging temperatures (470°, 520°, & 570° C)**
- ➢ **3 aging durations (fresh, 500, 1000 hours)**
- ➢ **Samples aged in atmosphere tube furnace**



✦ **Reactor Bench Test Conditions:**

- ➢ **Simulated diesel exhaust**
- ➢ **4 temperatures evaluated (250°, 325°, 400°, 520° C)**
- ➢ **Space velocity = 50,000 hr^{-1}**
- ➢ **NH_3/NOx = 0.9**
- ➢ **Chemiluminescence NOx analyzer, FTIR**

Gas	Concentration
CO_2	8 %
CO	500 ppm
NO	500 ppm
SO_2	30 ppm
C_3H_6	50 ppm
O_2	9 %
H_2O	7 %
N_2	balance

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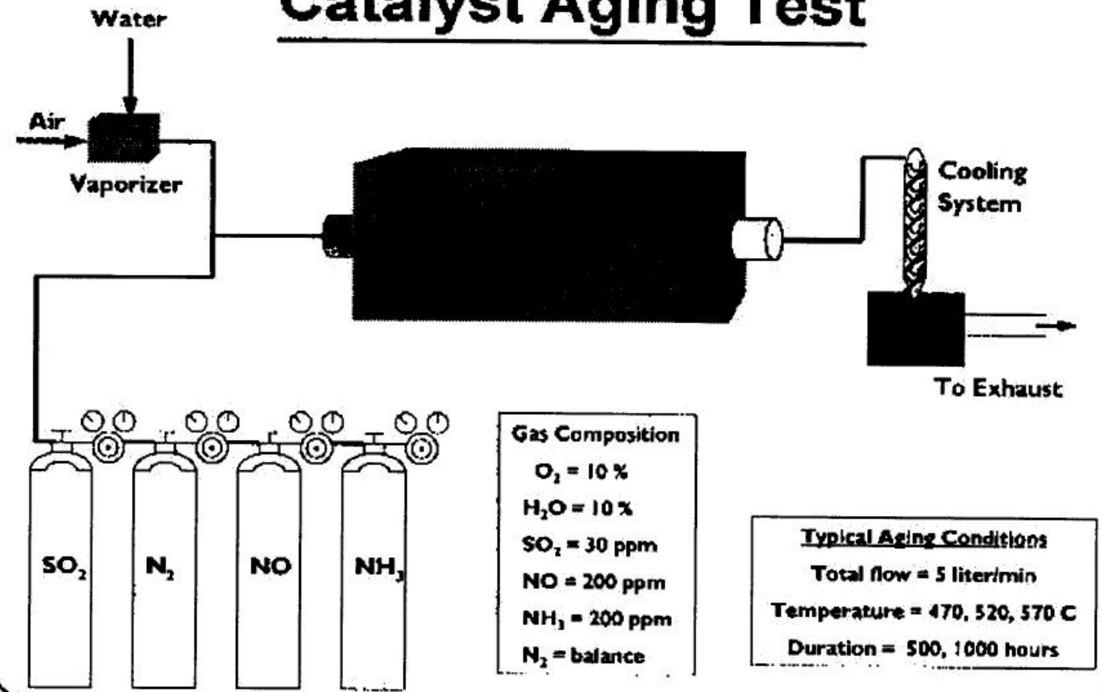
Catalyst Aging Test



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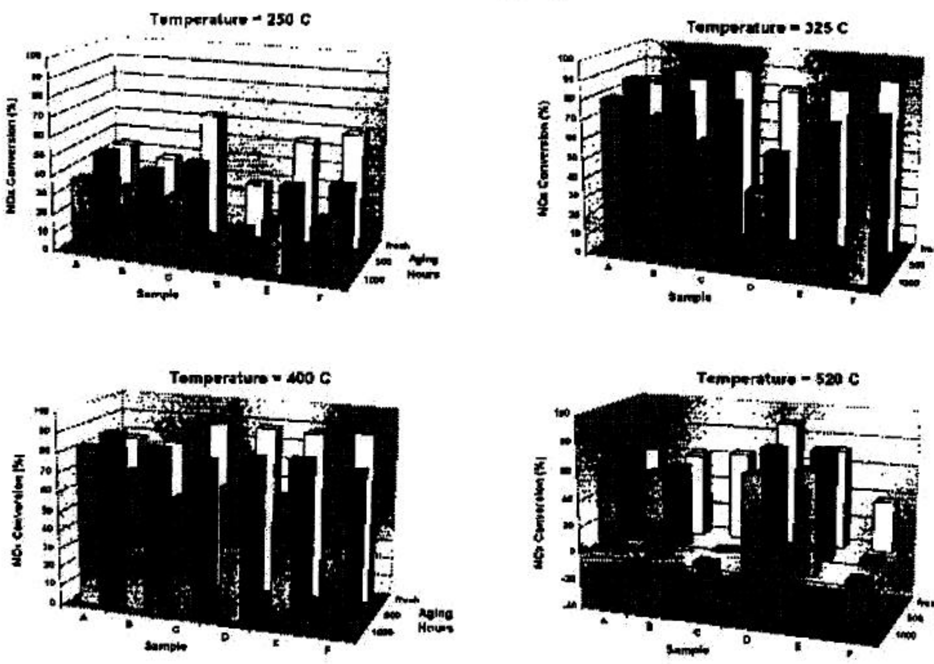
NOx Conversion Performance
Thermal Aging = 470° C



