RYPOS

Active Diesel Emission Control

A PLAN TO RETROFIT 3 DIESEL GENERATORS WITH RYPOS TRAP

Final Report

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Submitted to
California Air Resources Board
Research Division, Suite 540
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PROJECT ABSTRACT

The objective of this project was to demonstrate the capability of the RYPOS TRAP diesel emission control system to remediate particulate matter from diesel exhaust. This report presents the results of a field demonstration of the RYPOS TRAP. This demonstration was partially funded by the ICAT program of the California Air Resources Board. The RYPOS TRAP is an actively regenerated diesel exhaust particulate trap that is self-cleaning and automatic in operation.

The field demonstration consisted of a nine-month series of tests on three electrical backup generators, all located in Riverside, CA. The generators were rated at 100 kW, 225 kW, and 350 kW. Measurements of the diesel emissions were made before installation of the RYPOS TRAP, after installation of the trap, after accumulating hours of operation under varying load conditions, and after removal of the trap. This provided an accurate record of the performance of each RYPOS TRAP.

The demonstration showed that the RYPOS TRAP can effectively remove from 69 to 97% of the soot in diesel exhaust under field conditions, and clean itself reliably independent of engine exhaust temperature or fuel sulfur content. During these demonstrations, the backpressure remained within acceptable limits.

The completion of all three phases of the demonstration program have shown that the RYPOS TRAP is a viable solution to the problem of particulates in the exhaust of diesel engines operated under low exhaust temperature or high sulfur fuel conditions. During this demonstration program, the RYPOS TRAP maintained consistently low back pressure under a variety of engine loads, and stayed within our target for regeneration efficiency.

Valuable practical field experience has been gained during this program. As a result of these demonstrations, RYPOS is redesigning the filter for lower weight, smaller size, and lower power consumption. The demonstrations have confirmed our decision to target the initial marketing effort for the product to electrical generators. After the initial product introduction, RYPOS intends to adapt the filter to other market segments, such as trucks, buses, marine, locomotive, and off-road construction equipment. RYPOS expects to have the next generation RYPOS TRAP available by the end of 2002.

DETAILED REPORT

1. Objective

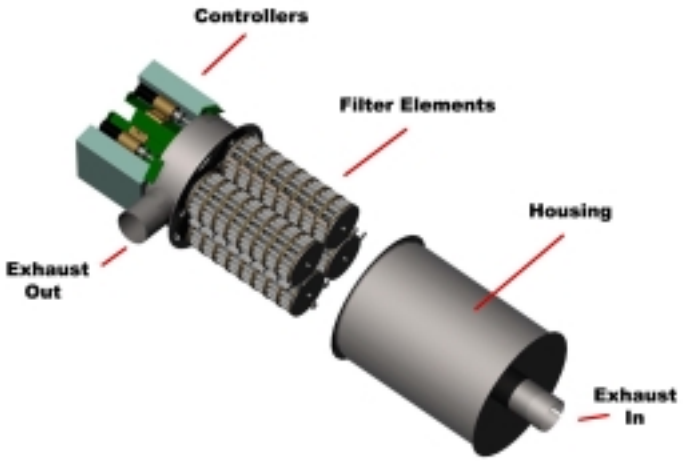
The main objective of this project was to demonstrate the capability of RYPOS TRAP. To achieve this objective, the following tasks were proposed:

- Retrofit a 100 kW stationary/portable diesel generator,
- Retrofit a 200 kW stationary/portable diesel generator,
- Retrofit a 400 kW stationary/portable diesel generator,
- Collect performance data,
- Monitor each of these three installations.
- Collect test data and get feedback to refine our design.
- Increase awareness of RYPOS TRAP

The results of this project were expected to help RYPOS promote its technology and establish a presence in the diesel exhaust treatment market in California.

2. Product Description

The RYPOS TRAP is a highly effective Diesel particulate filter for exhaust emission control. The system consists of filter housing, flow control, electrical control circuit, and removable filter cartridges. The trap itself is composed of fine metal fibers that are shaped into filter elements and then incorporated into filter cartridges; these sintered fibers are capable of capturing the very fine carbon particles present in the exhaust stream. It can be used alone or in conjunction with a Diesel oxidation catalyst to reduce the soluble organic fraction, gaseous hydrocarbons, and carbon monoxide while suppressing the formation of sulfate.



It is an active regeneration system (pre-determined for on/off control) with significantly high efficiency and soot holding capacity and is regenerated independently of the exhaust temperature. The filter element is electrically heated while the exhaust flow is shut off, thereby saving considerable energy during the regeneration cycle. Each element, which represents a small fraction of the total filter, is regenerated individually to reduce the

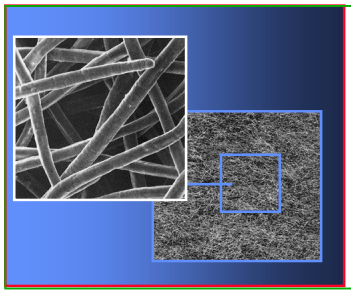
maximum amount of electrical energy required. In a medium size engine (100-200hp), fuel penalty is less than 1% of the rated horsepower of the engine.

