

Data Sources and Analysis of a Heavy Vehicle Event Data Recorder – V-MAC III

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ABSTRACT

Heavy trucks can have the capability to record vehicle status and performance data. In many applications, this capability is intrinsic to the powerplant's electronic controls. However little information has been published regarding Heavy Vehicle Event Data Recorder (HVEDR) data obtained from Mack trucks equipped with the V-MAC vehicle electronic control units. This study is focused on data from Mack trucks and the influence of wheel slip on the HVEDR-reported vehicle speed. Additionally, the influence of variables such as initial speed and loaded condition are discussed. A late model Class 8 Mack was instrumented with a calibrated data acquisition package (DAQ) and put through a series of tests so that the HVEDR data could be compared to the data collected by the DAQ.

INTRODUCTION

Many modern trucks are equipped with an HVEDR function that has the ability to record data that can be useful in the analysis or reconstruction of crashes. However, the investigator must take care to consider the reliability of such data when analyzing or applying it.

Previous studies have shown that the HVEDR reported vehicle speed is often under-reported during periods of heavy braking due to the effect of wheel slip at the drive axle's tire to road surface interface.¹⁻⁴ Additionally, some studies have shown that in certain HVEDRs the sampling frequency is improperly reported.⁵⁻⁶ Little information has been published regarding the HVEDR data obtained from Mack trucks equipped with the V-MAC III system. These would include Mack vehicles built in model years 1998 to 2008.

V-MAC III SYSTEM

The Vehicle Management And Control (V-MAC) system for V-MAC III utilizes two electronic control modules; the Engine Electronic Control Unit (EECU) and the Vehicle Electronic Control Unit (VECU). These modules operate and communicate over the J1939 high speed and J1708/J1587 diagnostic serial data buses to control and report a variety of engine and vehicle cab functions.⁷⁻⁸

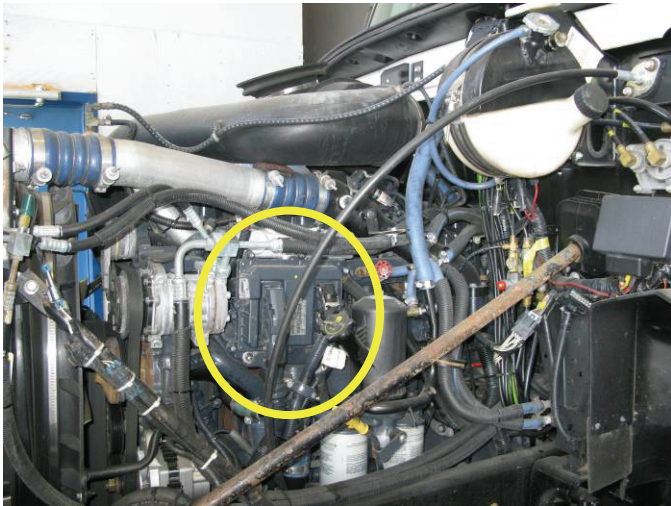


Figure 1. EECU.

On the chassis used in this series of tests, the EECU was bolted to the left (driver's) side of the engine on the intake manifold (Figure 1). On some earlier model year vehicles, the EECU can be located on the right (passenger) side of the engine below the turbocharger and covered by a heat shield. The EECU performs a variety of functions designed to operate and optimize performance of the engine. It receives data from numerous engine- and vehicle-mounted sensors and communicates with other modules on the truck.



Figure 2. VECU, black plastic box on right.

The VECU (Figure 2) was, and usually is, mounted on a panel underneath the dashboard, directly in front of the passenger seat on conventional truck and truck-tractor models. On the LE model, the VECU is located under the left side floor panel and on the MR model, under the tunnel cover adjacent to the forward bulkhead. It also receives data from various sensors and communicates with other modules via the J1939 serial data bus.

Both the VECU and EECU have on-board diagnostic capabilities. If an anomalous condition is detected within the system, a fault code or diagnostic trouble code

(DTC) will be logged in one or both of the modules' memory and the operator may or may not be notified via an Electronic Malfunction Lamp (EML). Fault codes can later be viewed through the use of a diagnostic computer, scan tool, or on some chassis, through the use of blink codes available to the vehicle's instrument cluster or other DTC indicator.

HVEDR FUNCTION

Data of interest to the accident investigator may include the vehicle data log and the incident log.

VEHICLE DATA LOG - The Vehicle Data Log is a trip-type recorder that contains various metrics regarding the operation of the vehicle since the last reset of the trip computer and for the life of the vehicle. While not a comprehensive list, some examples of trip information include distance traveled, average speed, maximum speed and hard braking occurrences.

INCIDENT LOG - The Incident Log function within the V-MAC III VECU has the ability to record up to two triggered incidents, or in some cases, one triggered incident and one last stop event. By default and as programmed from the factory, the recording of an incident is triggered by a change in vehicle speed of +/- 10 mph/sec combined with a change in engine speed of +/- 50 rpm/sec.

