ATTACHMENT 1

TO

SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT

CEN17FA168

Pilatus PC-12/45, S/N 105; Honeywell Examination

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25 October 2017

Re: NTSB ID: CEN17FA168, N933DC, Pilatus PC-12/45, S/N 105; Honeywell examination

Dear Sirs,

The equipment detailed below from N933DC was examined at the Honeywell facility in Olathe, Kansas, on 21-22 June 2017 and 05 October 2017. The units inspected were received in three sealed boxes. Box 1 contained the Roll, Pitch, and Yaw servos and was shipped by the Denver field office. Box two contained the KTA-336 Pitch Trim Adaptor and was shipped from the NTSB in Washington DC. Box three contained the KCP-220 Flight Computer which arrived at the Olathe, KS Honeywell facility from the Denver Field office on 07-Sept-2017. Michael Hauf with the NTSB provided government oversight during the 21 June and 22 June equipment examination.

At the conclusion of the 21-22 June inspection the accident items were packaged in two boxes, were sealed by NTSB Representative Michael Hauf and were retain in locked storage at Honeywell pending a follow-up examination of the KSA-372 Pitch Servo Actuator. Chris McVay, FAA provided government oversight for the 05-October-2017 follow-up equipment examination of the KCP 220 Flight Computer and the KSA 372 Pitch Servo.

In addition to the listed equipment a KMH 820 Multi-hazard Computer Serial Number 2760, Honeywell Part Number (HPN) 066-01175-2101 was forwarded to the Honeywell – Redmond, WA facility for data extraction.

KSA 372 Servo Actuator (Pitch), P/N 065-0056-59, S/N M5626
KSM 375 Servo Mount (Pitch), P/N 065-0015-00, S/N 7245
KSA 372 Servo Actuator (Yaw), P/N 065-0056-80, S/N 3600
KSM 375 Servo Mount (Yaw), P/N 065-0015-01, S/N 7327
KSA 372 Servo Actuator (Roll), P/N N/A, S/N N/A – No Serial Tag found
KSM 375 Servo Mount (Roll), P/N 065-0015-N/A, S/N 7301
KTA 336 Trim Adaptor, P/N 065-00164-0100, S/N 1794
KCP 220 Flight Computer, P/N 065-0064-XX, S/N 1898
KMH 820 Multi-hazard Computer, N/A, S/N N/A*
*Unit was forwarded to Honeywell – Redmond, WA by NTSB for data recovery. The memory devices were found damaged and no data was recoverable.

Package Inspection: Box 1

Shipping Package 1 as received at Honeywell.

Shipping Package 1 as received at Honeywell.

Shipping Package 1 contents as received at Honeywell.

Shipping Package 1 contents as received at Honeywell.

Package Inspection: Box 2

Shipping Package 2 as received at Honeywell.

Shipping Package 2 as received at Honeywell.

Shipping Package 2 contents as received at Honeywell.

Shipping Package 2 contents as received at Honeywell.

Package Inspection: Box 3

Shipping Package 3 as received at Honeywell.


Shipping Package 3 as received at Honeywell.

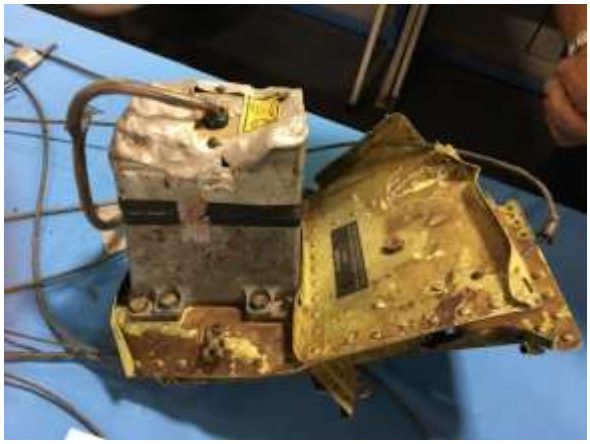

Shipping Package 3 contents as received at Honeywell.

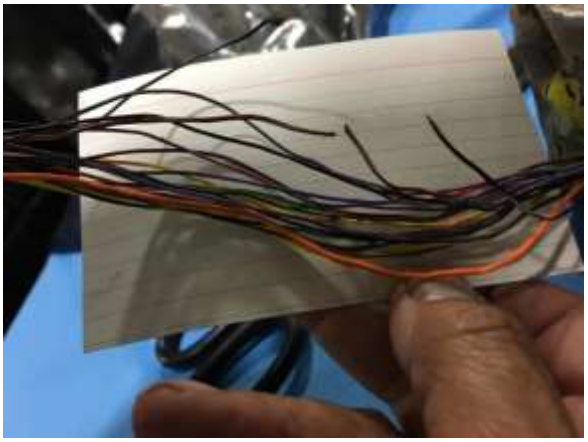

Shipping Package 3 contents as received at Honeywell.

