

## **AMERICAN MOBILE RESEARCH, INC.**

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### **SULFUR PASSIVATION STUDY ON VARIOUS METAL SAMPLING CYLINDERS**

IN DECEMBER, 2002, AMERICAN MOBILE RESEARCH, INC. CONDUCTED A CONTROLLED STUDY OF THE REACTIVITY OF SEVERAL COMMON SULFUR SPECIES, FOUND TO EXIST IN NATURAL GAS AND NATURAL GAS LIQUIDS, TO THE LINING OF VARIOUS METAL SAMPLING CYLINDERS CURRENTLY USED TO OBTAIN THESE PRODUCTS. THIS STUDY WAS PERFORMED SO THAT WE COULD BETTER UNDERSTAND THE REACTIVENESS BETWEEN THE CYLINDERS AVAILABLE FOR PRODUCT SAMPLING AND VARIOUS SULFUR SPECIES. PASSIVITY IS A PROPERTY SHOWN BY IRON, ALUMINUM, AND RELATED METALS INVOLVING THE LOSS OF THEIR NORMAL CHEMICAL ACTIVITY WHEN SUBMITTED TO A CORROSIVE ENVIRONMENT.

THE SCOPE OF THE STUDY WAS TO DETERMINE HOW EACH SULFUR SPECIES REACTED WITH EACH DIFFERENT TYPE OF METAL CYLINDERS, OVER A PERIOD OF TIME. EACH OF THESE PRIMARY TYPES OF CYLINDERS WERE USED FOR THIS STUDY:

- 1) **CARBON STEEL**
- 2) **ALUMINUM**
- 3) **TEFLON-LINED ALUMINUM**
- 4) **STAINLESS STEEL**
- 5) **TREATED STAINLESS STEEL (SULFINERT BRAND)**

EACH CYLINDER WAS FILLED TO A PRESSURE OF 1000 PSIG WITH AN NBS TRACEABLE STANDARD GAS CONTAINING APPROXIMATELY 10 PARTS PER MILLION / VOLUME OF THE FOLLOWING SULFUR COMPOUNDS:

<b><u>SULFUR SPECIES</u></b>	<b><u>CONCENTRATION</u></b>
<b>HYDROGEN SULFIDE</b>	<b>10.1 PPM/VOLUME</b>
<b>CARBONYL SULFIDE</b>	<b>10.2 PPM/VOLUME</b>
<b>METHYL MERCAPTAN</b>	<b>10.1 PPM/VOLUME</b>
<b>ETHYL MERCAPTAN</b>	<b>10.4 PPM/VOLUME</b>
<b>2-PROPYL MERCAPTAN</b>	<b>10.9 PPM/VOLUME</b>
<b>DIMETHYL SULFIDE</b>	<b>10.2 PPM/VOLUME</b>
<b>DIMETHYL DISULFIDE</b>	<b>10.4 PPM/VOLUME</b>

UPON FILLING THESE CYLINDERS WITH THE SULFUR MIXTURE, ANALYSIS WAS PERFORMED ON EACH CONTAINER TO DETERMINE THE AMOUNT OF PASSIVATION OF EACH SULFUR SPECIES, VERSUS THE AMOUNT OF TIME THE STANDARD GAS WAS IN EACH CYLINDER. THE ANALYSIS OF THESE SULFUR COMPOUNDS WERE PERFORMED ON A SIEVERS MODEL 355 SULFUR CHEMILUMINESCENCE DETECTOR CHROMATOGRAPH\* AT INTERVAL OF 1 HOUR, 2 HOURS, 24 HOURS AND 72 HOURS AFTER SUBMITTING THE SULFUR STANDARD GAS INTO EACH TYPE OF CYLINDER.

THE RESULTS OF EACH CYLINDER ANALYSIS WERE CALIBRATED AND COMPARED TO TWO PRIMARY NBTS SULFUR STANDARDS, PRODUCED BY DCG PARTNERSHIP, LTD. THE RESULTS OF EACH CYLINDER TESTED ARE OUTLINED BELOW:

**TYPE OF CYLINDER.....STAINLESS STEEL (304)**

**SAMPLE TIME IN CYLINDER**

<u>SULFUR COMPOUND</u>	<u>1 HOUR</u>	<u>% LOSS 24 HOURS</u>	<u>% LOSS 72 HOURS</u>	<u>% LOSS</u>
HYDROGEN SULFIDE	0.030 PPM	99.70% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
CARBONYL SULFIDE	10.175 PPM	0.25% 9.913 PPM	2.81% 9.841 PPM	3.52%
METHYL MERCAPTAN	1.550 PPM	84.65% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
ETHYL MERCAPTAN	2.593 PPM	75.07% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
2-PROPYL MERCAPTAN	2.425 PPM	77.75% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
DIMETHYL SULFIDE	10.200 PPM	0.00% 9.907 PPM	2.87% 9.640 PPM	5.49%
DIMETHYL DISULFIDE	10.306 PPM	0.91% 9.758 PPM	6.17% 9.447 PPM	9.16%