The RYPOS TRAP is able to capture on average 80-90% of the soot present in the exhaust stream.

The RYPOS TRAP also serves as a sound absorption device and can be designed to fit the same envelope as the muffler or catalytic converter it replaces.

2.1 Sintered Metal Fibers

The filter medium is a sintered metal fiber element that is electrically conductive with high soot holding capacity that captures the very fine particles in the exhaust system. The filter is regenerated through the presence of an electric current, sufficient to heat the element to cause the collected soot to burn. The filter and heating element are one and the same.



- o Electro-conductive
- o High porosity (85%)
- o Low back pressure
- o Withstands high temperatures
- o Fast Heating (low thermal mass)
- o High filtering efficiency

2.2 Advantages of RYPOS TRAP

RYPOS Diesel particulate filter (RYPOS TRAP) maintains the following advantages over the existing competition:

- RYPOS TRAP is fully automatic (no operator intervention),
- RYPOS TRAP is self-cleaning (continuous electrical regeneration with no downtime).
- RYPOS TRAP is energy efficient. A maximum of 1.5 kW (2.0 hp) of power is used during the regeneration cycle. Under typical operating conditions, the average power consumed is about 0.75 kW (1.0 hp),
- RYPOS does not require ultra low sulfur fuels,
- RYPOS TRAP requires minimal maintenance, and will provide extended service life, based on actual accelerated life test data (est. 20,000 engine hours),
- RYPOS TRAP is a modular design, which can be scaled for any size diesel engine (Size can be adapted from 15 to 2000 HP engines).

3. Project Schedule (Tasks)

The start date for the project was expected to be January 2002; but the final grant approval letter was sent to RYPOS on Feb. 21st, 2002, and the agreement was signed on Feb 23rd, 2002. As a result, RYPOS had to shift the project's original schedule by 2 months (as shown below)

2002

Month / Task	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Identify 100 kW D.G. Location	x	x							
Manufacture a System for 100 kW D.G		x							
Retrofit 100 kW D.G.			x						
Monitor 100 kW D.G. System			x	x	x	x			
Identify 200 kW D.G. Location			x						
Manufacture a System for 200 kW D.G			x						
Retrofit 200 kW D.G.				x					
Monitor 200 kW D.G. System				x	x	x	x		
Identify 400 kW D.G. Location					x				
Manufacture a System for 400 kW D.G					x				
Retrofit 400 kW D.G.						x			
Monitor 400 kW D.G. System						x	x		
Collect Performance Data			x	x	x	x	x	x	x
Progress Reports			x			x	x		
Final Report									x

3.1 Task 1

Task 1 included the following sub-tasks:

- Identify a suitable location and arrange for retrofitting a 100 kW diesel generator.
- Manufacture a system for the 100 kW generator
- Retrofit the 100 kW generator with a the RYPOS TRAP
- Monitor the performance of the installed RYPOS TRAP.

Picture1: The 100 kW installation.

The first parts of Task 1 were accomplished by installing a RYPOS TRAP on April 8th, 2002. “Johnson Power Systems” did the installation on a 100 kW Caterpillar generator in their facilities at Riverside, Ca. The system installed in this Task is coupled to a DOC to enhance the performance of the system.
Before the installation of the RYPOS TRAP, the following operation characteristics of the diesel generator were monitored to help evaluate the performance of the trap:

- Engine load,
- Engine Speed,
- Exhaust temperature,

After the installation, and in order to assess the efficiency and overall performance of the RYPOS TRAP, the following activities were carried out:

- Measure PM before the installation of the RYPOS TRAP

- Measure the PM after the system is installed and after one day of operation

The system installed on the 100 kW generator performed very well through the demonstration period. The engine ran for more than 100 hours after being retrofitted with the RYPOS TRAP, the Back pressure was kept in the range 40 -140 mBar. The efficiency measured for the system ranged between 70% and 95%, with the lower readings recorded when the engine was loaded to about 40% of its maximum load. The RYPOS TRAP was removed in July. The engine was tested after the RYPOS TRAP was uninstalled and it was clear that there were no negative effects whatsoever to the engine or its performance as a result of having been retrofitted with the RYPOS TRAP.

3.2 Task 2

The main activity of Task 2 of the ICAT project was: To install a RYPOS TRAP on a 200 kW Generator. The following sub-tasks were planned:

- Identify a suitable 200 kW diesel generator.
- Manufacture a “RYPOS TRAP” system for the 225 kW generator.
- Retrofit the 200 kW diesel generator.
- Monitor the performance of the RYPOS TRAP installed on the 225 kW generator.

Picture 2: The 225kW installation.

