

NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

May 16, 2019

Cockpit Displays – Recorded Flight Data

Specialist's Factual Report
By Sean Payne

1. EVENT SUMMARY

Location: Lone Tree, Colorado
Date: May 11, 2018
Aircraft: Cirrus SR22
Registration: N507TX
Operator: Private
NTSB Number: CEN18FA168

On May 11, 2018, about 2019 mountain daylight time, a Cirrus Design Corporation SR22 airplane, N507TX, impacted terrain near Lone Tree, Colorado. The private pilot was fatally injured. The airplane was destroyed. The personal flight was conducted under the provisions of Title 14 *Code of Federal Regulations* Part 91. Visual meteorological conditions prevailed and no Federal Aviation Administration (FAA) flight plan had been filed for the flight. The airplane had just departed from Centennial Airport (APA), Denver, Colorado, and was en route to Grand Junction Regional Airport (GJT), Grand Junction, Colorado.

2. RECORDED FLIGHT DATA GROUP

A recorded flight data group was not convened.

3. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following electronic devices:

Recorder Manufacturer/Model: **Avidyne PFD**
Recorder Serial Number: **21304414**

Recorder Manufacturer/Model: **Avidyne MFD (CF Card Only)**
Recorder Serial Number: **N/A**

3.1. Avidyne Primary Flight Display (PFD) Description

The PFD unit includes a solid-state Air Data and Attitude Heading Reference System (ADAHRS) and displays aircraft parameter data including altitude, airspeed, attitude, vertical speed, and heading. The PFD unit has external pitot/static inputs for altitude, airspeed, and vertical speed information. Each PFD contains two flash memory devices mounted on a riser card. The flash memory stores information the PFD unit uses to generate the various PFD

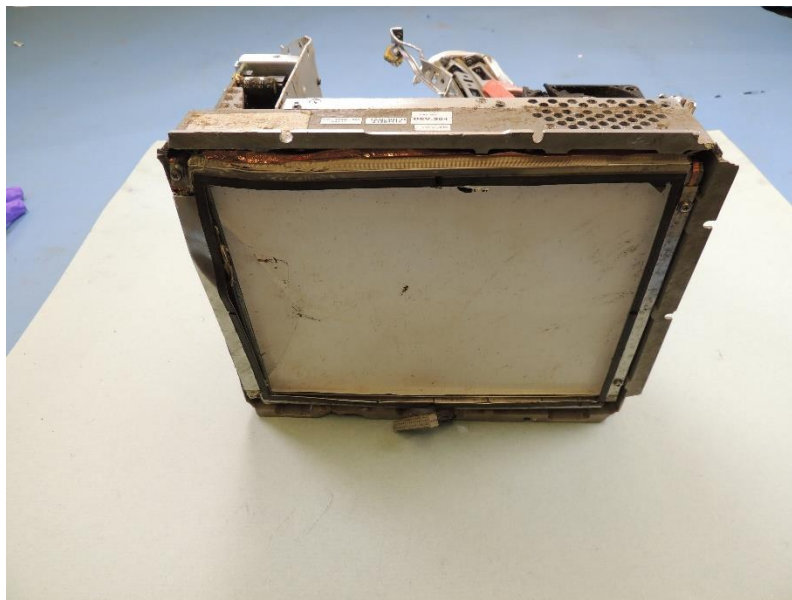
displays. Additionally, the PFD has a data logging function, which is used by the manufacturer for maintenance and diagnostics. Maintenance and diagnostic information recording consist of system information, event data and flight data.

The PFD samples and stores several data streams in a sequential fashion; when the recording limit of the PFD is reached, the oldest record is dropped and a new record is added. Data from the Attitude/Heading Reference System (AHRS) is recorded at a rate of 5 Hz. Air data information such as pressure altitude, indicated airspeed, and vertical speed are recorded at 1 Hz. Global Positioning System (GPS) and navigation display and setting data are recorded at a rate of 0.25 Hz, and information about pilot settings of heading, altitude, and vertical speed references are recorded when changes are made.

3.1.1. PFD Data Recovery

The recorder was damaged in the event. The extent of the damage is shown in figure 1. The U101 and U102 chips were extracted from the device and were read in a binary reader. The binary chip files were then converted using NTSB software and converted to engineering units.

Figure 1. Damaged exterior of flight recorder.