KSA 372 Servo Actuator (Pitch)
Honeywell Serial Number: M5626
Honeywell Part Number: 065-0056-59
Unit Mods: Unknown. Mod tag missing from servo dust cover

KSA 372 SN M5626 Data Plate

KSA 372 S/N M5626 Inspection:
Visual inspection of the Pitch Servo revealed the following:
There was some crushing of the dust cover at the rear of unit in addition to a tear in the dust cover.
The servo is covered with dried clay / dirt.
The wiring harness is damaged.
The Fieldtech Warranty seal is intact.


Crush damage at rear of the dust cover.
Tear in dust cover.


Impact damaged wiring harness.

Bridal cable control clamps are intact.

Bridal cable control clamps are intact.

The dust cover was removed to allow inspection of the servo wiring and the circuit cards. The rear component mounting plate is bent inward.

Side view of servo with dust cover removed. The rear component mounting plate bent inward toward circuit board.

Opposite side view of the rear component mounting plate bent inward toward circuit board.

Side view of servo with dust cover removed. The rear component mounting plate bent inward toward circuit board.

Broken diode (CR403) on the rear plate.

Servo Drive Train Inspection:

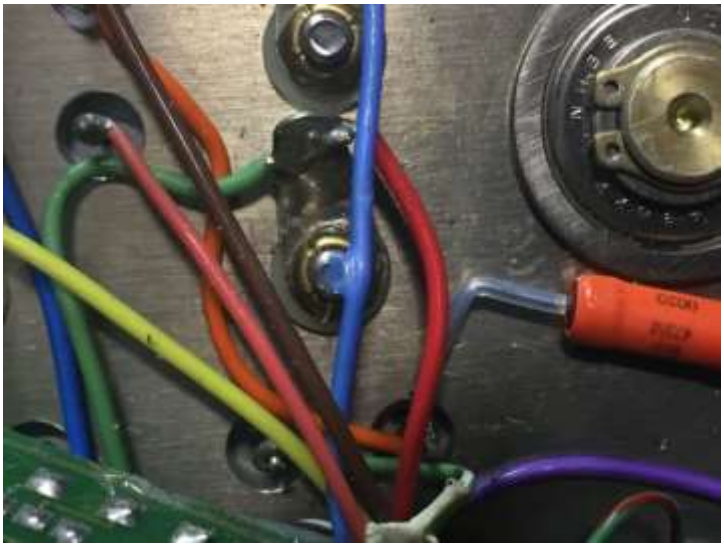
No anomalies were found during the servo drive train inspection.

View through inspection plate of main drive gear.

Servo testing:

Under the supervision of the NTSB Investigator: The servo was visually confirmed to be in the disengaged state when received. The servo was connected to a test panel and power was applied. There was no clutch engagement or motor drive. Severed wires, related to impact damage, were found in the wiring harness. The severed wires were repaired and power was reapplied. The motor ran briefly followed by a resistor smoking. Power was removed. Power was reapplied and clutch engagement was tested. The clutch would not engage.

Circuit board (200-06444-0012) was lifted to visually examine the components. A blue wire was found contacting a screw due to the circuit board pressing up against it (impact related) resulting in a shorting condition. The blue wire had damaged insulation. The blue wire was moved away from screw.



KSA 372 SN M5626 Impact damaged blue wire.

When power was reapplied to the servo and the unit began an un-commanded run. The clutch engaged and disengaged when commanded.

Power was removed again. The smoked resistor was replaced with an exemplar resistor. Power was reapplied to the servo and motor drive was satisfactory in the clockwise (CW) direction. The motor would not rotate in the counterclockwise direction. Due to time constraints, further inspection was deferred to a later date.

Testing of the pitch servo resumed the afternoon of October 5 with the following being accomplished:

Power off resistance measurements were taken at various locations within the servo amplifier and drive circuitry comparing the accident servo to an exemplar servo. No perceived differences were detected.

As a precaution, the accident servo motor drive transistors Q 201, Q 202, Q 203, and Q 204 were replaced with exemplar drive transistors. The original drive transistors were retained with the accident servo.

An exemplar test aid diode was installed for the broken CR403.

The case of Q310 appeared to be crushed onto the leads of Q310. Q310 was repositioned to provide additional spacing between the leads and the case. Resistance measurements were taken of Q310 and compared to Q310 within an exemplar servo. There was no discernable difference of the measurements.

Following installation of the exemplar power transistors, installation of the exemplar CR403, and repositioning of Q310 power on testing of the servo resumed. During testing the Trim Drive signals were monitored while driving the servo in the Clockwise (CW) and Counter Clockwise (CCW) directions. Monitoring of the drive signals revealed the servo drive on the CCW direction was latch at 13 V dc.