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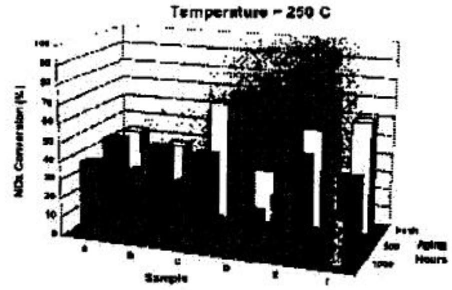
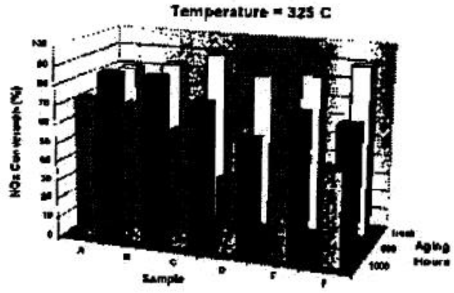
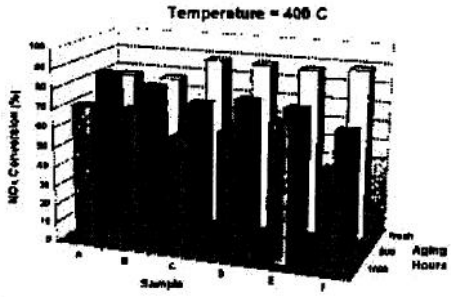
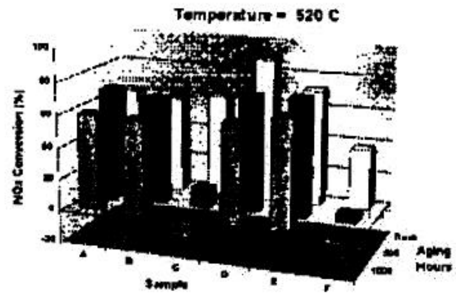
NOx Conversion Performance
Thermal Aging = 520° C









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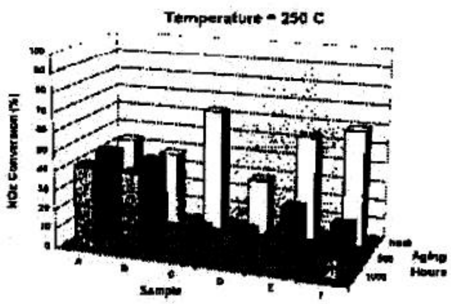
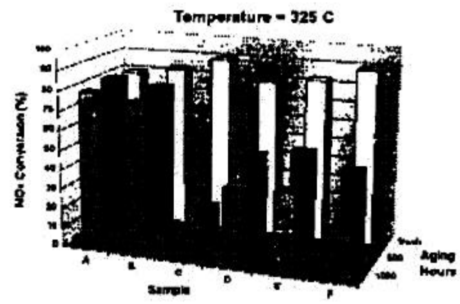
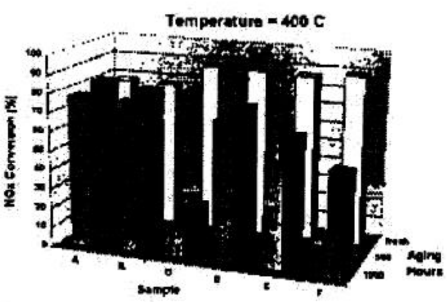
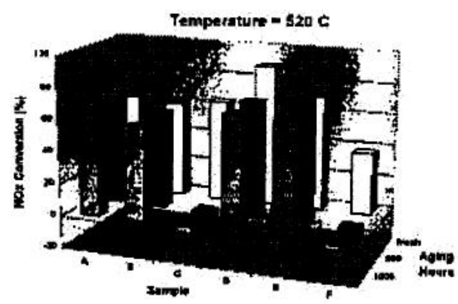
NOx Conversion Performance
Thermal Aging = 570° C









