

From: [David](#)
To: [Stein Stephen](#)
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek
Date: Friday, June 26, 2020 11:42:49 AM

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Hi Stephen

I'm sorry. We didn't tear it down any further. We were forced to seriously downsize our resources due to the effects of the COVID19 shutdown. That instrument cluster is very old and of obsolete design. I'm not sure we would learn any more, since we already know there is some friction in those old meter movements.

David

From: Stein Stephen [mailto:]
Sent: Wednesday, June 24, 2020 2:29 PM
To: David
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

Hi David,

I hope this email finds you well. Did you guys end up tearing down that instrument cluster to analyze it further?

Thanks,

Stephen

From: David
Sent: Thursday, April 9, 2020 9:07 AM
To: Stein Stephen
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

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Stephen

Most of the error is in the left fuel sender, 5.2 ohms where it should be 0 ohms. I won't tear into the fuel sender because it is not our product. I just wondered if I should send these parts back to you, or if you need more?

David

From: Stein Stephen [REDACTED]
Sent: Thursday, April 09, 2020 10:26 AM
To: David [REDACTED]
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

I didn't know that was an option. Would we get any closer to sourcing the high resistance?

From: David [REDACTED]
Sent: Thursday, April 9, 2020 5:42 AM
To: Stein Stephen [REDACTED] >
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

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Stephen

Do you need us to disassemble the instrument cluster and analyze it further?

David

From: Stein Stephen [REDACTED]
Sent: Wednesday, April 08, 2020 3:12 PM
To: David [REDACTED]
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

Thanks, David.

From: David [REDACTED]
Sent: Wednesday, April 8, 2020 12:38 PM
To: Stein Stephen [REDACTED]
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

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Stephen

The readings at 30 ohms or "F" were slightly low. The readings at 0 or "E" were high. The cause of these errors was not determined.

I don't have specs for the fuel senders but using data from the tests at Mooney, the left sender at empty was 5.2 ohms. That is equivalent to about 17% of scale or about 25 lbs. of fuel. The indication would read erroneously high by at least 25 lbs. This would add to the error seen at "E" and would be close to the 36 lbs indication at empty, seen in the NTSB draft page 4.

The only low readings I saw was at the top of the scale where both indicators were slightly below "F".

The vibration in the operating environment will normally remove the friction errors. I saw more friction in both indicators than I would like to see, but I don't know how much of that is damage to bearing surfaces from the impact.

In my opinion the erroneously high reading of the left fuel indicator is due to a combination of, high left fuel sender resistance of 5.2 ohms at low position, and a positive offset in the indicator at "E".

David

From: Stein Stephen [REDACTED]
Sent: Wednesday, April 08, 2020 11:28 AM
To: David <[REDACTED]>
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

David –

Thank you, that was a well-crafted explanation.

In your report, you state that both indicators have friction greater than the new specs allow and errors at both ends of the scale.

Could you please explain the reading errors you referenced in your report? Are you talking about the erroneously high reading in one gauge and low reading in the other?

In your opinion could the increased friction cause erroneously higher or lower readings or both?

Stephen

From: David [REDACTED]
Sent: Wednesday, April 8, 2020 7:38 AM
To: Stein Stephen [REDACTED] >
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

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Stephen

The way I understand this indicator is that it is based on an electrical resistance bridge circuit. The visible pointer is connected to a moving electromechanical element which seeks to balance the bridge current or to reach a point of equilibrium between a known resistance and an unknown one. The unknown resistance in this case being the resistance of the fuel sender, which varies with the

position of the float. The friction error is due to mechanical resistance to movement inherent in the bearing point or pivot point of the moving element. This friction prevents the moving element from reaching a perfect point of equilibrium when the force of the unbalance current flowing in the bridge circuit is less than the opposing friction force. Application of vibration helps to overcome the force of friction in the indicator through the induced oscillation.

As for calibration, the resistance of the electrical bridge circuit is adjusted to compensate for variances in the electrical and mechanical parameters. This instrument uses a rheostat, the arms of which are mechanical positioned to achieve the electrical resistance required to give correct indication. In any electrical meter circuit of this type there are two adjustments, zero or offset and span or gain. In this case one adjustment would be made with 0 ohms input and the other adjustment made with 30 ohms input. These adjustments are usually repeated until the desired accuracy is achieved.

To my knowledge, there is no recommended re-calibration timeframe for this type of instrument. I was always told that the requirement for maintenance is based on condition.

Thanks
David Baugher
Quality Assurance Manager
Sigma Tek, Inc.

From: Stein Stephen [REDACTED]
Sent: Tuesday, April 07, 2020 4:28 PM
To: David <[REDACTED]>
Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

David –

This is perfect. Thank you for helping us out with this.

My apologies if this is a stupid question, but would you mind defining friction error? I'm afraid it's a new term for me.

And how are these gauges calibrated? Is there a recommendation for how often they should be re-calibrated?

Thanks,

Stephen

From: David [REDACTED]
Sent: Tuesday, April 7, 2020 11:35 AM
To: Stein Stephen [REDACTED]

Subject: RE: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek

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Stephen

I have done an evaluation of the instrument cluster. Please see attached report and instrument drawing.

Let me know if you need further investigation.

Thanks

David Baugher

Quality Assurance Manager

Sigma Tek, Inc.

From: Stein Stephen [REDACTED]
Sent: Monday, March 23, 2020 10:46 AM
To: [REDACTED]
Cc: Robert Collier [REDACTED]; Arizpe, Jose (FAA) [REDACTED]; Helgeson, Troy <[REDACTED]>
Subject: Mooney M20C N78988 - Fuel Gauge Cluster Examination - Sigmatek
Importance: High

Good morning David,

Thank you for taking my call today. As discussed, I'm going to ask Mooney to ship fuel parts to you. In the box will be:

- 2 fuel senders
- 1 engine instrument cluster

Our goal is to test the engine instrument cluster functionally and to perform whatever ATP that's available to determine why the left instrument gauge is reading erroneously high. I would also like to understand why the right one is reading erroneously low in the sender high point position, but that's a lower priority.

Enclosed is a copy of our examination notes and Mooney's subsequent notes on their test on the fuel senders and cluster for your knowledge.

As this is an open, active case, I ask that you please not circulate these documents to anyone unless they are supporting this examination in a technical capacity.

Thanks and best regards,

Stephen

Stephen Stein

Aviation Accident Investigator

National Transportation Safety Board

[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]

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