The following tables contain the data recorded during the test.

Exemplar Servo Data:

Rotation Direction	Drive Voltage	Connector Location
CCW	25 V dc	N
CCW	2 V dc	L
CW	2 V dc	N
CW	25 V dc	L

Accident Servo Data:

Rotation Direction	Drive Voltage	Connector Location
CCW	13 V dc	N
CCW	13 V dc	L
CW	2 V dc	N
CW	25 V dc	L

Summary:

During a commanded CCW rotation the drive voltage monitored at Connector N is driven toward +28 Vdc while the monitored drive voltage and connector location L is driven toward ground. The delta between the two voltages determine the rotation speed of the servo motor. With the drive voltage latch at 13 V dc, there was not a voltage differential across the motor, thus preventing it from rotating. Due to the extensive impact damage resulting in severed wires and crushed / broken components a cause of the latched drive voltage could not be determined.

KSM 375 Servo Mount (Pitch)
Honeywell Serial Number: 7245
Honeywell Part Number: 065-0015-00
Unit Mod: 1, 2

KSM 375 SN 7245 Data Plate

KSM 375 SN 7245 Inspection:
Mounting plate appears to in good condition. Dried clay/dirt observed on the mounting plate, the capstan, and the capstan / clutch cover.


KSM 375 SN 7245 Back side view

Observed impact damage to the Capstan and Capstan cover.

KSM 375 SN 7245 Front side and Capstan view

Clutch Assembly inspection and testing:
The clutch assembly was removed from the Servo Mount and inspected. No anomalies were detected.

KSM 375 SN 7245 Servo mount with clutch removed for testing

Servo clutch assembly was mounted to a Honeywell clutch test stand and was tested with the following results:

KSM375 Pitch Servo Mount SN 8133 Torque Settings		
Direction	Torque as Tested	Torque Specification
Clockwise	50 in lbs	40 +/- 5 in lbs
Counter Clockwise	50 in lbs	40 +/- 5 in lbs

Summary

The KSM 375 Pitch Servo Mount functioned correctly; however, the clutch slipped at approximately 50 in/lbs (CW) and 50 in/lbs (CCW) against a limit of 40 +/- 5 in/lbs. The out of tolerance condition would not have an adverse impact on operation. The Aircraft Flight Manual provides preflight instructions to confirm proper operation and ability to overpower the autopilot clutches.

KSA 372 Servo Actuator (Yaw)
Honeywell Serial Number: 3600
Honeywell Part Number: 065-0056-80
Unit Mod: N/A

KSA 372 SN 3600 Data Plate

KSA 372 SN 3600 Inspection:
The KSA 372 Yaw servo was received attached to portion of the accident aircraft airframe. The servo was removed from the airframe to facilitate inspection of the servo and mount.

Visual inspection of the Yaw servo revealed the following:

The servo was visually confirmed to be in the disengaged state when received.
The dust cover was crushed.
The servo circuit cards were found detached from the main servo housing.
The gear train appeared to be out of alignment.
The servo housing was cracked
A mounting boss was found broken.
Connector back shell found broken.
Wires found severed in the wiring harness.

KSA 372 SN 3600: As received

Under the oversight of the NTSB, the dust cover was removed from the circuit card housing to facilitate visual examination. The following conditions were noted:

The back plate was found bent / crushed.
The circuit cards were found crushed and broken.
The access panel was removed from the servo housing and the clutch was found Not Engaged.
The motor/gear assembly turned freely by hand.

KSA 372 SN 3600 with dust cover removed.

Servo Testing:

The servo was removed from the Servo Mount for further testing / examination. The impact damage precluded testing of the servo. At the request of the NTSB Investigator, the Servo Motor and Clutch Solenoid were functionally tested.

Servo Motor Testing:

The motor wiring was isolated from the servo control circuitry. Power was applied to the servo motor via an external power supply. With power applied to the drive motor, it started turning at 1.6 V. Applying 28V DC to the Red wire and Ground to the Black wire, the motor shaft rotated in the counterclockwise (CCW) direction. The Tach voltage measured +11.05 VDC indicating the tach motor is functional.

Applying 28V DC to the Black wire and Ground to the Red wire, the motor shaft rotated in the clockwise (CW) direction. The Tach voltage measured -11.1 VDC indicating the tach motor is functional.

The motor functioned correctly in the Clockwise and Counter Clockwise directions.

Clutch Solenoid testing:

The clutch solenoid wiring was isolated from the servo control circuitry. Power was applied to the servo clutch solenoid via an external power supply. The clutch solenoid engaged and disengaged satisfactorily.

