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TECHNICAL MEMORANDUM
TM-2294-AMP

FUEL CATALYST -

Technology Evaluation Report

by

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September 1998

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EXECUTIVE SUMMARY

Purpose: The purpose of this report is to define Fuel Catalyst (FC) theory and test results. potential benefits of FC (reduced fuel consumption, less pollutants, cleaner engines) are described as a result of using after-market Fuel Catalysts on Marine Corps equipment.

Results: The evaluation of the FC began with robust intentions using some thirteen vehicles in a multi-phase evaluation. In the end, only three of the thirteen vehicles could be counted on for verification of the FC performance. A fourth vehicle (MK48/16) had no Phase three data and load Opacity readings for Phase 4 were very questionable (.33).

Two of the three remaining vehicles were 5-Ton trucks and one HMMV. Of those three remaining candidates, one 5-Ton truck showed no improvement in particulates and only marginal improvement in fuel consumption.

The varification was then left to a single M998-HMMV and a single 5-Ton truck. The M998-HMMV showed considerable reductions in particulates (both Snap Idle and Load) but actually experienced higher fuel consumption using the FC (+4%).

The 5-Ton truck showed moderate reductions in particulates and considerable reductions in fuel consumption (-44%).

Conclusions: In general, it is difficult to draw specific conclusions from the fact a single vehicle of thirteen candidates actually verified advertised contentions of the FC vendors (reductions in particulates while simultaneously increasing fuel economy). Given the disparity of the data and the singularity of the positive verification of simultaneous fuel consumption and particulate emissions decrease, one is left with a simple generalization. If FC's contribute to the vehicles operation, they contribute more so in the areas of reduced particulates (50% and 39% reductions) rather than reduced fuel consumption (21% increase in fuel economy). Since State regulations only address particulates and not fuel consumption, FC's do contribute in the most important regulated area.

Recommendations: It is recommended that FC's be procured on an individual, experimental basis for only those vehicles with moderate engine hours having moderate to high expected hours of future usage driven or operated in highly regulated areas for which there exists no other choice or alternative for reducing particulates.

It expected that FC's do enhance mileage on certain vehicles but operator training in operation of the vehicle (acceleration and braking habits) and proper maintenance of engines, transmissions, final drives, and tires (proper tire inflation) may have much significance on fuel consumption than the installation of a FC.

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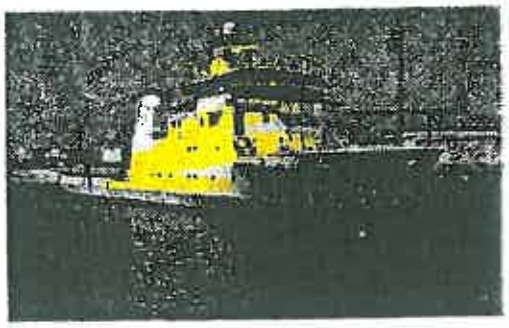
The performance of the representative Fuel Catalyist (FC) system has been identified in view of the three technology issues and the test data as determined from the four phase field measurements. The data and analysis is discussed for each issue separately.

In addition, the RENTAR FC was installed on the research vessel Independence to obtain independent data on the performance of FC's. The Independence has twin Cummins KTA-3067-M engines. The results of that independent experiment showed a 2% reduction in fuel consumption (Appendix C).



5.1 Test Results

Of the thirteen test vehicles only two completed all tests of all four phases of the evaluation.

Two (M998-HMMWV and M923-5-Ton) were exchanged after Phase three with no Phase three test data recorded.

Two (MK48/14 LVS and MK48/18 LVS) were combat deadline after Phase three.

Two (MK48/18 LVS and MK48/16 LVS) were Code H after Phase three.

Three (MK48/15 LVS, MK48/14 LVS, and M998-HMMWV) were not available after Phase three.

One vehicle (MK48/16 LVS) was available for all phases but no phase three test data was available.

One vehicle (M998-HMMWV) completed all phases except the load Opacity test and the Snap Idle Opacity test of Phase three.

During Phase four completed June 29 through July 1, 1998, four of the original thirteen vehicles completed 32 [illegible]7 miles each in a controlled loop mileage test.