The first 3 parts of Task 2 were accomplished by installing a RYPOS TRAP on May 13th, 2002. As in the first installation of this project, "Johnson Power Systems" did the installation on a 225 kW Caterpillar generator in their facilities at Riverside, Ca. A different configuration was used in this installation, two RYPOS TRAP units were coupled together as one system to be able to handle the amount of the exhaust.

Before the installation of the RYPOS TRAP, the following operation characteristics of the diesel generator were monitored:

- Engine load,
- Engine Speed,
- Exhaust temperature,

After the installation, the same parameters were monitored again. And in order to assess the efficiency and overall performance of the RYPOS TRAP, the following activities were also carried out:

- Measure PM before the installation of the RYPOS TRAP
- Measure the PM after the system is installed and after one day of operation

The engine ran for more than 100 hours after being retrofitted with the RYPOS TRAP, with efficiency ranging between 52% and 97%. The RYPOS TRAP was removed in the first week of August 2002.

3.3 Task 3

The main activity of Task 3 task of the ICAT project was: To install a RYPOS TRAP on a 400 kW Generator. The following sub-tasks were planned:

- Identify a suitable 400 kW diesel generator.
- Manufacture a "RYPOS TRAP" system for the 400 kW generator.
- Retrofit the 400 kW diesel generator.
- Monitor the performance of the RYPOS TRAP installed on the 400 kW generator.

The first 3 parts of Task 3 were accomplished by installing a RYPOS TRAP on July 13th, 2002. Unfortunately, the only available larger size engine was a 350 kW generator which had different performance characteristics than the one modeled for the design of the system.

As in the first two installations of this project, "Johnson Power Systems" did the installation on a 350 kW Caterpillar generator at their facilities at Riverside, Ca.
Again, and as in the 200 kW installation, two units were coupled together as one system. Before the installation of the RYPOS TRAP, the operational parameters of the diesel generator were monitored as in the first two installations:

- Engine load,
- Engine Speed,
- Exhaust temperature,

- Back pressure

Picture 3: The 350kW installation.

MEASUREMENTS AND RESULTS

Before the installation of each of the RYPOS TRAPs, the following operation characteristics of the diesel generator were monitored to help evaluate the performance of the trap:

a. Engine load,
b. Engine Speed,
c. Exhaust temperature,

Exhaust samples were collected before and after the installation of the systems and the Total Particulate Matter (TPM) measurements were used to evaluate the Traps' efficiency.

Below is a summary of the results obtained, the "Initial Efficiency" shows the efficiency as measured when the systems were first installed, while the "Final Efficiency" shows the results of the final week of operation.

Expecting that the efficiency of the Rypos Trap installed on the third installation (350 kW generator), would be similar to the first two installations, no measurements were taken. However, the Back Pressure was monitored and the regeneration duty cycle and the Energy Penalty were recorded.

100 kW System

Load	Initial Efficiency	Final Efficiency
Idle	77%	78%
40 kW	70%	86%
80 kW	96%	89%

225 kW System

Load	Initial Efficiency	Final Efficiency
Idle	52%	85%
125 kW	95%	86%
175 kW	97%	91%

Figure 1 below shows the pressure profile of the 100 kW generator, running for a day. The pressure measurements were taken every second. Different segments of the graph depict different engine load settings:

1- Idle, for about 1 hour
2- 40 kW, for about 3.5 hours
3- 80 kW, for about 30 minutes.

Figure 2 shows the backpressure for the 225 kW generator, after the installation of the

RYPOS TRAP. As in Figure1, the following settings can be distinguished:

1- The first part shows the engine idling for about 30 minutes,
2- The second part, 125 kW for about 20 minutes
3- The third part, 175 kW for 20 minutes.

The pressure line shows that the system used was over-sized for this engine.

Figure 3 shows the backpressure for the 350 kW generator, after the installation of the RYPOS TRAP. Three settings can be distinguished:

1- The first part shows the engine idling for about 1 hour,
2- The second part, 50 kW for about 1.5 hours
3- The third part, 150 kW for 2.5 hours.

Notice that the measurements in Graph 3 were taken using a different device, thus the different shape of the graph points. On this installation, the effect of under-sizing the unit show clearly on the high magnitudes of the pressure line.