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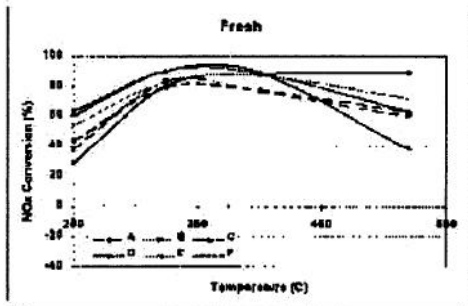
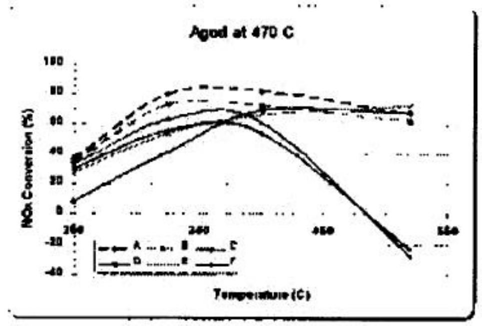
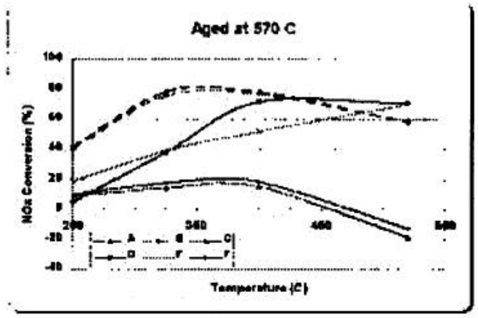
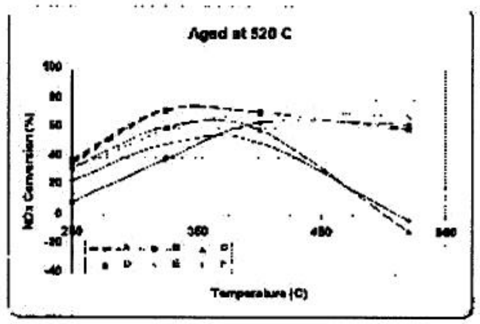
Thermal Aging Results: Fresh vs. 1000 Hour Aged









➤ ***Samples A & B exhibited superior durability.***

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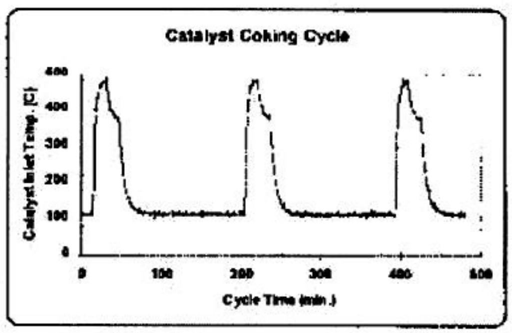
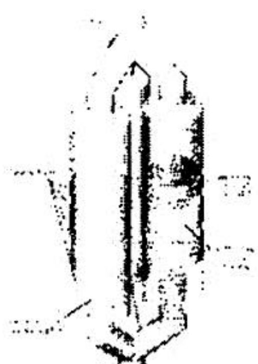
Engine Aging (Coking Cycle) Evaluation



✦Aging Conditions:

- ➤ **6 SCR catalyst formulations (A - F)**
- ➤ **14.6 liter HDD engines (MY'98)**
- ➤ **Coking cycle**
- ➤ **Exhaust split through "3 pack"**
- ➤ **3 aging durations (fresh, 500, 1000 hours)**



✦Performance Testing Conditions:

- ➤ **14.6 liter engines**
- ➤ **5 temperatures evaluated (~250°, 340°, 420°, 470°, 525° C)**
- ➤ **Space Velocity = 15,000 - 35,000 hr^{-1}**
- ➤ **NH_3/NOx = 0.8 (0.6 at 250° C)**
- ➤ **Chemiluminescence NOx analyzer, FTIR**