Issue 1. **Determine the Opacity during Snap Idle tests with and without the FC.**

TEST RESULT:

Vehicle #	Vehicle Type	Engine	Snap Idle Opacity Phase 1	Snap Idle Opacity Phase 3	Snap Idle Opacity Phase 4*
544684	M998-HMMWV	AM GEN	36.7	NP	14.3
517959	M923-5-Ton	CUM-250	13.3	14.3	10.6
532264	M923-5-Ton	CUM-250	8.3	7.0	8.3
560565	M998-HMMWV	AM GEN	16.0		
582554	M988-HMMWV	AM GEN	39.0	5	
530095	M923-5-Ton	CUM-250	8.7	8	
517807	M923-5-Ton	CUM-250	4.7	3.6	
563216	MK48/14 LVS	DDA-8V92	13.7	17.3	
561147	MK48/16 LVS	DDA-8V92	14.0	23.3	
561202	MK48/18 LVS	DDA-8V92	19.0		
563245	MK48/15 LVS	DDA-8V92	7.0		
563566	MK48/18 LVS	DDA-8V92	12.0	17.7	
566859	MK48/16 LVS	DDA-8V92	19.0	NP	23.7

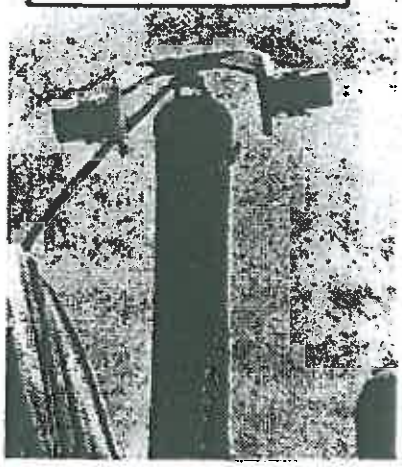
Non Participant (NP)

ANALYSIS:

The Opacity or particulates in general decreased with the use of the FC for two of the four vehicles completing all phases of the tests. This was consistent with the Load (engine loaded) Opacity (Issue 2) below with the exception of vehicle 566859 for which there was no Phase three data. Of the two vehicles experiencing reduced Snap Idle particulates, the average decrease in particulates between Phase one and Phase four was 50%.


MK48/16 LVS

Opacity sensors installed on 5-Ton truck



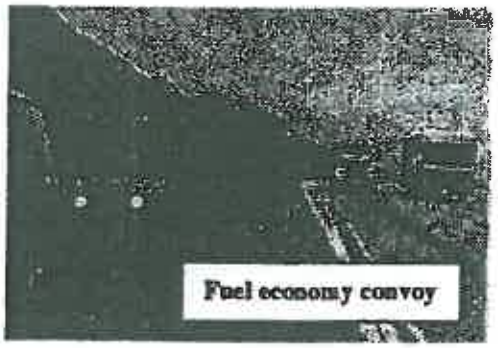
Issue 3. Determine the fuel savings using the FC.

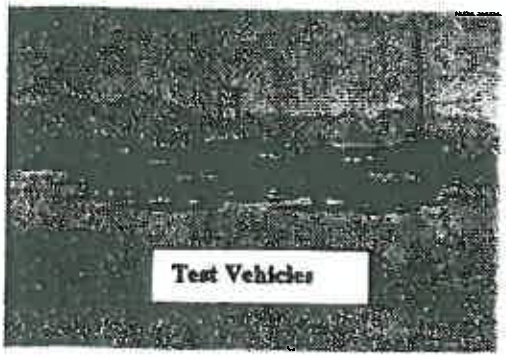
TEST RESULT:

Vehicle #	Vehicle Type	Engine	Miles per gallon Phase 1	Miles per gallon Phase 3	Miles per gallon Phase 4
544684	M998-HMMWV	AM GEN	14.5	15.1	13.9
517959	M923-5-Ton	CUM-250	7.1	7.9	10.3
532264	M923-5-Ton	CUM-250	10.3	9.4	11.3
560565	M998-HMMWV	AM GEN	16.6	NP	
582554	M988-HMMWV	AM GEN	15.4	16.0	
530095	M923-5-Ton	CUM-250	7.6	8.3	
517807	M923-5-Ton	CUM-250	10.3	8.8	
563216	MK48/14 LVS	DDA-8V92	2.1	4.6	
561147	MK48/16 LVS	DDA-8V92	3.6	4.7	
561202	MK48/18 LVS	DDA-8V92	4.2	4.0	
563245	MK48/15 LVS	DDA-8V92			
563566	MK48/18 LVS	DDA-8V92	4.8	3.2	
566859	MK48/16 LVS	DDA-8V92	3.7		7.56

ANALYSIS:

The fuel consumption decreased with the use of the FC for three of the four vehicles completing all phases of the tests. The fuel consumption average decrease (miles per gallon increase) between Phase one and Phase four for the four vehicles tested was 1.9 mpg or 21% fuel savings mileage.


