National Transportation Safety Board
Office of Research and Engineering
Washington, DC 20594

CEN23LA107

ENGINE DATA MONITORS

Specialist's Factual Report

November 15, 2023

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A. ACCIDENT

Location: Lakeway, Texas
Date: February 12, 2023
Time: 0958 central standard time (CST)
Airplane: Mooney M20K, private operator, N304MA

B. ENGINE DATA MONITORS SPECIALIST

Specialist: Matthew Yandrick
Electrical Engineer – Recorder Specialist
National Transportation Safety Board (NTSB)

C. DETAILS OF THE INVESTIGATION

An engine data monitor group was not convened.

The NTSB Vehicle Recorder Division received the following electronic devices:

Recorder Manufacturer/Model: JPI EDM-700
Part Number: EGT-701-6C
Recorder Serial Number: 27837

Recorder Manufacturer/Model: Shadin Avionics Miniflo-L™
Part Number: 912041T-D
Recorder Serial Number: 7451

1.0 EMD-700 Description

The J. P. Instruments EDM-700 is a panel mounted gauge that the operator can monitor and will record up to 24 parameters related to engine operations. Depending on the installation engine parameters monitored can include:

- Exhaust Gas Temperature (EGT)
- Cylinder Head Temperature (CHT)
- Oil Pressure and Temperature
- Manifold Pressure
- Outside Air Temperature
- Turbine Inlet Temperature
- Engine Revolutions per Minute

- Compressor Discharge Temperature
- Fuel Flow
- Carburetor Temperature
- Battery Voltage
- Mode Indication

The unit can also calculate, in real-time, horsepower, fuel used, shock cooling rate, and EGT differentials between the highest and lowest cylinder temperatures. The data recorded is dependent on installed options and user configuration.

The unit contains non-volatile memory (NVM) for data storage of the parameters recorded and calculated. The rate at which the data is stored is selectable by the operator from 2 to 500 seconds per sample. The memory can store up to 20 hours of data at a 6 second per sample rate. The data can then be downloaded by the operator using the J.P. Instruments software.

1.1 EDM-700 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the EDM-700 was in good condition (see figure 1) and data were downloaded using the manufacturer's procedure.

Figure 1. Front and side view of EDM-700, as received.

1.2 EDM-700 Data Description

The EDM recording contained approximately 15 hours of data over 15 power cycles (sessions) from December 23, 2022, through February 12, 2023. The accident flight was the last flight of the recording, and its duration was approximately 38 minutes and 7 seconds on February 12, 2023. The data rate was found to be 6 seconds per sample during automatic mode and 1 second per sample during

LeanFind[1] mode. Both modes provide engine monitoring information. During automatic mode each cylinder and each parameter value is automatically sequenced and shown in the digital display for a few seconds, even in flight.

1.3 EDM-700 Time Correlation

The EDM records time with the first data sample based on the unit's internal clock. This clock is set and updated by the operator. The recorded time of the accident flight was 6 hours ahead of CST (local time). All times in this report are given in recorder device time.

2.0 Shadin Avionics Miniflo-L™ Description

The Miniflo-L™ is a digital fuel management system designed to provide fuel management information under real flight conditions using an electronic numerical display. The unit is connected to engine fuel flow transducer for fuel flow information. The unit can be connected to a Loran-C or GPS receiver serial port for navigation data, such as ground speed, distance, and estimated time enroute. The unit is also capable of transmitting fuel information to certain GPS receivers for additional calculations and display of fuel management data. The unit can display the following information to the crew:

- Specific Range[1]
- Fuel to Destination[2]
- Fuel Reserve[1]
- Endurance
- Fuel Flow
- Fuel Used
- Fuel Remaining

The unit contains limited non-volatile memory for data storage and records the fuel set state at the beginning of the flight (user selection of the amount of fuel onboard) and the amount of fuel used during the flight.

The unit does not interface with an aircraft's fuel quantity indicating system.[3] The unit requires the flight crew to enter the initial fuel on board the aircraft. All

[1] The purpose of LeanFind mode is to find the first and last cylinder to peak with true peak detect, and eliminate false peaks.
[2] Real time calculation that requires an active Loran-C or GPS input.
[3] The operating manual states in the preflight procedures section, "Miniflo-L™ is a fuel flow measuring system and NOT a quantity-sensing device. A visual inspection and positive determination of the usable fuel in the fuel tanks is a necessity. Therefore, it is imperative that the determined available usable fuel be manually entered into the system."

calculations and data provided by the unit are based on fuel flow and any provided navigational information.