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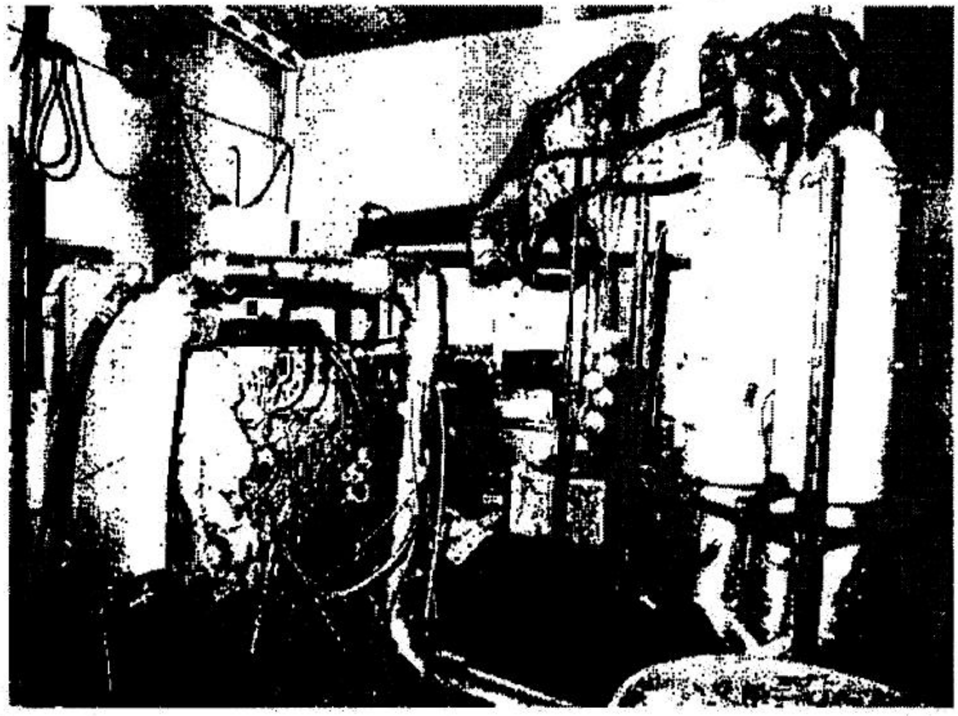
Engine Aging Test Setup



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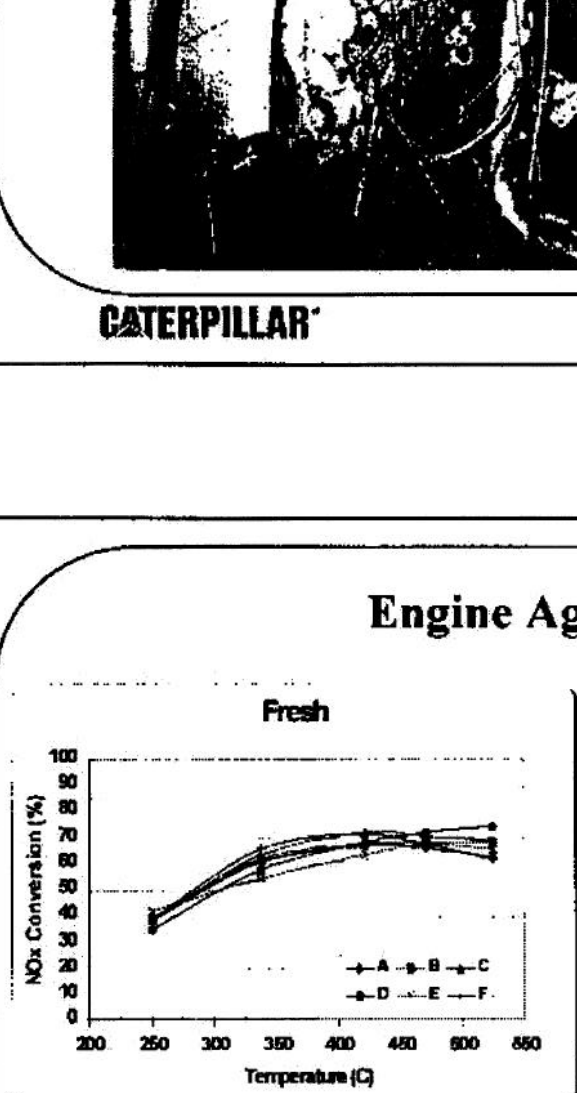
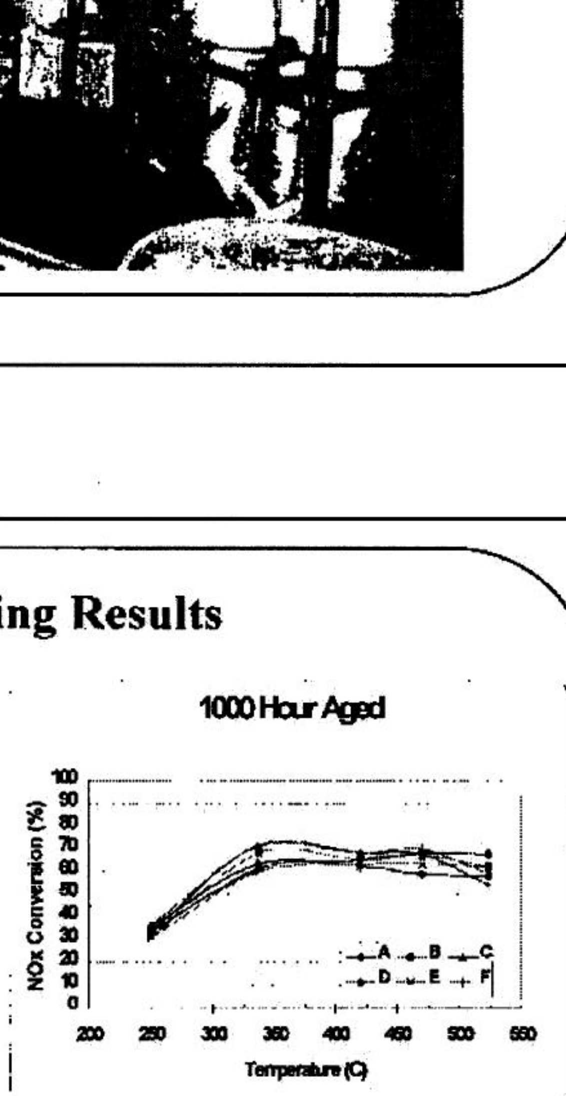
Engine Aging Results