Fuel economy convoy


Test Vehicles

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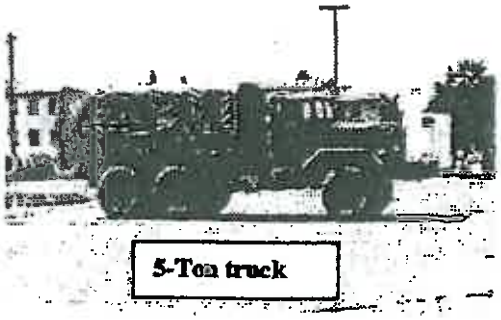
5.2 Discussion Of Results

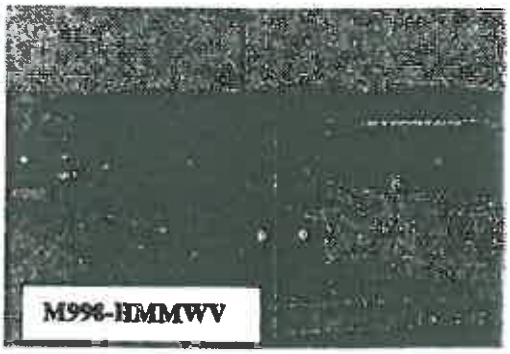
Investigation of the FC began with robust intentions using some thirteen vehicles in a multi-phase evaluation. In the end, only three of the thirteen vehicles could be counted on for verification of the FC performance. A fourth vehicle (MK48/16) had no Phase three data and load Opacity readings for Phase 4 were very questionable (.33).


MK48/16 LVS

Two of the three remaining vehicles were 5-Ton trucks and one HMMWV. Of those three remaining candidates, one 5-Ton truck (#532264) showed no improvement in particulates and only marginal improvement in fuel consumption.


5-Ton truck

The varification was then left to a single M998-HMMWV and a single 5-Ton truck. The M998-HMMWV showed considerable reductions in particulates (both Snap Idle and Load) but actually experienced higher fuel consumption using the FC (+4%).


M998-HMMWV

The 5-Ton truck showed moderate reductions in particulates and considerable reductions in fuel consumption (-44%).

5.3 Vehicle Range Model

A vehicle RANGE model was developed to assess expected miles that could be driven with fuel on board. As can be seen, range or fuel economy depends on many conditions including condition of road or terrain, fuel type, ambient temperature, vehicle average speed, altitude of operation, and gross vehicle weight (added weight). A couple of examples of the range model for the MK48 and 5-Ton truck are shown.

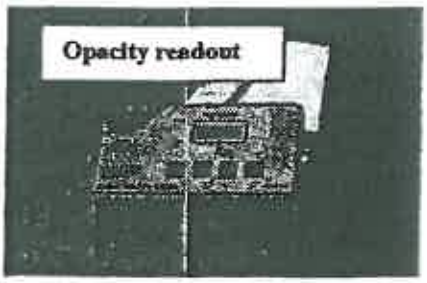
Issue 2. Determine the Opacity during engine load conditions with and without the FC.

TEST RESULT:

Vehicle #	*Vehicle Type*	*Engine*	*Load Opacity Phase 1*	*Load Opacity Phase 3*	*Load Opacity Phase 4*
544684	M998-HMMWV	AM GEN	24.7	NP	15.0
517959	M923-5-Ton	CUM-250	15.7	16.6	9.3
532264	M923-5-Ton	CUM-250	5.7	3.7	5.7
560565	M998-HMMWV	AM GEN	8.7	NP	
582554	M988-HMMWV	AM GEN	7.3	2.6	
530095	M923-5-Ton	CUM-250	10.0	7	
517807	M923-5-Ton	CUM-250	4.3	5	
563216	MK48/14 LVS	DDA-8V92	3.7	5.7	
561147	MK48/16 LVS	DDA-8V92	27.7	27	
561202	MK48/18 LVS	DDA-8V92	26.0	8	
563245	MK48/15 LVS	DDA-8V92	35.0		
563566	MK48/18 LVS	DDA-8V92	34.0	11.3	
566859	MK48/16 LVS	DDA-8V92	33.7		

ANALYSIS:

The Opacity or particulates under load conditions in general decreased with the use of the FC for two of the four vehicles completing all phases of the tests. This was consistent with the Snap Idle Opacity (Issue 1) with the exception of vehicle 566859 for which there was no Phase three data.