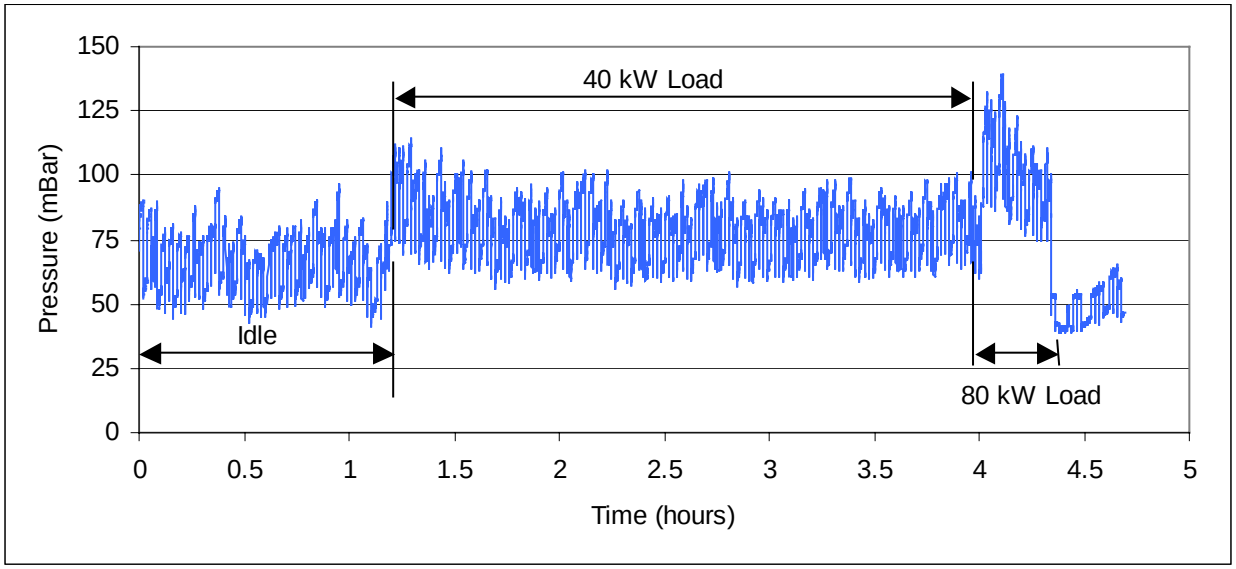


Figure 1: Pressure Drop (mbar), Diesel Power Gen Set; 100 KW Caterpillar (Perkins) May 13, 2002

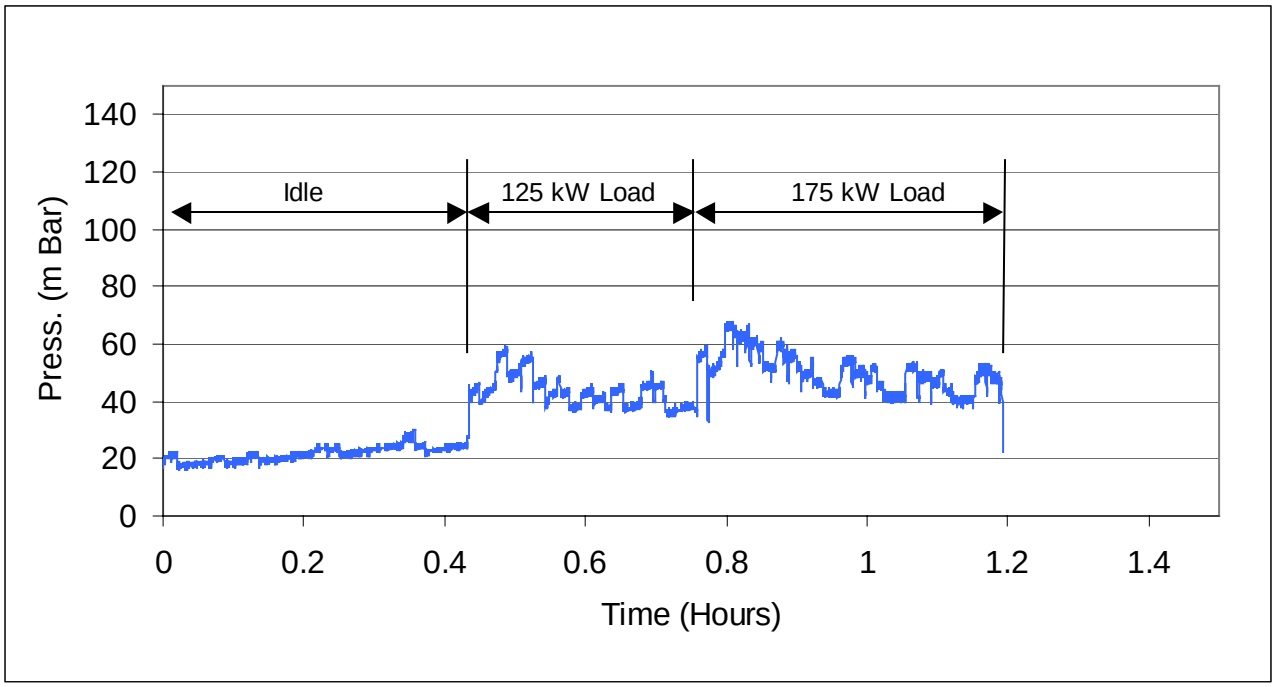


Figure 2: 225 KW Power Gen Set - Caterpillar Diesel Engine (3306)
May 17, 2002
(Over-sized System)