- *Fresh performance was similar for all 6 samples.*
- *Engine aging did not identify any samples significantly impacted by coking deactivation.*

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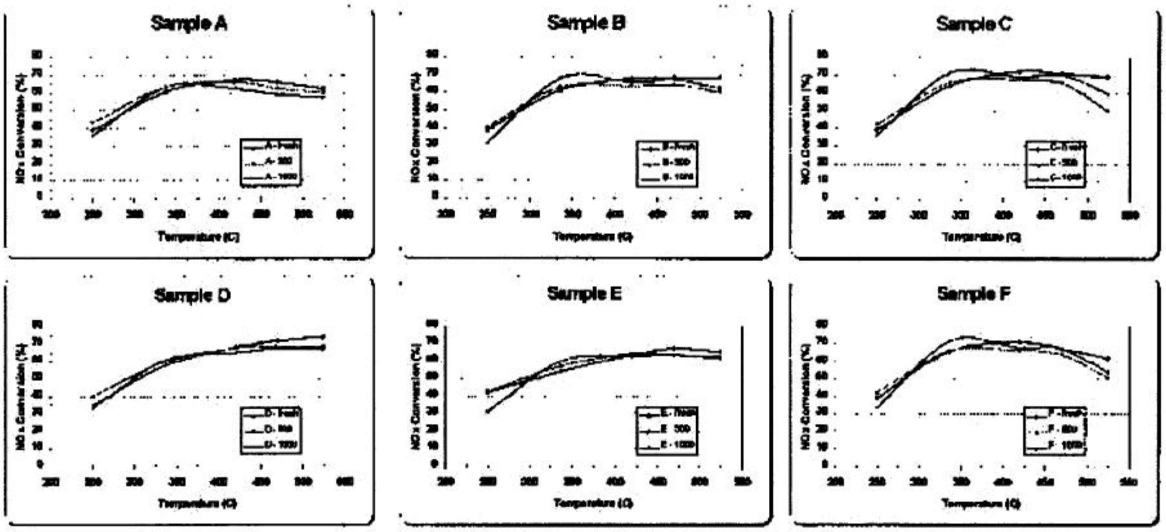
Engine Aging Results
Fresh vs. Aged



➢ *No discernible degradation trends were observed after 1000 hours.*

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Summary

- 6 SCR catalysts were subjected to laboratory (furnace) and engine tests for durations up to 1000 hours.
- Tests were used as a durability screening tool to evaluate the catalyst's resistance to thermal and coking deactivation.

➢ Fresh NOx conversion performance differences were noted in bench testing (at low and high temps) but not in engine testing.

➢ The samples exhibited significantly different thermal deactivation resistance.

  *Samples A & B showed superior durability.

➢ Through 1000 hours of aging, no clear trends were observed for coking deactivation/durability among the samples.

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Conclusions

- ➢ Deactivation tests are an effective tool for evaluating the long-term durability of SCR catalyst formulations from suppliers.

- ➢ Thermal deactivation appears to be more of an issue than coking deactivation for SCR catalysts.
  - •More significant at higher aging temperatures
  - •1500 hour aging data will be examined

- ➢ Perform physical analysis on tested samples to correlate material changes with performance results.

- ➢ Investigate development of a more effective coking test for future screening work.

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