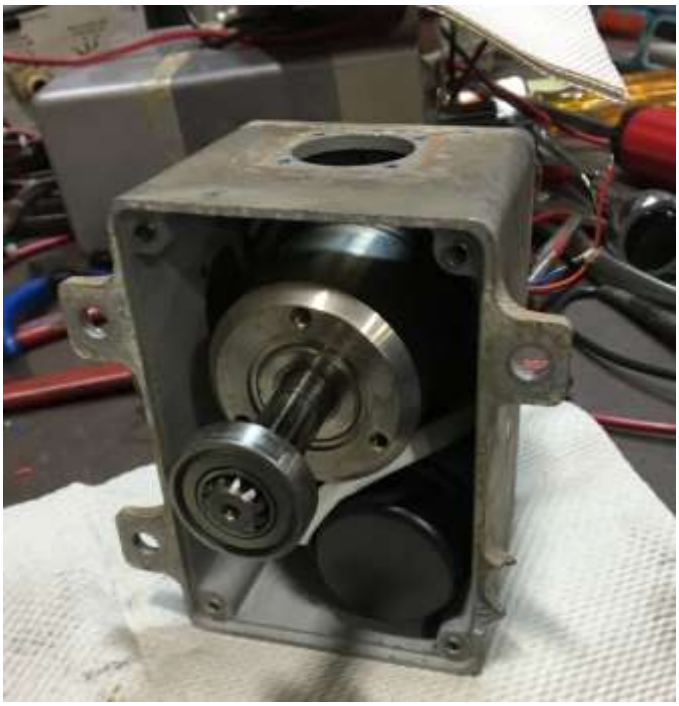
KSA 372 SN 3600 testing of the servo motor and clutch solenoid.

Clutch Gear Teeth Examination:

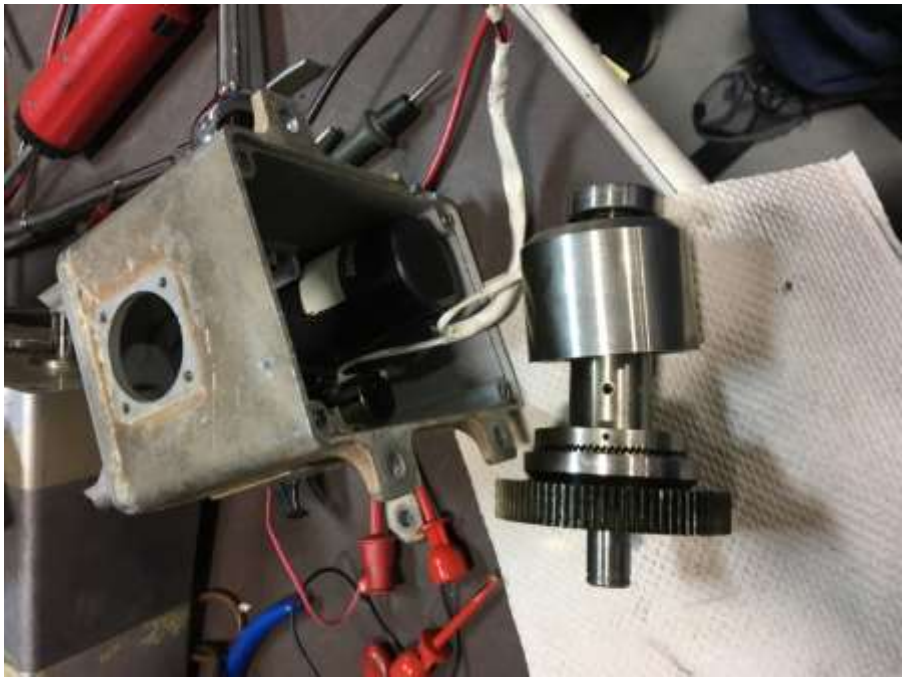
Under the supervision of the NTSB, the servo was disassembled to facilitate examination of the servo clutch gear assembly. The following conditions were observed:

Main bearing rotated freely

No witness marks were observed on the clutch gear teeth crowns..



KSA 372 SN 3600: Cover removed to examine servo gear train.



KSA 372 SN 3600: Gear train removed for examination.

KSA 372 SN 3600: Gear train disassembled to examine “poker chip” gear face.

KSA 372 SN 3600: Gear train disassembled to examine “poker chip” gear face.

KSA 372 SN 3600: Gear train disassembled to examine “poker chip” gear face.

Summary:

No witness marks were observed on the clutch gear teeth crowns. Due to extensive damage, testing of the complete servo was not possible. No adverse operation observed during standalone testing of the clutch solenoid and drive motor.

KSM 375 Servo Mount (Yaw)
Honeywell Serial Number: 7327
Honeywell Part Number: 065-0015-01
Unit Mod: 1, 2

KSM 375 SN 7327 Data Plate

KSM 375 SN 8227 Inspection:
Mounting plate appeared to be in good condition. Dried clay/dirt observed on the mounting plate.