**TYPE OF CYLINDER.....ALUMINUM**

**SAMPLE TIME IN CYLINDER**

<u>SULFUR COMPOUND</u>	<u>1 HOUR</u>	<u>% LOSS 24 HOURS</u>	<u>% LOSS 72 HOURS</u>	<u>% LOSS</u>
HYDROGEN SULFIDE	2.806 PPM	72.22% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
CARBONYL SULFIDE	9.991 PPM	2.05% 9.163 PPM	10.17% 8.734 PPM	14.37%
METHYL MERCAPTAN	2.052 PPM	79.68% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
ETHYL MERCAPTAN	0.363 PPM	96.51% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
2-PROPYL MERCAPTAN	0.092 PPM	99.16% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
DIMETHYL SULFIDE	10.030 PPM	1.67% 9.571 PPM	6.17% 8.420 PPM	17.45%
DIMETHYL DISULFIDE	10.264 PPM	1.31% 9.790 PPM	5.87% 8.837 PPM	15.03%

**TYPE OF CYLINDER.....CARBON STEEL**

**SAMPLE TIME IN CYLINDER**

<u>SULFUR COMPOUND</u>	<u>1 HOUR</u>	<u>% LOSS 24 HOURS</u>	<u>% LOSS 72 HOURS</u>	<u>% LOSS</u>
HYDROGEN SULFIDE	< 0.010 PPM	100.00% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
CARBONYL SULFIDE	< 0.010 PPM	100.00% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
METHYL MERCAPTAN	3.018 PPM	70.12% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
ETHYL MERCAPTAN	5.249 PPM	49.53% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
2-PROPYL MERCAPTAN	4.826 PPM	55.73% < 0.010 PPM	100.00% < 0.010 PPM	100.00%
DIMETHYL SULFIDE	8.154 PPM	20.06% 0.916 PPM	91.02% < 0.010 PPM	100.00%
DIMETHYL DISULFIDE	7.593 PPM	26.99% 2.530 PPM	75.67% < 0.010 PPM	100.00%

**TYPE OF CYLINDER.....TEFLON-LINED ALUMINUM**

**SAMPLE TIME IN CYLINDER**

<u>SULFUR COMPOUND</u>	<u>1 HOUR</u>	<u>% LOSS 24 HOURS</u>	<u>% LOSS 72 HOURS</u>	<u>% LOSS</u>
HYDROGEN SULFIDE	10.086 PPM	0.14% 10.047 PPM	0.53% 10.022 PPM	0.77%

CARBONYL SULFIDE	10.169 PPM	0.30%	10.118 PPM	0.80%	10.102 PPM	0.96%
METHYL MERCAPTAN	10.020 PPM	0.79%	10.009 PPM	0.90%	9.976 PPM	1.23%
ETHYL MERCAPTAN	10.355 PPM	0.43%	10.282 PPM	1.14%	10.091 PPM	2.97%
2-PROPYL MERCAPTAN	10.872 PPM	0.26%	10.790 PPM	1.01%	10.503 PPM	3.64%
DIMETHYL SULFIDE	10.147 PPM	0.52%	10.056 PPM	1.44%	9.981 PPM	2.15%
DIMETHYL DISULFIDE	10.294 PPM	1.02%	10.173 PPM	2.18%	10.009 PPM	3.76%

**TYPE OF CYLINDER.....TREATED STAINLESS STEEL**

#### **SAMPLE TIME IN CYLINDER**

<u>SULFUR COMPOUND</u>	<u>1 HOUR</u>	<u>% LOSS</u>	<u>24 HOURS</u>	<u>% LOSS</u>	<u>72 HOURS</u>	<u>% LOSS</u>
HYDROGEN SULFIDE	10.097 PPM	0.030%	10.090 PPM	0.100%	10.086 PPM	0.14%
CARBONYL SULFIDE	10.198 PPM	0.020%	10.196 PPM	0.040%	10.192 PPM	0.08%
METHYL MERCAPTAN	10.088 PPM	0.120%	10.079 PPM	0.210%	10.076 PPM	0.24%
ETHYL MERCAPTAN	10.391 PPM	0.090%	10.298 PPM	0.980%	10.275 PPM	1.20%
2-PROPYL MERCAPTAN	10.885 PPM	0.140%	10.878 PPM	0.210%	10.837 PPM	0.58%
DIMETHYL SULFIDE	10.200 PPM	0.000%	10.192 PPM	0.080%	10.141 PPM	0.58%
DIMETHYL DISULFIDE	10.399 PPM	0.010%	10.390 PPM	0.100%	10.368 PPM	0.31%