3.1.2. PFD Data Description

The PFD recording contained records of a number of power cycles associated with the usage of the device. The accident flight was identified by comparing the converted data to the accident date and time. The duration of the PFD's recording for the power cycle associated with the accident flight was approximately 25 minutes and 56 seconds. Timing of the PFD data is measured in seconds from power-on.

As stated in section 3.1, the PFD records most data at regular time intervals. The recorded data has shown, at times, to drop data records for up to 6 seconds in duration. The drop-out condition has been reported to the manufacturer of the PFD. The condition that causes

the dropouts is related to time overruns in the low-priority data logging code, which results in the input buffer overflowing. In later PFD software versions, if a drop-out occurs, an event is recorded in the event log.

3.1.3. PFD Engineering Units Conversions

Conversion of the PFD data from the raw recorded information to engineering units is performed by Avidyne. Acceleration data, as provided by Avidyne, was converted from meters per second-squared (m/s^2) to standard acceleration units (g).

Where applicable, changes to the conversions have been made to ensure the parameters conform to the Safety Board's standard sign convention that climbing right turns are positive (CRT=+).¹

APPENDIX A lists the PFD parameters verified and provided in this report.

3.2. Avidyne Multi-Function Display (MFD) Description

The MFD unit is able to display the pilot checklist, terrain/map information, approach chart information and other aircraft/operational information depending on the specific configuration and options that are installed. One of the options available is a display of comprehensive engine monitoring and performance data.

Each MFD contains a compact flash (CF) memory card located in a slot on the side of the unit. This memory card contains all of the software that the MFD needs to operate. Additionally, this card contains all of the checklist, approach charts, and map information that the unit uses to generate the various cockpit displays.

During operation, the MFD display receives information from several other units that are installed on the aircraft. Specifically, the MFD receives GPS position, time and track data from the aircraft's GPS receiver. The MFD may also receive information from the aircraft concerning altitude, engine and electrical system parameters, and outside air temperature. This data is also stored on the unit's CF memory card.

The MFD generates new data files for each MFD power-on cycle. The oldest file is dropped and replaced by a new recording once the storage limit has been reached. MFD data are sampled every six seconds, and is recorded to memory once every minute. If an interruption of power occurs during the minute between MFD memory write cycles, data sampled during that portion of a minute are not recorded.

3.2.1. MFD Data Recovery

The MFD's CF card was in good condition and the data were downloaded using the manufacturers' procedure via a surrogate unit in a bench top setup at the NTSB laboratory.

¹ CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Left Aileron Trailing Edge Down = -, Right Aileron Trailing Edge Up = +, Pitch Up = +, Elevator Trailing Edge Up = +.

Figure 2. Photo of MFD CF card.



3.2.2. MFD Data Description

The MFD CF card contained data files associated with a multitude of previous flights by the accident aircraft. One data file was identified as recording during the accident flight. The data file was approximately 25 minutes and 06 seconds in duration.

3.2.3. MFD Engineering Units Conversions

The data files downloaded from the MFD are in engineering units.

APPENDIX B APPENDIX A lists the MFD parameters verified and provided in this report.

3.3. Time Correlation

Correlation of the PFD data to MDT was established using the recorded GPS time parameter from the PFD data. Recorded GPS time is updated in 6 second intervals on the PFD². The GPS time is recorded in Universal Coordinated Time (UTC). The difference between MDT and UTC is six hours, or 21,600 seconds. The PFD starts recording when power is applied to the unit. Each power cycle the timing begins at 0 seconds and the PFD data is measured in seconds from power-on. An offset is applied to each power cycle plotted to display the data with the local time zone. Therefore, for the rest of this report, all times are referenced as MDT, not recorded time³.

Due to the six second update rate of the GPS time, the times noted in this report could be up to six seconds off from actual GPS time

² GPS information is recorded at 4 second (0.25 Hz) intervals; however it is possible to have the same UTC time recorded in consecutive GPS data records due to the 6 second update rate of the GPS time parameter.

³ The GPS overlays presented in Google Earth are shown with UTC time. There is a six hour difference between UTC and MDT.

3.4. Plots and Corresponding Tabular Data

The following two figures contain both PFD and MFD data recorded during the May 11, 2018 event.

Figure 3 displays PFD and MFD data from the start of the recording around 19:53:00 to the accident which occurred approximately at 20:18:54.

Figure 4 displays PFD and MFD data from the portion of the recording that contained data while the aircraft was in flight. The plot begins at 20:11:00 and ceases at the time at which the accident occurred which was approximately 20:18:54.