KSM 375 SN 7327 Mounting plate and clutch

KSM 375 SN 7327 Mounting plate and clutch

The clutch assembly was removed from the Servo Mount and inspected. The last service date noted on clutch assembly was in 1994. Month and day were not discernible. The clutch appears to be original for the airframe. The Clutch assembly appeared to be in good condition.

Clutch Torque Testing:

Servo clutch assembly was mounted to a Honeywell Clutch test stand and the clutch assembly was tested with the following results:

KSM 375 Yaw Servo Mount SN 8227 Torque Settings		
Direction	Torque as Tested	Torque Specification
Clockwise	50 in lbs	85 +/- 5 in lbs
Counter Clockwise	50 in lbs	85 +/- 5 in lbs

Summary

The KSM 375 Yaw Servo Mount functioned correctly; however, the clutch slipped at approximately 50 in/lbs (CW) and 50 in/lbs (CCW) against a limit of 85 +/- 5 in/lbs. The out of tolerance condition would not have an adverse impact on operation. The Aircraft Flight Manual provides preflight instructions to confirm proper operation and ability to overpower the autopilot clutches.

KSA 372 Servo Actuator (Roll)
Honeywell Serial Number: Unknown
Honeywell Part Number: Unknown

The data plate for the KSA 372 Roll Servo was not recovered from the wreckage.

KSA 372 Roll Servo Inspection:
The Roll servo was received in a severely damaged state.

KSA 372 Roll Servo mounting plate and clutch

Roll Servo components, clockwise starting on the left:

- Back plate / electronics assembly.
- Bridle cable
- Capstan with fractured mounting plate.
- Clutch solenoid assembly with slip clutch.
- Capstan cover.
- Dust cover.

Clutch solenoid testing:

+28 VDC was applied to the blue and white Clutch Solenoid wires. The solenoid engaged and disengaged properly with the application and removal of power.

KSA 372 solenoid assembly.

The clutch solenoid was disassembled for visual inspection. The "poker chip" gear was inspected and a witness mark was observed on the edge of the friction clutch gear from the blue/black mark counterclockwise (CCW) spanning approximately 180 degrees.

KSA 372 gear and shaft assembly.

KSA 372 Witness marks in edge of gear teeth..

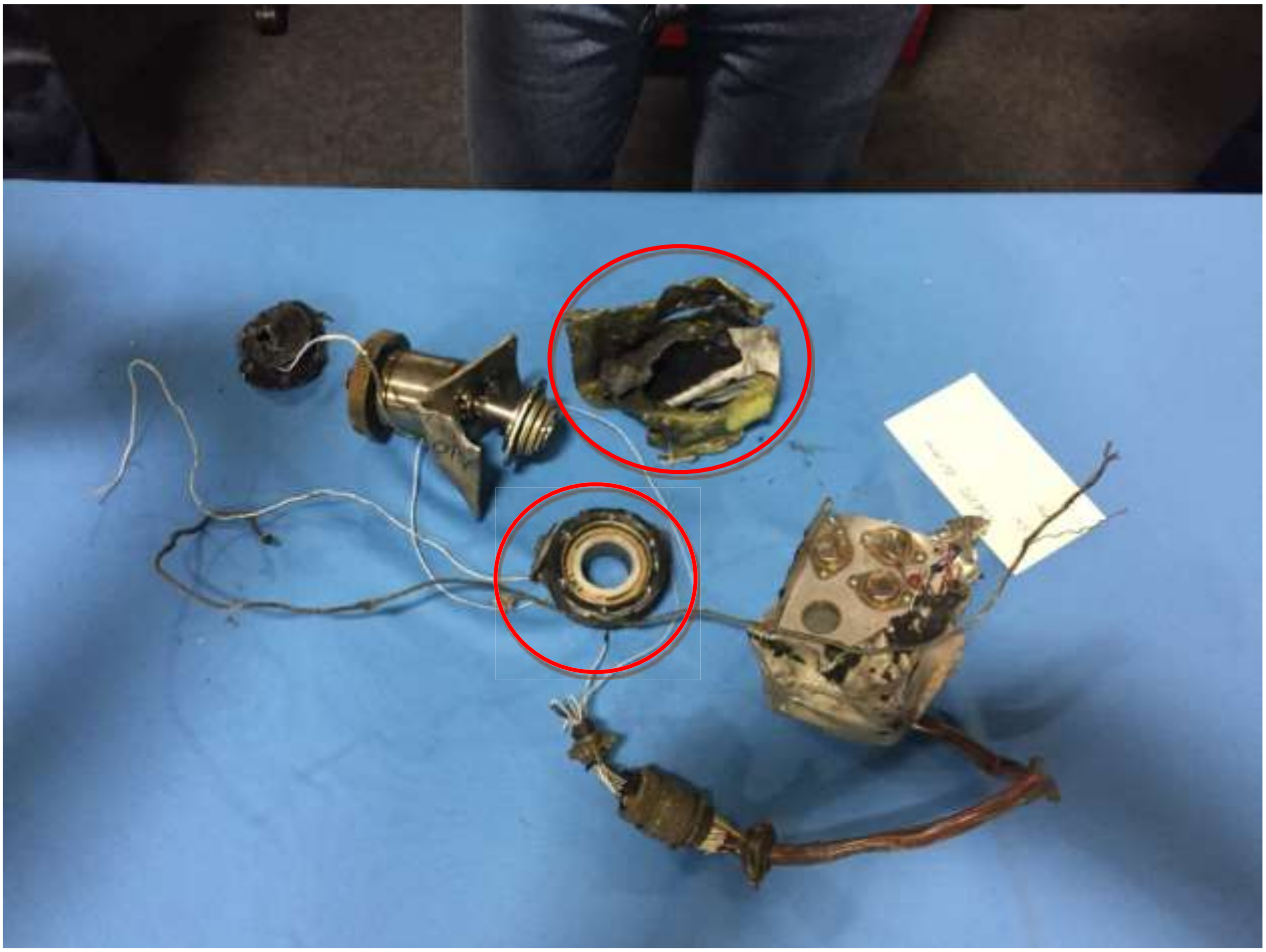
Summary:

Witness marks were observed on the edge of the Clutch gear teeth crowns. Due to the extensive damage testing of the complete servo was not possible. The clutch solenoid and drive motor were tested with no adverse operation observed.

KSM 375 Servo Mount (Roll)
Honeywell Serial Number: 7301
Honeywell Part Number: 065-0015-Unreadable
Unit Mod: 1, 2

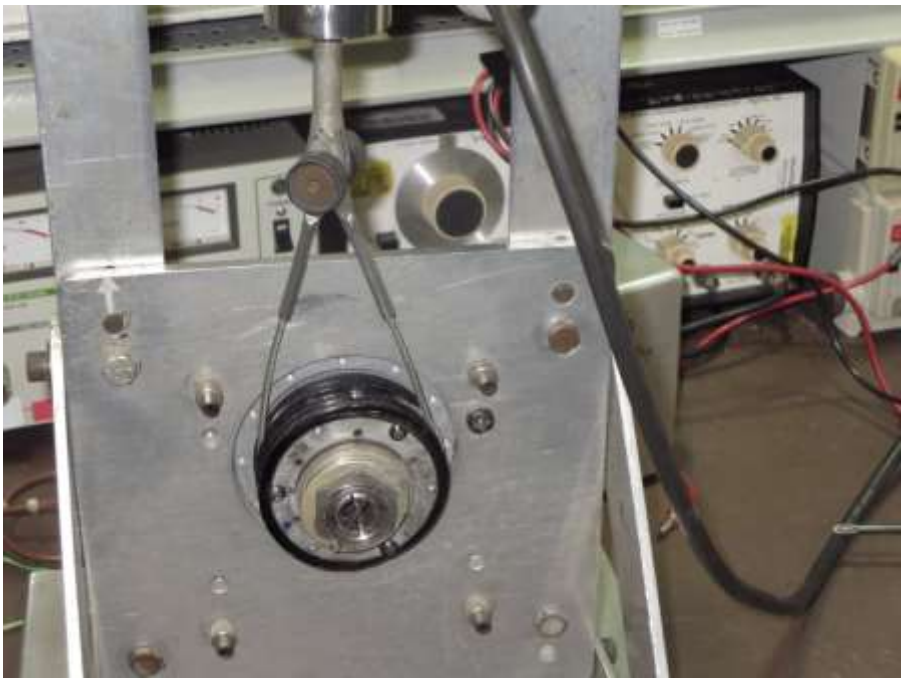
KSM 375 SN 7301 Data Plate

Servo Mount Inspection:
The only portions of the servo mount recovered were a portion containing the ID plate, a portion behind the capstan, and a portion attached to a piece of the airframe.


KSM 375 SN 7301 Red circle: Portions of the servo mount

The friction clutch was separated from the capstan. The top of the clutch in the area of the torque nut was found with impact damage. There was also evidence of damage to the clutch disk.

KSM 375 SN 7301 Impact damage to clutch



KSM 375 SN 7301 Clutch disk mounted on test stand

Clutch Torque Testing:

Under the supervision of the NTSB Investigator the clutch assembly was mounted to a Honeywell Clutch test stand and was tested with the following results:

KSM 375 Yaw Servo Mount SN 8227 Torque Settings		
Direction	Torque as Tested	Torque Specification
Clockwise	37 – 62 in lbs*	80 +/- 5 in lbs
Counter Clockwise	37 – 62 in lbs*	80 +/- 5 in lbs

*At initial run, the torque breakout was approximately 75 in lbs. As the clutch was operated in the CW and CCW directions, the torque decreased to a range of 37 to 62 in lbs. Further inspection revealed the carbon clutch disk was damaged / broken as a result of impact forces.