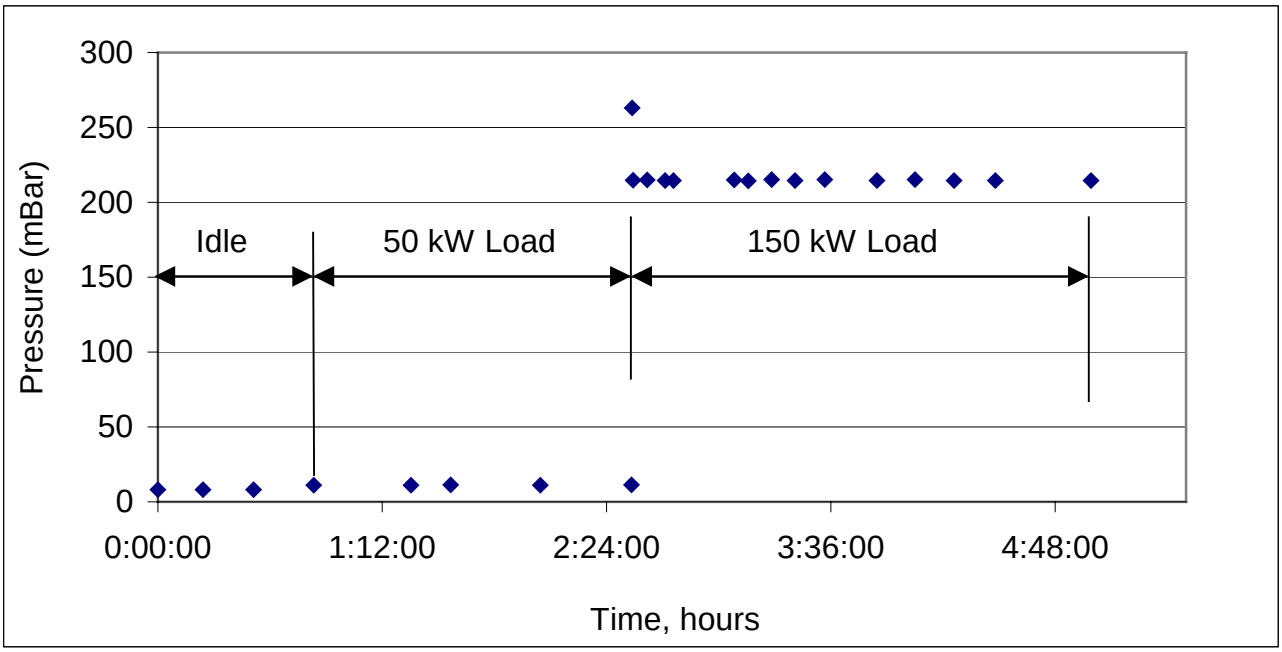


Figure 3: 350 KW Power Gen Set - Caterpillar Diesel Engine (3406)
July 18, 2002
(Under-sized System)

Observed Energy Penalty

100 kW Generator

Setting	Regeneration duty cycle	Energy Consumption	Energy Penalty (%)
Idle	20%	0.3 kW	NA
40 kW	35%	0.53 kW	1.3%
80 kW	50%	0.75 kW	0.9%

225 kW Generator

Setting	Regeneration duty cycle	Energy Consumption	Energy Penalty (%)
Idle	10%	0.3 kW	NA
125 kW	20%	0.6 kW	0.5%
175 kW	30%	0.9 kW	0.5%

350 kW Generator

Setting	Regeneration duty cycle	Energy Consumption	Energy Penalty (%)
Idle	20%	0.6 kW	NA
50 kW	33%	1.0 kW	2.0%
150 kW	100%	3.0 kW	2.0%

The "*Energy Penalty*" reflects the percentage of average power consumption needed to regenerate as compared to the power generated by the engine. Notice that for both the 100kW and 225kW generators at "*Idle*", the PM production is minimum, which results in the minimum regeneration duty cycle. As the PM production increases, the regeneration duty cycle increases from about 20 to 50% for the 100kW generator and from 10% to 30% for the 225kW generator.
The system used in the 350 kW generator was under-sized on purpose to help us optimize our design, this resulted in higher regeneration duty cycle and relatively high energy penalty.

DISCUSSION OF COMMERCIAL AND ECONOMIC POTENTIAL

RYPOS has chosen to focus on the stationary diesel electrical generator market for initial introduction of the product. Both aftermarket retrofit and new installations will be targeted. Through the ICAT project, RYPOS was able to demonstrate the effectiveness of the technology, and how it can be optimized to enable users to meet emission requirements of different engine sizes while at the same time draw local attention to the product in California, which is a leading target in our marketing efforts.

As a direct result of this project, RYPOS Inc. is now negotiating with different companies to jointly develop products for the exhaust remediation market, as well as to establish local production and distribution facilities in California. Until production facilities are established in California, RYPOS will contract with California-based companies to install and maintain the particulate traps in that market segment.

While a final price for the product has not been established, preliminary estimates indicate that it will be well within the prevailing costs of comparable technologies. Furthermore the system is now being optimized to minimize un-necessary regeneration, thus reducing the fuel penalty typical in currently available systems.