#### **DISCUSSION OF RESULTS**

PRIOR TO SAMPLING A GAS OR LIQUID HYDROCARBON, WHETHER FOR TREATER DESIGN OR ABSORBER ANALYSIS, THE ANALYST SHOULD HAVE SOME UNDERSTANDING OF WHAT SULFUR COMPOUNDS MAY BE PRESENT IN THE SOURCE TO BE SAMPLED. THE RATE OF PASSIVATION, OR % LOSS AS EXPRESSED IN THE ABOVE REPORT, SHOWS HYDROGEN SULFIDE IS MOST REACTIVE WITH CARBON, STAINLESS AND ALUMINUM. WITHIN 1 HOUR OF STARTING THE STUDY, MOST OF THE HYDROGEN SULFIDE WAS PASSIVATED IN CARBON STEEL AND STAINLESS STEEL. ALUMINUM LOST OVER 70% OF THE HYDROGEN SULFIDE THROUGH PASSIVATION WITHIN 2 HOURS. ONLY TEFLON-LINED ALUMINUM AND TREATED STAINLESS HELD THEIR HYDROGEN SULFIDE CONCENTRATIONS BEYOND 72 HOURS. BOTH SHOWED LOSSES OF LESS THAN 1% H<sub>2</sub>S AT THE 72 HOUR TEST PERIOD.

BOTH, TEFLON LINED AND TREATED STAINLESS SHOWED THE LEAST AMOUNT OF ABSORPTION OF VOLATILE SULFUR COMPOUNDS DURING THIS TEST PERIOD. REGULAR STAINLESS, ALUMINUM AND CARBON TYPE CYLINDERS SHOWED SIGNIFICANT LOSS OF VOLATILE SULFURS WITHIN HOURS OF FILLING THEM. THIS STUDY WAS PRODUCED TO ASSIST ANALYST IN THE DECISION OF WHICH CYLINDERS PROVIDE THE BEST DEFENSE AGAINST SAMPLE PASSIVATION.

IT SHOULD BE NOTED THAT LABORATORIES USING THE TEFLON-LINED AND TREATED STAINLESS SAMPLE CYLINDERS SHOULD PERFORM REGULAR PASSIVATION TESTING OF THEIR CYLINDERS TO ASSURE THEMSELVES THAT THE CYLINDER WILL CONTINUE TO MAINTAIN A MINIMAL PASSIVATION OF SULFURS. TESTING PERFORMED ON PURCHASED CYLINDERS HAVE SHOWN FAILURES, OR SULFUR PASSIVATION, EVEN THOUGH THEY ARE NEW. ROUTINE TESTING AND DOCUMENTATION OF CYLINDERS USED FOR SULFUR SAMPLING SHOULD BE MAINTAINED TO DEVELOP A HISTORY ON THE CYLINDERS USEAGE AND TO CONFIRM THE CYLINDERS ABILITY TO PREVENT PASSIVATION. ALL SAMPLE CYLINDERS, INCLUDING NEW ONES, SHOULD BE TESTED REGULARLY.

ALSO, SAMPLES TAKEN IN THESE CYLINDERS SHOULD BE ANALYZED AS QUICKLY AS POSSIBLE TO REDUCE THE CHANCE OF PASSIVATION. SAMPLES WHICH REQUIRE TRANSPORTATION TO A LABORATORY FOR TESTING SHOULD BE SENT BY THE FASTEST METHOD AVAILABLE. TESTING LABS CAN NOT BE HELD RESPONSIBLE FOR SAMPLE DEGRADATION WITHIN A CYLINDER. AS THIS STUDY SHOWS, SAMPLES REQUIRING MORE THAN 72 HOURS TO SHIP AND ANALYZE WILL RISK

AN INCREASED CHANCE FOR SULFUR PASSIVATION TO OCCUR. TESTING LABS CAN ONLY REPORT ACCURATE NUMBERS IF THEY RECEIVE THE SAMPLES WITHIN A REASONABLE AMOUNT OF TIME AFTER SAMPLING.

BEFORE SAMPLING, CONSULT YOUR LABORATORY TO DETERMINE WHICH SULFUR COMPOUNDS MIGHT BE PRESENT IN THE TYPE OF GAS YOU ARE SAMPLING. THEN, CHOOSE THE PROPER METAL TYPE CYLINDER TO STORE THE SAMPLE UNTIL TESTING CAN BE PERFORMED.

AMERICAN MOBILE RESEARCH, INC. MAINTAINS A LARGE STOCK OF ALUMINUM, STAINLESS, AND TEFLON LINED ALUMINUM CYLINDERS FOR YOUR SAMPLING NEEDS. CONTACT OUR LABORATORY, AT 307-235-4590, TO REQUEST THESE CYLINDERS FOR YOUR NEXT SAMPLING PROJECT.