2.1 Shadin Avionics Miniflo-L™ Data Recovery

The Shadin Miniflow-L™ arrived in good condition, see figure 2. The unit was not connected to any fuel flow sensors or GPS/Loran devices during the data recovery process. Using procedures described in the Shadin Avionics Miniflo-L™ operating manual[4], data was recovered by applying power to the unit and cycling through the displayed values.

Figure 2. Front and top view of Shadin Miniflo-L™, as received.

2.2 Shadin Avionics Miniflo-L™ Data Description

Upon power up, the fuel flow indicator performed a self-test and reported a status of "-Good-" indicating a successful test (see figure 3). Fuel used and fuel remaining were displayed by moving the GAL. USED/GAL. REM. toggle switch to the appropriate USED and REM positions. Figure 4 showed the fuel used reporting a value of 1.9 gallons and figure 5 shows the fuel remaining reporting a value of 60.3 gallons[5]. The device's fuel value may not represent the total fuel amount relevant to the accident flight as it relies on proper user input to reflect accurate fuel load values upon engine start.

Diagnostic software test values were displayed by pressing the ENTER/TEST button. A success test was indicated by a "-Good-" appearing in the display window.

[4] For further information on configuration settings refer to Shadin Avionics Miniflo-L™ operating manual for P/N: 91204XT-D, publication number OP91204E

[5] Fuel remaining is calculated by the unit by subtracting fuel used from the initial starting fuel entered by the crew.

This was followed by the K-factor setting of 29.0 and the units of measure set to gallons, figure 6. Then “LoF” appeared indicating no Loran or GPS signal, figure 7. Then the maximum usable fuel reported a value of 75.6 gallons, figure 8. The last displayed value was the software version 60.01.72, figure 9.

Figure 3. The Shadin Miniflo-L™ self test upon power up.

Figure 4. The Shadin Miniflo-L™ indicating the amount of fuel used.

Figure 5. The Shadin Miniflo-L™ indicating the amount of fuel remaining.

Figure 6. The Shadin Miniflo-L™ indicating the K-factor setting (left) and units of measure (right).

Figure 7. The Shadin Miniflo-L™ indicating no Loran/GPS signal.

Figure 8. The Shadin Miniflo-L™ indicating the maximum usable fuel.

Figure 9. The Shadin Miniflo-L™ indicating the software version.

The unit was also configured to enable the inspection of the group 2 configuration settings.[6] Group 1 settings, in general, are set up by the distributer and contain information defined by the part number. Group 1 settings were not examined for this investigation.

Group 2 settings, in general, are set up by the user or installer to change Loran or GPS input and output parameters, warning type, and fuel flow filtering types. Table 1 contains the group 2 settings retrieved from the unit.

[6] For further information on configuration settings refer to Shadin Avionics Miniflo-L™ operating manual for P/N: 91204XT-D, publication number OP91204E

Table 1. Group 2 Configuration Settings

Display	Value	Description
O	5	GPS/Output Type: Generic, used to communicate with most Garmin GPS
I	1	GPS/Loran Input: On
d	0	Endurance Warning Time: 45 minutes
F	0	Filter Type: Injector
u	0	No (default) setting used with Shadin Flow Meter. With GPS, set to zero (0)

The unit does not retain any information related to the four available rotary switch positions (nautical miles per gallon, gallons to destination, gallons reserve settings and endurance).

D. FIGURES AND TABULAR DATA

Data obtained from the EDM-700 was used to produce the following figures and tabular data. Figures 10 and 11 are plots of parameters recorded during the accident on February 12, 2023. All the parameters listed in table 2 are plotted. Figure 10 covers the time period from 15:38:18 to the end of the recorded data at 16:16:25. Figure 11 covers the time period from 15:54:00 to 16:02:00 when cylinder head temperature #6 peaks at approximately 15:58:25. There is a loss of data from exhaust gas temperature #6 with the last data point at 15:59:02.

The corresponding tabular data used to create figures 10 to 11 are provided in electronic comma-separated value (CSV) format as attachment 1 to this report.

