Transport Canada Transports Canada

Freight Transportation Case Studies

#2

Testing Novacab truck cab heating and cooling system

Organization
Groupe Énerstat Inc.

Major Findings
This novel cab climate control system reduced idling fuel consumption by about $5,600 per year (based on fuel at $0.90 per litre).

Project Timeline
December 2004 to March 2006

Please note that some figures such as fuel prices are based on data from the period that this project took place.

Introduction

Transportation accounts for about one quarter of Canadian greenhouse emissions and freight transportation – the movement of goods by the aviation, rail, trucking and marine industries – is a major user of fossil fuels that cause these emissions. Transport Canada's *Freight Sustainability Development Program* (FSDP) was one of several initiatives for reducing fuel consumption, and associated emissions in the freight sector. Groupe Énerstat Inc., with the financial support of Transport Canada's FSDP, tested the Novacab truck-cab heating and cooling system as a cost-effective alternative to engine idling for providing interior climate comfort for drivers.

A typical intercity tractor-trailer idles an estimated 1,830 hours per year, during operator rest periods. In North America, there are nearly 480,000 long-distance trucks. For one truck, idling hours can use almost 6,000 litres of diesel fuel per year and give off 21 tonnes of CO_2, 120 kg of NO_x and 21 kg of CO emissions.

North American truckers face many climatic conditions, from very cold (-30°C) to very warm (35°C). Typically, truckers have used the main engine to provide interior comfort control during rest stops. Using the main engine to heat or cool a truck cab wastes energy,

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causes additional emissions, and is noisy. Therefore, reducing truck idling is an important environmental and operating challenge.

Novacab is an integrated climate control system that makes use of state-of-the-art phase-change materials, electronic controls, and heat pump technology to heat and cool a truck when its engine is off. The technology performed well, and reduced fuel consumption and emissions.

Project Description

This study involved a one-year assessment of the Novacab integrated climate control system through laboratory and on-road testing, in five long-haul trucks operated by five local trucking companies. Two of the companies were mainly north/south shippers between Canada and the southern United States. The others were primarily east/west shippers, moving freight from eastern Canada to western North America. The trips monitored were usually one to three weeks long, and covered a wide range of climatic conditions.

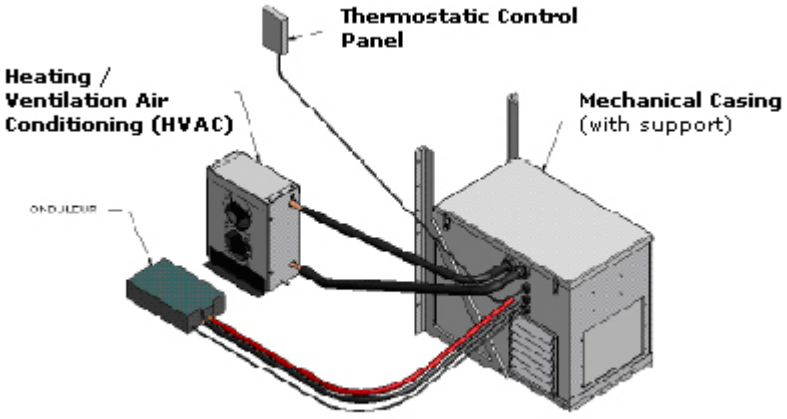
The Novacab system used waste heat to charge the system for heating, so the additional energy required by the system was negligible, except for extreme conditions. Extra electrical energy was required to charge the system for cooling. Using a high-efficiency thermal storage technology (based on phase change of specific materials), with a very high-energy storage density, the climate control system operates independently of the internal combustion engine as follows:

- when a vehicle runs, the system operates in charging mode;
- when the truck stops and the engine is turned off, the stored energy meets heating or air-conditioning needs for up to ten consecutive hours.

The system is made up of several interconnected parts (Figure 1):

- the electronic control system allows the driver to select the sleeper cab temperature. It continually monitors interior and exterior temperatures, ventilation, and re-circulated airflow, and selected evaporator and condenser pressures/temperatures to optimize system operation;
- the thermal energy storage unit stores heat and cold, for 6 to 10 hours of service;
- the heating, ventilating, and air conditioning (HVAC) unit inside the sleeper cab, provides the desired temperature.

Figure 1 - Components of the Novacab system



Project Objectives

The primary objective of this project was to evaluate the Novacab integrated climate control system, as a cost-effective system for heating and cooling long-distance truck cabs.

The project goals were to:

1. reduce the idling and related fuel consumption of long-distance trucks;
2. achieve a payback period of less than two years;
3. ensure comfortable conditions for drivers;
4. minimize capital and operation costs;
5. produce a system that could be easily integrated into existing vehicles; and
6. meet health, safety, indoor air quality and environment requirements including anti-idling regulations in several North American jurisdictions.

Project Methodology

Testing of the Novacab integrated climate control system began in December 2004, and was completed in March 2006. There were three main stages to the research:

1. Laboratory Testing
2. Road testing
3. Qualitative testing

Laboratory Testing

Before the Novacab systems were installed, the five test trucks were calibrated in the laboratory to determine the energy required to charge the systems in both heating and cooling modes, and to estimate the potential greenhouse gas emissions and fuel consumption reductions. The trucks were operated at low idle to simulate the emissions, and fuel consumption resulting from cab heating and at fast idle, to simulate the emissions and fuel consumption required to cool the cab.

Baseline data for the test trucks was also collected before on-road testing. Fleet managers provided fuel consumption data for comparing fuel use, before and after equipment installation. Once calibration was completed, the five test trucks were returned to their fleets for installation of the Novacab systems, under the supervision of Groupe Énerstat.

Road Testing
Once laboratory testing and Novacab installations were complete, the trucks were released back to their fleets for regular long-haul service.