Figure 5 is an overlay of recorded GPS data on Google Earth. This figure shows GPS data from the entire recording. Pressure altitude data was used to create the figure in lieu of GPS altitude data. The overlay is oriented in a north-up manner.

Figure 6 is an overlay of recorded GPS data on Google Earth during the final portion of flight. Pressure altitude data was used to create the figure in lieu of GPS altitude data. The overlay is oriented looking toward the southwest.

Additional parameters that have been validated, but have not been plotted, are available in the attached tabular data. The tabular data used to create these two plots are provided in electronic (*.csv⁴) format as Attachment 1 to this report.

⁴ Comma Separated Value format.

Figure 3. Plot of parameters during entire flight.

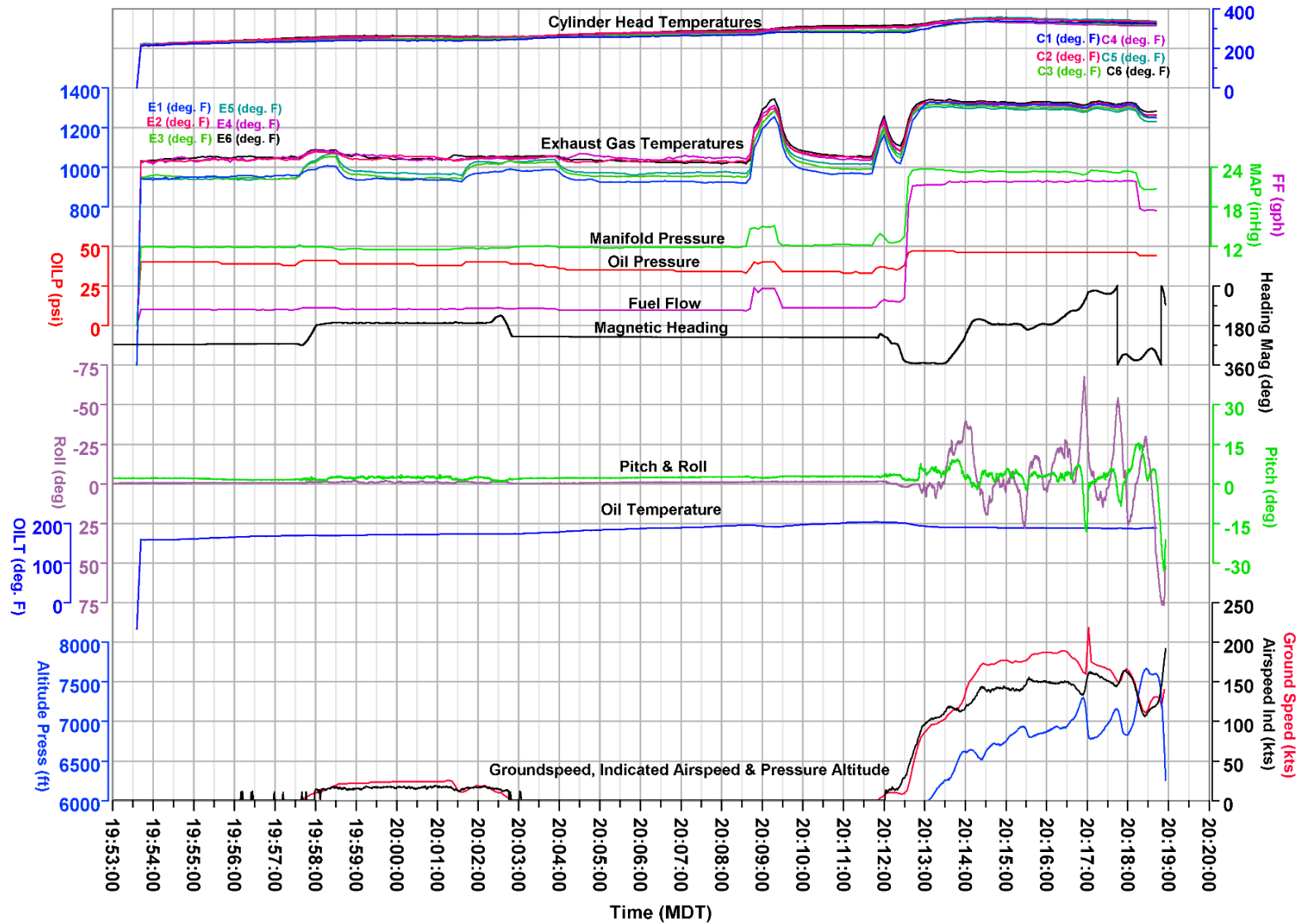


Figure 4. Plot of parameters during the final portion of flight.