Additionally, and with an average efficiency of up to 90%, the RYPOS TRAP will give diesel engine users the opportunity to increase the utilization of their engines without incurring significant costs in terms of pollution abatement. Electric generator users will be able to peak-shave during periods of high usage, and to continue usage of generators that would otherwise have to be retired from service.

CONCLUSIONS

The completion of all three phases of the demonstration program have shown that the RYPOS TRAP is a viable solution to the problem of particulates in the exhaust of diesel engines operated under low exhaust temperature or high sulfur fuel conditions. During this demonstration program, the RYPOS TRAP maintained consistently low back pressure under a variety of engine loads, and stayed within our target for regeneration efficiency.

Valuable practical field experience has been gained during this program. As a result of these demonstrations, RYPOS is redesigning the filter for lower weight, smaller size, and lower power consumption. Also sizing the unit for different applications and different size engines should be carefully done to minimize the energy penalty.
The demonstrations have confirmed our decision to target the initial marketing effort for the product to electrical generators. After the initial product introduction, RYPOS intends to adapt the filter to other market segments, such as trucks, buses, marine, locomotive, and off-road construction equipment. RYPOS expects to have the next generation RYPOS TRAP available by the end of 2002.

APPENDIX A

GRANT DISBURSEMENT REQUEST AND EXPENDITURES SUMMARY

Grant No.: 01-6

Project Title: A Plan to Retrofit 3 Diesel Generators with RYPOS TRAP

Period covered: December 2001 to April 2002 Task #: **1**

Direct Costs	**ICAT-Funded Expenses**	**Grantee's Cash Expenses**	**Other Expenses ***	**Total**
1. Labor with Benefits		$23,523.10		$23,523.10
2. Subcontractors and Consultants	$10,048.46			$10,048.46
3. Equipment		$ 9,887.90		$ 9,887.90
4. Travel and Subsistence	$ 5,329.25			$ 5,329.25
5. Materials & Supplies	$ 3,962.94		$ 4,800	$ 8,762.94
6. Other Direct				
Subtotal, Direct Costs:	$19,340.65	$33,411.00	$ 4,800	$57,551.65
Indirect Costs				
7. Overhead	$ 6,821.70			$ 6,821.70
8. Other indirect	$ 4,138.51			$ 4,138.51
Subtotal, Indirect Costs:	$10,960.21			$10,960.21
Total	$30,300.86	$33,411.00	$ 4,800.00	$68,511.86

* grantee's non-cash expenses and partners' in-kind labor

I certify that, to the best of my knowledge and belief, the information contained in the attached progress report, including the accounting of expenditures on the project as summarized above, is correct and complete and is in accordance with the grant. In addition, I hereby authorize the California Air Resources Board to make any inquiries to confirm details in the progress report.

_____ _____

Grantee's Signature Date

APPENDIX A
GRANT DISBURSEMENT REQUEST AND EXPENDITURES SUMMARY

Grant No.: 01-6

Project Title: A Plan to Retrofit 3 Diesel Generators with RYPOS TRAP

Period covered: April 2002 to June 2002 Task #: **2**

Direct Costs	**ICAT-Funded Expenses**	**Grantee's Cash Expenses**	**Other Expenses ***	**Total**
1. Labor with Benefits		$17,947.62		$17,947.62
2. Subcontractors and Consultants	$16,211.71			$16,211.71
3. Equipment		$ 1,555.00		$ 1,555.00
4. Travel and Subsistence	$ 1,926.59	$ 1,926.60		$ 3,853.19
5. Materials & Supplies	$ 7,824.48		$9,600.00	$17,424.48
6. Other Direct				
Subtotal, Direct Costs:	$25,962.78	$21,429.22	$9,600.00	$56,992.00
Indirect Costs				
7. Overhead (29% of #1)	$ 5,204.81			$ 5,204.81
8. Other indirect (22% of #2 & #5)	$ 7,399.96			$ 7,399.96
Subtotal, Indirect Costs:	$12,604.77			$ 12,604.77
Total	$38,567.55	$21,429.22	$ 9,600.00	$ 69,596.77

* grantee's non-cash expenses and partners' in-kind labor

I certify that, to the best of my knowledge and belief, the information contained in the attached progress report, including the accounting of expenditures on the project as summarized above, is correct and complete and is in accordance with the grant. In addition, I hereby authorize the California Air Resources Board to make any inquiries to confirm details in the progress report.