KSM 375 SN 7301 Collected portions clutch disk.

Summary

The KSM 375 Roll Servo Mount sustained extensive damage. Visual inspection showed damage to the clutch disk prior to testing. The clutch torque was in spec upon initial testing and decreased as the clutch was tested. Also observed were portions of the clutch disk accumulating at the base of the test stand

KTA 336 Trim Adaptor
Honeywell Serial Number: 1794
Honeywell Part Number: 065-00164-0100
Unit Mod: 1 - 4

KTA 336 SN 1794 Data Plate

KTA336 S/N 1120 Inspection and Testing:

Visual inspection of the KTA 336 Trim Adaptor revealed the following:

Crush damage to the case of the unit.

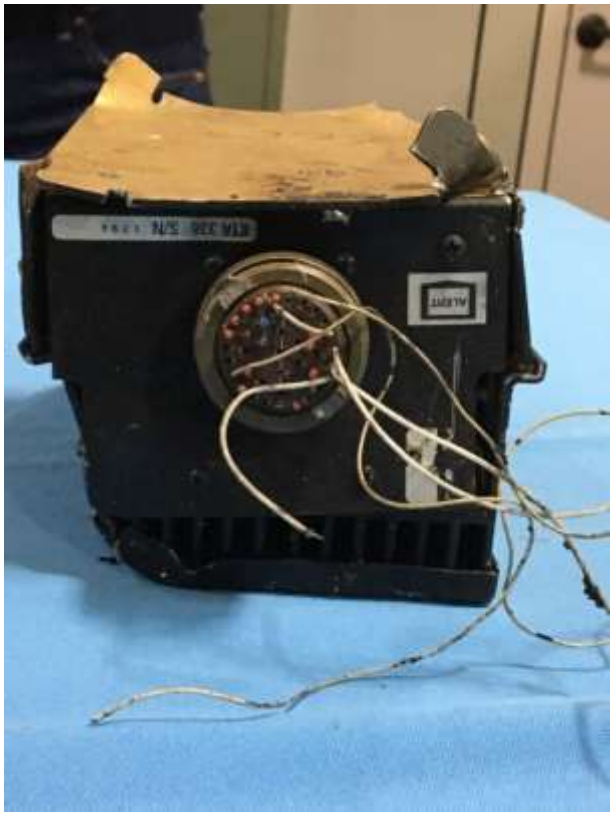
Damage to the unit base plate and connector plate.

Under the oversight of the NTSB Investigator the unit was opened and inspected for any physical damage.


KTA 336 SN 1794 Exterior view 1.


KTA 336 SN 1794 Exterior view 2.

KTA 336 SN 1794 Exterior view 3.



KTA 336 SN 1794 Exterior view 4.

The dust cover was removed from the unit and a visual inspection of the internal components was performed with the following observations:

Delamination of the rear connector board.
Delamination on a corner of the servo amp board
The audio transformer was found detached from the monitor board.
The connector on the servo amp board to the rear connector board was found damaged.
A power supply inductor on the connector board was found displaced.
A filter cap was found with a lead detached.
The rear connector was found displaced form the read connector board.
The servo amp board was found crushed in close proximity to the power transistors.

Under the direction of the NTSB Investigator, repairs were made to the extent possible to reestablish broken circuit connections. Bent pins on the Servo Amp board J101 ribbon cable were straightened to allow connection to the mating connector. When attempting to straighten the bent pins, Pin 1 (AT CMD UP) of the ribbon cable to J101 broke at the base of the pin. The Servo amp board was moved away from the power transistors on the heatsink assembly. Due to the broken ribbon cable pin, Servo Amp was deferred for the initial power on test.

Testing:

Power was applied to the KTA 336 Trim Adaptor. After approximately 30 seconds and audible "click" was heard and the unit drew high current. A transistor on the Logic board was found with the transistor case crushed into the transistor leads. The transistor leads were reformed to lift the case off the leads. The Servo Amp was connected to the Connector board and a retest was attempted. Upon the reapplication of power, the unit drew high current. The power transistors were measured with two showing shorted. The transistors were removed from their holder and tested individually for continuity with the transistors testing good. A short in the Servo amp board due to crush damage precluded any further testing.

KTA 336 SN 1794 Interior view 1.

KTA 336 SN 1794 Interior view 2.

KTA 336 SN 1794 Interior view 3.

KTA 336 SN 1794 Interior view 4.

Summary:
Due to the impact damage, testing was not accomplished on the KTA 336 Trim Adaptor.

KCP 220 Flight Computer
Honeywell Serial Number: 1898
Honeywell Part Number: 065-0064-XX
Unit Mods: 7, 8, 9, and 11 Less 1-6, and 10
Note: Not all installed mods could be determined due to Mod Label damage.