There are 160 registers available for incident recording. The first 80 registers constitute the circular RAM buffer and are continually written to volatile memory. If the triggers are defeated, then the first 80 registers are immediately written to EEPROM (Electrically Erasable Programmable Read Only Memory). An additional 80 registers are recorded directly to EEPROM for the post trigger time. At a recording resolution of 5 Hz (every 200 msec), this provides for 32 seconds of incident data (15.8 seconds before the trigger and 16 seconds after the trigger). Some early versions of V-MAC III trucks recorded 40 seconds of pre-trigger data and 40 seconds of post-trigger data at a resolution of 2 Hz (every 500 msec).

Data that is recorded in the incident log includes vehicle speed, engine speed and the status of the following switches: service brake, park brake, clutch pedal, engine brake low, engine brake high, cruise control, ignition key and one unprogrammed or indeterminate value.

VEHICLE SPEED CALCULATION

The vehicle speed recorded within the incident log of the VECU is derived from information received from the Vehicle Speed Sensor (VSS). The VSS senses the rotational speed of a 16-tooth tone ring mounted on the output shaft of the transmission. It senses the

rotational speed of the driveshaft). The vehicle speed is then calculated from the rotational speed of the driveshaft, the drive axle ratio, and the tire size.

Because the vehicle speed is derived as a function of the rotational speed of the driveshaft, it becomes apparent that the reported vehicle speed will be affected by conditions that produce dynamic changes in the rotational speed of the driveshaft. Such conditions include:

- lockup or wheel slip of the drive wheels during braking;
- spinning of the drive wheels (from engine power) on low friction surfaces; and,
- yawing of the vehicle.

The result is that the vehicle speed as determined from the VSS might not be representative of the true speed at which the vehicle is translating over the ground.

METHODS

During this study, testing was performed on a 2003 class-8 Mack truck that was instrumented with a data acquisition system (DAQ) to compare the vehicle speed reported in the Incident Log of the V-MAC III system to that measured by the DAQ during periods of steady state driving and full-braking events. The influence of variables such as initial speed and loading condition are discussed.

When analyzing data sourced from a V-MAC system, it is important to document the installed tire size on the drive axle(s), the axle ratio stamped on the axle’s identification tag, and the transmission model number to obtain gear ratios and the VSS tooth count. These mechanical parameters can be compared to the EECU’s or VECU’s electronic configuration to confirm that any logged vehicle speed correlates with any logged engine speed and is correct.

TEST LOCATION

Testing was conducted on a 10,000 foot runway at the retired El Toro Marine Corp Air Station (El Toro MCAS) located near Irvine, California. The runway was oriented in a compass direction of 160°/340° and was relatively flat. The runway surface was comprised of concrete in some areas and asphalt in others. Tests were run on both surface types and in both directions.

The test runs were completed during a one day period in daylight hours. The weather was clear and hot with a temperature of around 94°F and low humidity.

TEST VEHICLE



Figure 3. Test truck & trailer

A 2003 Mack CX613 6x4 conventional truck-tractor with sleeper was used for the evaluation of the MACK V-MAC III system. This CX613 was powered by a MACK AC-460 turbo-diesel engine controlled by a V-MAC III Engine and Vehicle Control Unit. At the time that testing began, the tractor had approximately 180,000 miles on the odometer.

The CX613 was equipped with an Eaton/Fuller 13-speed manual transmission and a Jacobs Engine Brake ®. The CX613 was also equipped with an S-cam airbrake system complemented with a Knorr/Bremse 4S/4M (4 sensor/4 modulator) Anti-Lock Brake System (ABS). The brake components were documented and adjustments measured prior to testing. All brake components are summarized in Table 1.

All tires on the CX613 were documented and their details and condition are summarized in Table 2.

Table 1. Tractor brake component details.

AXLE 1	LEFT	RIGHT
Chamber Type	MGM, Type-20	MGM, Type-20
Slack Adjuster	5.50" Haldex ASA	5.50" Haldex ASA
Brake Lining	> 0.50"	> 0.50"
Stroke	1"	1"
AXLE 2	LEFT	RIGHT
Chamber Type	Anchorlok, Type-30	Anchorlok, Type-30
Slack Adjuster	5.50" Haldex ASA	5.50" Haldex ASA
Brake Lining	> 0.50"	> 0.50"
Stroke	3/4"	1-1/4"
AXLE 3	LEFT	RIGHT
Chamber Type	Anchorlok, Type-30/30	Anchorlok, Type-30/30
Slack Adjuster	5.50" Haldex ASA	5.50" Haldex ASA
Brake Lining	> 0.50"	> 0.50"
Stroke	1-3/8"	1-1/4"