Grantee's Signature Date

APPENDIX A
GRANT DISBURSEMENT REQUEST AND EXPENDITURES SUMMARY

Grant No.: 01-6

Project Title: A Plan to Retrofit 3 Diesel Generators with RYPOS TRAP

Period covered: June 2002 to July 2002 Task #: **3**

Direct Costs	**ICAT-Funded Expenses**	**Grantee's Cash Expenses**	**Other Expenses ***	**Total**
1. Labor with Benefits		$23,563.69		$23,563.69
2. Subcontractors and Consultants	$13,956.26			$13,956.26
3. Equipment		$ 2,338.30		$ 2,338.30
4. Travel and Subsistence	$ 3,249.74			$ 3,249.74
5. Materials & Supplies	$ 5,852.32	$9,600.00		$15,452.32
6. Other Direct				
Subtotal, Direct Costs:	$23,058.32	$35,501.99		$58,560.31
Indirect Costs				
7. Overhead (29% of #1)	$ 1,473.49	$5,359.98		$ 6,833.47
8. Other indirect (22% of #2 & #5)	$ 4,961.53	$1,508.36		$ 6,469.89
Subtotal, Indirect Costs:	$6,435.02	$ 6,868.34		$13,303.36
Total	$29,493.34	$42,370.33		$71,863.67

* grantee's non-cash expenses and partners' in-kind labor

I certify that, to the best of my knowledge and belief, the information contained in the attached progress report, including the accounting of expenditures on the project as summarized above, is correct and complete and is in accordance with the grant. In addition, I hereby authorize the California Air Resources Board to make any inquiries to confirm details in the progress report.

Grantee's Signature Date

APPENDIX A
GRANT DISBURSEMENT REQUEST AND EXPENDITURES SUMMARY

Grant No.: 01-6

Project Title: A Plan to Retrofit 3 Diesel Generators with RYPOS TRAP

Period covered: July 2002 to August 31, 2002 Task #: 3 s

Direct Costs	ICAT-Funded Expenses	Grantee's Cash Expenses	Other Expenses*	Total
1. Labor with Benefits		$5,258.42		$5,258.42
2. Subcontractors and Consultants	$ 188.80	$ 411.21		$ 600.01
3. Equipment				
4. Travel and Subsistence	$1,449.45	$1,449.45		$2,898.90
5. Materials & Supplies				
6. Other Direct				
Subtotal, Direct Costs:	$1,638.25	$7,119.08		$8,757.33
Indirect Costs				
7. Overhead (29% of #1)		$1,524.94		$1524.94
8. Other indirect (22% of #2 & #5)		$ 132.00		$ 132.00
Subtotal, Indirect Costs:		$1,656.94		$1,656.94
Total	$1,638.25	$8,776.02		$10,414.27

* grantee's non-cash expenses and partners' in-kind labor

I certify that, to the best of my knowledge and belief, the information contained in the attached progress report, including the accounting of expenditures on the project as summarized above, is correct and complete and is in accordance with the grant. In addition, I hereby authorize the California Air Resources Board to make any inquiries to confirm details in the progress report.

Grantee's Signature Date

APPENDIX B
BUDGET SUMMARY

Grant No.: 01-6

Project Title: A Plan to Retrofit 3 Diesel Generators with RYPOS TRAP

Period covered: December 2001 to August 31, 2002 Task #'s: 1, 2, 3 & 3s Summary

Direct Costs	ICAT-Funded Expenses	Grantee's Cash Expenses	Other Expenses*	Total
1. Labor with Benefits		$ 70,292.83		$ 70,292.83
2. Subcontractors and Consultants	$ 40,405.23	$ 411.21		$ 40,816.44
3. Equipment		$ 13,781.20		$ 13,781.20
4. Travel and Subsistence	$ 11,955.03	$ 3,376.05		$ 15,331.08
5. Materials & Supplies	$ 17,828.54	$ 9,600.00	$14,400.00	$ 41,639.74
6. Other Direct				
Subtotal, Direct Costs:	$ 70,000.00	$ 97,461.29		$181,861.29
Indirect Costs				
7. Overhead (29% of #1)	$ 13,500.00	$ 6,884.92		$ 20,384.92
8. Other indirect (22% of #2 & #5)	$ 16,500.00	$ 1,640.36		$ 18,140.36
Subtotal, Indirect Costs:	$ 30,000.00	$ 8,525.28		$ 38,525.28
Total	$100,000.00	$105,986.57	$14,400.00	$220,386.57

* grantee's non-cash expenses and partners' in-kind labor

I certify that, to the best of my knowledge and belief, the information contained in the attached progress report, including the accounting of expenditures on the project as summarized above, is correct and complete and is in accordance with the grant. In addition, I hereby authorize the California Air Resources Board to make any inquiries to confirm details in the progress report.

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APPENDIX C
TEST PROCEDURE

Exhaust samples for the engine with and without “RYPOS Trap” are compared to evaluate the effect of adding the RYPOS Trap across the exhaust stream of the engine.

The evaluation begins by taking baseline readings for the engine without the RYPOS Trap, to determine the operation characteristics of the engine and establish a reference against which the performance of the RYPOS Trap can be measured. The engine is allowed to idle, un-loaded, and settle for 20-25 minutes. The load and engine’s speed (rpm) were then varied at different operation conditions. 3 settings were usually tested: 0 hp, 40% and 80% of the engine’s rated load. Exhaust samples are taken for each of these modes.