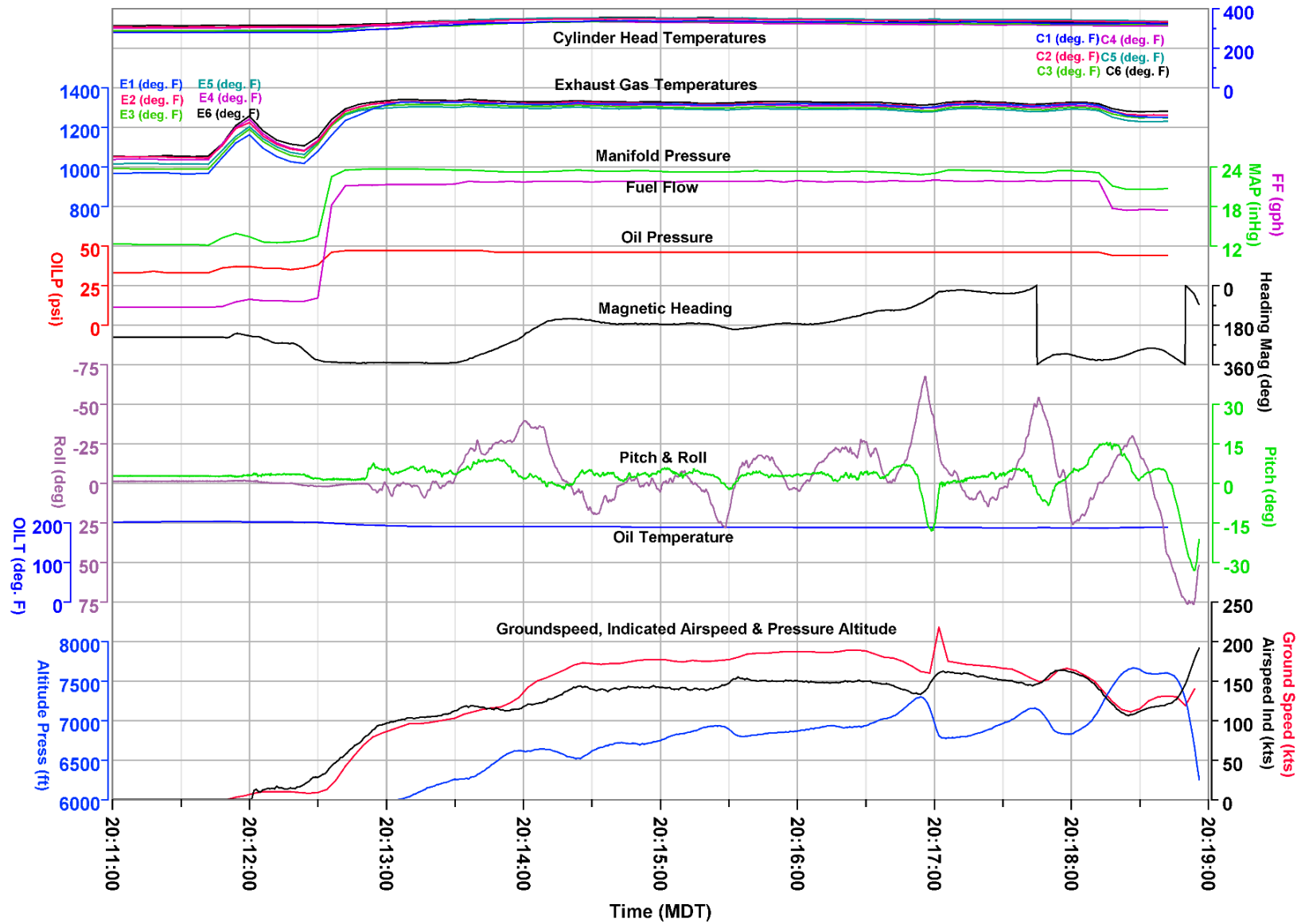


Figure 5. An overlay of recorded GPS data for the entire flight. The figure is oriented north-up.