Submitted by:

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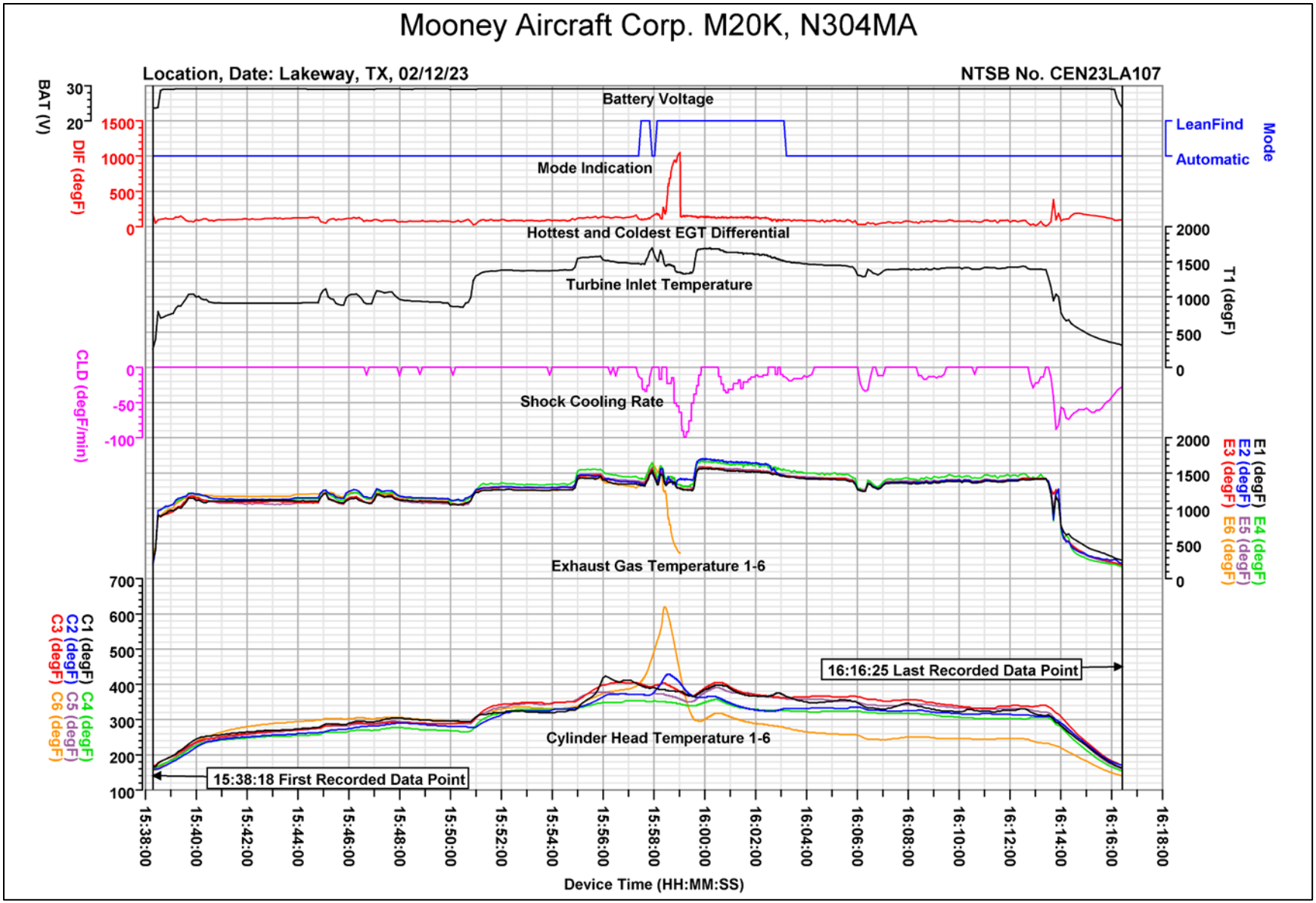

Figure 10. Plot of JPI EDM-700 parameters for entire accident flight.