Of the two vehicles experiencing reduced load particulates, the average decrease in

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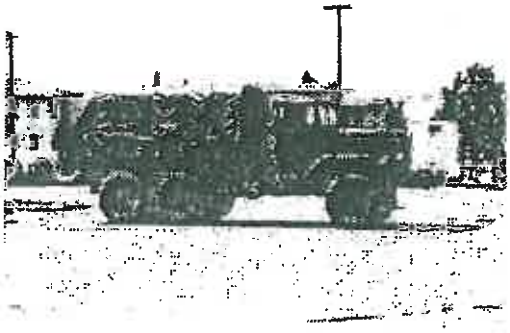

VEHICLE RANGE EXPECTATION
DEPENDING ON
DRIVING CONDITIONS AND TOTAL FUEL ONBOARD

Vehicle		1-HMMWV	2-LAV	3-AAAV	4-FIVE TON
		5-M1A1	6-MK48		
Fuel Type		1-diesel, 2-JP-4, 3-JP-5, 4-JP-8			
Soft Soil		Yes or No			
Muddy Soil		Yes or No	Notes:	Place information in BLUE boxes. Alter extra fuel (cell F15) and note range and change in range (cell F17).	
Ambient Temp		deg F			
Avg Speed		mph			
Fuel Onboard		% of Full	Extra Fuel		gal
Added Wt		% of empty wt	Range	637.9	miles
Altitude		ft ASL	Range +	0.0	miles

6.0 CONCLUSIONS

In general, it is difficult to draw specific conclusions from the fact a single vehicle of thirteen candidates actually supported advertised contentions of the FC vendors (reductions in particulates while simultaneously increasing fuel economy). Given the disparity of the data and the singularity of the positive verification of simultaneous fuel consumption and particulate emissions decrease, one is left with a simple generalization. [redacted] contribute to the vehicles operation, they contribute more so in the areas of reduced particulates (50% and 39% reductions) rather than reduced fuel consumption (21% increase in fuel economy). Since State regulations only address particulates and not fuel consumption, FC's contribute in the most important regulated area.

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Appendix C

FC tests on Independence

A summary of Independence FC tasks involving the testing of RENTAR FC are as follows:

On April 9, 1997 the vessel was contacted by Mr. Grant Davison of NFESC regarding the RENTAR fuel catalyst. On April 11, 1997 all parties concerned attended a meeting on board the Independence and agreed to install one RENTAR unit on the starboard main engine for testing.

On May 7, 1997 after conversations with Doug Arkfield regarding a means of metering the performance of the RENTAR fuel catalyst, a set of model 760G-3D-10 Floscan flow meters were purchased on May 19, 1997.

On May 30, 1997 one RENTAR fuel catalyst assembly was installed on the starboard main engine of the Independence.

On June 3, 1997 the Floscan meters were installed on both the port and starboard main engines. On June 6, 1997 both main engines were fitted with one new cylinder head each to test the fuel catalyst ability to decrease carbon buildup in the combustion chamber.

On October 16, 1997 the Independence departed Perarl Harbor, Hawaii for her home port of Port Hueneme, CA. During transit fuel consumption readings were taken and total fuel usage by each engine was measured. The port engine burned a total of 9,322 gallons of fuel and the starboard engine with RENTAR fuel catalyst installed burned 9,171 gallons. The difference in fuel usage was 151 gallons or 1.62% increase fuel economy of the engine with the FC.

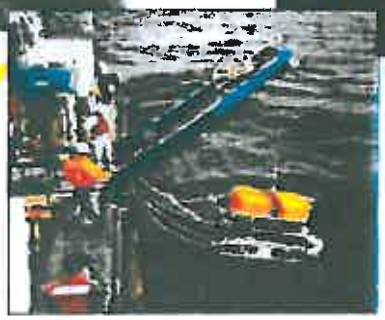
This assumes that both engines would have burned equal amounts of fuel without the FC installed.

The port cylinder head at the time of removal had 1,328 test hours and the starboard head had 1,408 actual test hours. Both heads showed no sign of valve burning and both appeared to have about the same amount of carbon build up on the valves and in the head cavity. The carbon on the port head cavity and valves was wet with fuel. The carbon on the starboard head cavity and valves was dry with the exception of an area around one valve guide.

Ocean Operations

M/V Independence

Deep Sea Diving Operations



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