Figure 6. An overlay of recorded GPS data for the final portion of flight. The wreckage location is depicted as a yellow pin. The view is oriented looking southwest.



APPENDIX A - PFD Parameters

This appendix describes the parameters provided and verified in this report. Table A-1 lists the PFD parameters and table A-2 describes the unit abbreviations used in this report for PFD parameters.

Table A-1 - Verified and provided parameters.

Parameter Name	Parameter Description	Source
Accel Lat (g)	Lateral Acceleration	PFD
Accel Long (g)	Longitudinal Acceleration	PFD
Accel Vert (g)	Vertical Acceleration	PFD
AHRS goNoGo - Attitude Flag (discrete)	AHRS goNoGo - Attitude Flag	PFD
Air Data goNoGo - Altitude Fail (discrete)	Air Data goNoGo - Altitude Fail	PFD
Air Data goNoGo - IAS Fail (discrete)	Air Data goNoGo - Indicated Air Speed Fail	PFD
Airspeed Ind (kts)	Indicated Airspeed	PFD
Airspeed True (kts)	True Airspeed	PFD
Altitude Press (ft)	Pressure Altitude	PFD
Heading Mag (deg)	Magnetic Heading	PFD
Latitude (deg)	Latitude	PFD
Longitude (deg)	Longitude	PFD
Pitch (deg)	Pitch	PFD
Roll (deg)	Roll	PFD
Temp TAT (deg)	Temp TAT	PFD
Turn Rate (deg/sec)	Turn Rate	PFD

The PFD records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event. The data from this accident showed that the altimeter bug was set to a pressure setting of 29.77 in Hg at the time of the accident.

Barometric altitude in feet, Mean Sea Level, is calculated using the pressure altitude and the barometric correction using the following formula:

$$Altitude_{Baro} (ft\ MSL) = Altitude_{Pressure} (ft) + (Baro\ Correction\ (inHg) - 29.92\ (inHg)) \times 924.82\ (ft/inHg)$$

Table A-2 - Unit abbreviations.

Units Abbreviation	Description
%	percent
rpm	revolutions per minute
amperes	Amperes
deg	degrees
char	one character (A-Z, 0-9)
deg/min	degrees per minute
deg/sec	degrees per second
degC	degrees Celsius
degF	degrees Fahrenheit
discrete	discrete
ft	feet
gal	gallons
gph	gallons per hour
hrs	hours
in	inches
inHg	inches of Mercury
kts	knots
psi	pounds per square inch
sec	seconds
V	Volts DC

NOTE: For parameters with a unit description of discrete, a discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.

APPENDIX B - MFD Parameters

This appendix describes the parameters provided and verified in this report. Table B-1 lists the MFD parameters and table B-2 describes the unit abbreviations used in this report for MFD parameters.

Table B-1 - Verified and provided parameters.

Parameter Name	Parameter Description
AMP1	Bus 1 Amps (amperes)
AMP2	Bus 2 Amps (amperes)
AMPB	Battery Bus Amps (amperes)
CHT Cyl# (deg F.)	Cylinder Head Temperature Cylinder # ⁵ (degrees Fahrenheit)
EGT Cyl# (deg F.)	Exhaust Gas Temperature Cylinder #5 (degrees Fahrenheit)
FF (gph)	Fuel Flow (gallons per hour)
Used (gal)	Fuel Used (gallons)
MAP (inHg)	Manifold Pressure (inches of mercury)
OilP (psi)	Oil Pressure (pounds per square inch)
OilT (deg F.)	Oil Temperature (degrees Fahrenheit)
RPM (rpm)	Revolutions Per Minute (revolutions per minute)
EBus (V)	Essential Bus Voltage (Volts)
MBus (V)	Main Bus Voltage (Volts)
OAT (deg C.)	Outside Air Temperature (degrees Celsius)

The MFD records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event.

Table B-2 - Unit abbreviations.

Units Abbreviation	Description
RPM	revolutions per minute
Amperes	Amperes
deg	degrees
deg C.	degrees Celsius
deg F.	Degrees Fahrenheit
gal	gallons
gph	gallons per hour
inHg	inches of Mercury
kts	knots
psi	pounds per square inch
V	Volts DC

NOTE: For parameters with a unit description of discrete, a discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter,

⁵ Depending on aircraft configuration, the number of cylinders that are instrumented varies. In the data plots the '#' is replaced with the appropriate cylinder ID.