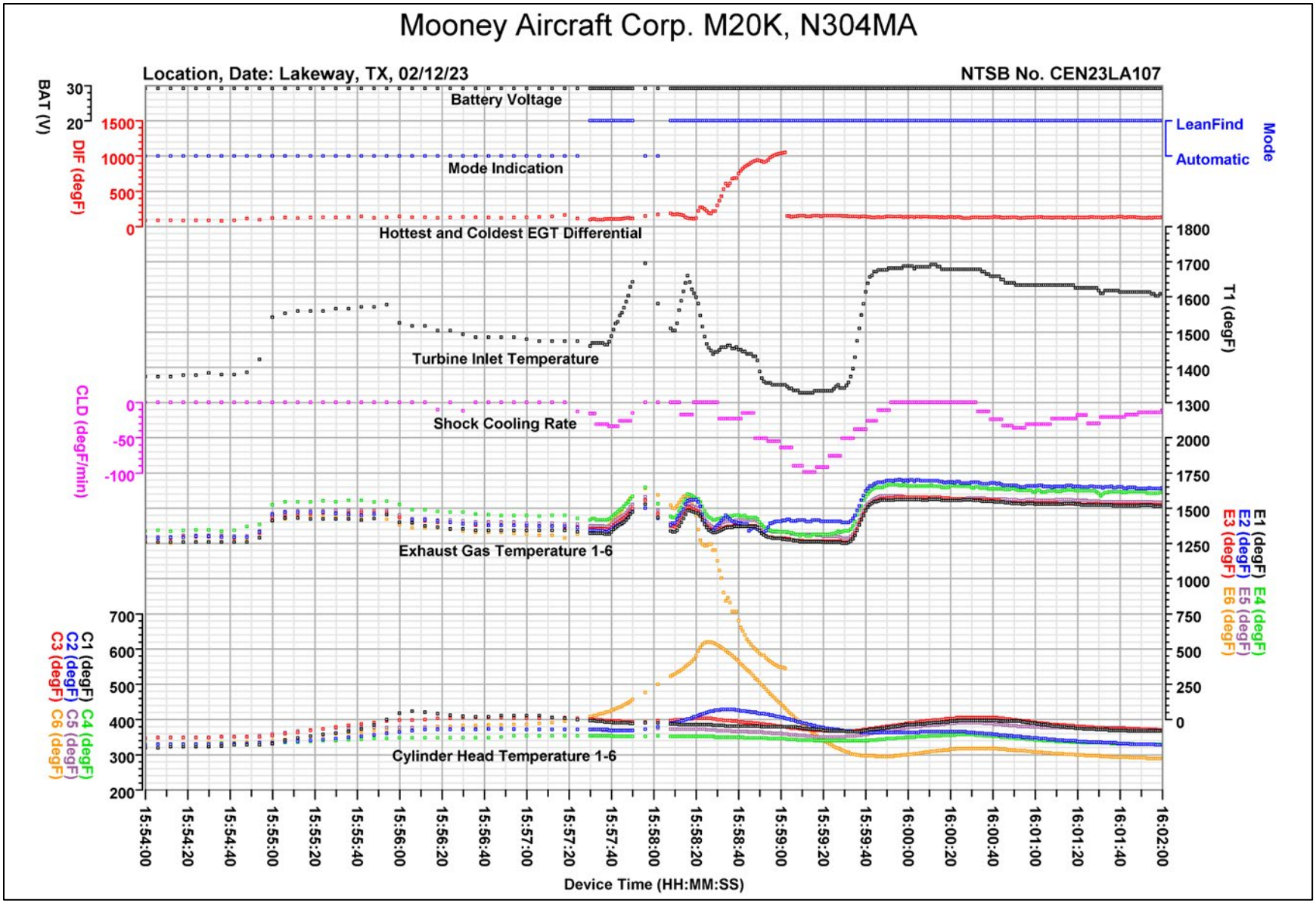

Figure 11. Plot of JPI EDM-700 parameters during C6 peak

APPENDIX A. VERIFIED AND PROVIDED PARAMETERS EDM-700

This appendix describes the parameters provided and verified in this report. Table 2 lists the parameters and table 3 describes the unit abbreviations used in this report.

Table 2. Verified and provided parameters.

Parameter Name	Parameter Description
Date (MM/DD/YYYY)	Device Date
Time (HH:MM:SS)	Device Time
E1-6 (degF)	Exhaust Gas Temperature
C1-6 (degF)	Cylinder Head Temperature
T1 (degF)	Turbine Inlet Temperature
DIF (degF)	Hottest and Coldest Exhaust Gas Differential
CLD (degF/min)	Shock Cooling Rate
BAT (V)	Battery Voltage
MARK	Mode Indication
LeanFind	Discrete, finds the first and last cylinder to peak with true peak detect
Automatic	Discrete, each cylinder and each parameter value is automatically sequenced and shown in the digital display for a few seconds

Table 3. Unit abbreviations.

Unit Abbreviations	Descriptions
MM/DD/YYYY	Month/Day/Year
HH:MM:SS	Hours:Minutes:Seconds
degF	Degrees Fahrenheit
degF/min	Degrees Fahrenheit per minute
V	Voltage

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.