Microprocessors monitored operational data, including system operating time, interior temperature, and ventilation set-point. Travel distance and fuel consumption data came from fleet management systems. Since the integrated system could supply both heating and cooling, weather data was collected and correlated with qualitative data collected from the drivers, to determine the relative performance of the system, in both heating and cooling modes.

Qualitative Data Collection
Drivers and fleet managers were surveyed throughout the course of the study. Drivers were asked about the comfort and performance of the system. Fleet managers also provided their evaluation of the technology in their fleets, and payload and operational data. In addition, the researchers held regular discussions with truckers and fleet operators for feedback.

Results

Since waste energy (heat) was used to charge the system for heating, the extra fuel used to charge the system with heat was negligible, except for extreme conditions. Cooling required extra electrical energy and this required additional fuel consumption. The additional energy used by the system was almost negligible, around ½ hp over an overall capacity of more than 450 hp. The analysis also considered the impact of the added weight of the system on fuel consumption.

For summer operation, there was a net reduction of 21.8 L of fuel per day for 7.1 hours of Novacab (engine-off) operation. The average consumption required to charge the system was 0.85 L per day – less than 4% of the fuel saved.

For winter operation, there was a net reduction of 28.4 L per day, for 9.7 hours of Novacab (engine-off) operation. The average consumption required to charge the system was 2.61 l/day. Due to a higher capacity in heating mode (about 5 kW compared to 2 kW in cooling mode), up to 9 % of the fuel saved by eliminating idling was required to generate heat from extreme cold conditions. In cold weather testing, engine starting (after shutdown) was never a problem. However, it is generally recommended that trucks operating in very cold weather (below –35°C) be equipped with engine block heating devices.

Results showed an average coefficient of performance (COP) of around 2.8 (defined as the energy supplied over the consumed (paid) energy). Typical COPs for truck cooling systems range from 1.3 to 1.5. Furthermore, the performance of the system increased when ambient temperatures were extreme (+35°C or -25°C). At 0°C the COP was around 2.5, while at –25°C it was 2.8, and at +35°C it was 2.7.

Table 1 shows how the average saving in fuel costs per year was calculated. It takes into account additional fuel to charge the system, and savings resulting from significantly fewer operating hours of the main engine, and the weight of the equipment.

Table 1 - Calculation of average savings (per truck, per year) resulting from using Novacab

Item	Technical Parameters	Cost saving (per year)	Cost increase (per year)
1. Fuel use at idle	3.21 litres per hour		
2. Idling hours eliminated by using the Novacab cab heater or air-conditioner	1,957 hours per year		
3. Fuel used to idle (#1 x #2)	6,282 litres per year		
4. Price of diesel fuel at the time of the study	$ 0.90 per litre		
5. Fuel saved by eliminating idling (#3 x #4)		$ 5,655	
6. Reduction in engine preventive maintenance costs (oil/filter changes) (#2 x 0.07) due to reduced idling		$ 137	
7. Reduction in engine wear due to reduced idling (#2 x 0.07)		$ 137	
8. Additional fuel required to charge the Novacab system	344 litres per year		
9. Cost of additional fuel to charge the Novacab system (#8 x #4)			$ 309
Total Savings (reduction in fuel costs + reduced preventative maintenance + reduced engine wear (#5 + #6 +#7) – extra fuel to charge Novacab (#10)		$ 5,620	

The benefits of the Novacab system are:

- net reduction of up to 5,938 L/yr per truck (6,282 – 344 L) of diesel fuel (90% less fuel consumption compared to engine idling), for a reduction of GHG emissions of up to 16,300 kg/year/truck and a net cost saving of $5,620 per truck per year;

- ability to reliably deliver up to 2 kW of cooling capacity and up to 5 kW of heating capacity;

- elimination of engine idling noise during shut-down periods, to the benefit of communities and resting drivers; and

- reduced engine hours (about 1,830 hours per year) and engine wear

The system's performance is almost independent of weather conditions. Unlike conventional air/air heat pumps, the system can operate at temperatures as low as -25°C or up to 35°C, and more than 80% relative humidity, without loss of effectiveness while both heating or cooling and ventilating the vehicle.

Surveys taken during the study recorded a high level of drivers and fleet manager satisfaction. For the drivers, the system was simple to operate and provided comfort and quiet. For the fleet managers, the system reduced engine-operating hours and did not increase maintenance requirements.

Costs and Payback

The Novacab truck cab climate control system reduced fuel costs in the order of $5,620 per year per truck (at a diesel fuel cost of $0.90 per litre). The payback for the system depended on the number of idling hours eliminated, and the cost of fuel. For the trucks tested, the payback period was between 12 and 18 months. This could be further reduced if fuel cost increased or if mass production of the Novacab system decreased the system purchase cost. Installing the system at the time of truck manufacture could also reduce costs.

Conclusion

Comprehensive performance analysis and laboratory and on-road testing indicated that the Novacab integrated climate control system met project objectives. This technology significantly reduced idling time, and consequently in fuel consumption, and emissions.

The system was able to reduce engine idling by 6 to 10 hours per day, and functioned well even in very hot and very cold ambient conditions. The simplified mechanical system (with no engine) functioned smoothly, and the level of maintenance required was low. The payback period was 12 to 18 months depending on the duty cycle.

The integrated climate control system reduced fuel consumption by 90%, compared to using engine idling to provide cab comfort. This reduced greenhouse gas emissions equal to16,000 kg of CO_2 annually, per truck. The system showed a high degree of reliability and met driver expectations for comfort.

This project showed that the Novacab integrated climate control system has significant advantages compared to present trucking practices.

Additional Information

- Groupe Énerstat Inc.
  <http://www.groupeenerstat.com/>