KCP 220 SN 1898 Data Plate

Visual Inspection:
The KCP 220 Flight Computer sustained crush damage with some twisting of the unit. Removal of the dust cover revealed a number of components were dislodged and tore from the circuit boards. Some circuit boards within the unit sustained fractures from the impact damage.

KCP 220 SN 1898 End view showing unit twisting.

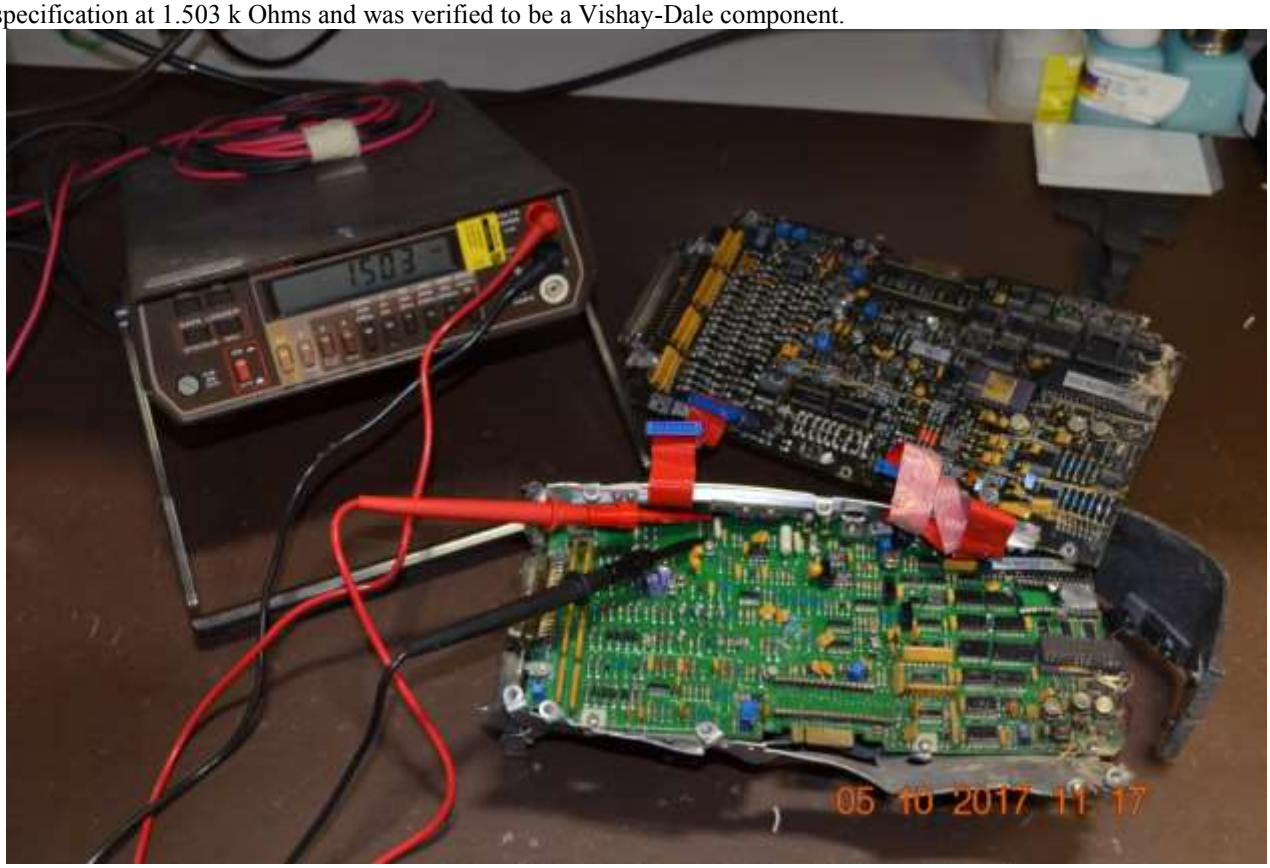
KCP 220 SN 1898 Exterior View 1

KCP 220 SN 1898 Exterior View 2

KCP 220 SN 1898 Interior view showing dislodged components and cracked circuit boards.

KCP 220 SN 1898 Interior view showing damage to the power supply circuitry.

R259 was visually and electrically verified to be the correct component per Unit Mod 11. R259 measured in specification at 1.503 k Ohms and was verified to be a Vishay-Dale component.



KCP 220 SN 1898 Interior view showing R 259 (attached to clip leads).

Summary:
The unit was impact damaged too extensively to allow for testing. The correct adaptor modules we verified to be installed in the unit either by visual inspection for electrical testing. Unit mod 11 (R 259) was verified installed in the unit by visual inspection and electrical testing.

Thank you for inviting Honeywell to assist with your investigation. Please advise should you have questions/comments.

Sincerely,

[redacted]