After establishing the engine’s baseline, RYPOS Trap is connected to the engine and the same steps done for establishing the baseline were then repeated.

Typically, 25-30 minutes runs were used for each of the settings when exhaust sample are to be collected, of which 4-6 minutes were used to collect the exhaust sample. In addition to exhaust samples, Back Pressure values and exhaust temperature were recorded every 15 seconds, using an on-board data logger.

For each of the three demonstrations, evaluation was carried in two sessions. The first session was when the system was installed for the first time. During that session, the first day is used to generally prepare the engine and take exhaust sample for each of the target settings without RYPOS TRAP (1^{st} base line readings). The second day is dedicated to collecting efficiency samples with the filter attached to the engine (three samples for each mode). The same procedure is repeated towards the end of the demonstration period, exhaust sample were collected with the Trap attached to the system, the Trap was then disconnected and the engine run to collect another set of exhaust samples at each of the above 3 modes to complete establishing the baseline for efficiency comparison (2^{nd} baseline readings) and to also check for any change in performance of the engine.

Sampling and Calculations:

In the tests described, particulates in the exhaust are collected on pre-weighed membrane filters. Two measurements are taken: TPM (Total Particulate Mass) which includes all materials collected on the filter during the sampling process, and Soot, which is the solid particles in the exhaust stream. The amount of TPM and Soot collected on the membrane filters determine the efficiency of the particulate trap.

For each load setting, three samples were taken and the averages are reported. Pre-weighed 47-mm Pallflex® Tissuequartz™ membrane filters are put inside an in-line filter holder. The holder is attached on one end to a tube whose other end is placed inside the exhaust pipe and perpendicular to the flow of the exhaust. A vacuum pump is then connected to the free end of the in-line filter holder. After the engine is allowed to settle in the selected rpm and load, the vacuum pump is turned on, forcing particulates to accumulate on the sampling filters. Sampling is done for 4 or 6 minutes (depending on the load and the amount of soot on the exhaust) after which the vacuum pump is stopped and the filters removed from the holder.

The two filters are put in a desiccator for 24 hours then weighed. The difference between the original weight and the second weight is roughly the weight of TPM. The two filters are then to be heated on a hot plate for 1-2 minutes to get rid of oils and other soluble matters in the exhaust. The filters are then to be weighed for a third time. The difference between the final weight and the original is the weight of the Soot.

APPENDIX D
PROJECT TEAM LEADERS

Frank DePetrillo, RYPOS, COO: *Mr. DePetrillo was a co-founder and CEO of Environmental Engineering Corporation. In that capacity, he raised capital, hired and trained staff, interfaced with government agencies, and managed the development of air pollution control products used in the industrial furnace industry and diesel exhaust remediation. Prior to that, he was a major account manager for 15 years for Digital Equipment Corporation, where he managed sales, field support, marketing, and strategic alliances for such accounts as Raytheon and the U. S. Navy. Previous to that, he was a Registered Representative with E. F. Hutton, managing stock, bond, and commodity portfolios for institutional and private accounts.*

Amin Saeid, RYPOS, Senior Research Engineer*. Mr. Saeid holds Masters degrees in both Energy Management and Policy, and International Marketing, from the University of Pennsylvania. He also holds a B.S. in Mechanical Engineering. He has designed and implemented the test protocols for the RYPOS TRAP, and is managing the process for the certification of the product.*

Klaus Peter, RYPOS, President: *Mr. Peter has over twenty-five years of design experience in consumer and industrial electronics. In 1984 he was co-founder, Executive VP, Director of Engineering, Treasurer, and a Director of Media Logic, Inc. Mr. Peter was instrumental in setting up an engineering department and creating a line of products that propelled the Company to over $28M in sales in 1992, making the Company a major player in the worldwide magnetic media tester market, as well as bringing the Company public in 1987 and later earning the Company a place on the American Stock Exchange. Previous to Media Logic, Mr. Peter held the position of Engineering Manager at Digital Equipment Corp. where he hired and directed a team of twenty-eight engineers and technicians to create hard disk drive products in the Magnetic Media Storage Division. Prior to this, Mr. Peter served as design engineer and chief engineer in the consumer electronics industry in Europe, USA, and the Far East. He received a degree in Electrical Engineering from the University of Ottawa, Canada.*

Osama Ibrahim, RYPOS,CEO: *Dr. Ibrahim graduated from the University of Wisconsin-Madison in 1991 with a Ph.D. degree in Mechanical Engineering and a minor in Chemical Engineering specializing in thermodynamics, combustion, engines, process design and optimization.Dr. Ibrahim is directing a multi-disciplinary research program with emphasis in energy and air pollution. The objective of his research program is to generate innovative ideas that could lead to more efficient energy systems and protect the environment through pollution prevention and reduction of emissions In the last ten years, he has been involved in several research projects on emission reduction of diesel engine exhaust and energy systems.*