VALVE RESEARCH
& MANUFACTURING COMPANY

[redacted]
Deerfield Beach, FL 33442 USA
[redacted]

Investigation Report (FRACAS)

NTSB Investigation CEN14LA127

Rev NC

Customer:	Eaton Corp.	**R/O Number:**	Hand Carried
Part Number:	453847	**P/O Number:**	
VRM P/N:	40459-1B	**Serial Number:**	0319
Date Received:	4/9/14	**Debit:**	TBD

Written By: M. Shinkunas Date: 04/17/14

Approved: M. Cruz Date: 04/21/14

1.0 Reason for Investigation

National Transportation Safety Board (NTSB) investigation related to an accident involving a Piaggio P180 aircraft that had an un-commanded landing gear collapse during landing roll following an emergency landing gear extension. NTSB Investigation: CEN14LA127.

2.0 Investigation

On-scene investigation determined that there was a malfunction of the Directional Control Valve (DCV) 40459-1B (Eaton P/N 453847). Computerized tomography (CT-scanning) identified a single particle within the DCV preventing the spool from returning to the default (de-energized) position.

The DCV was hand carried to Valve Research by Todd Fox, Air Safety Investigator (NTSB). The disassembly and evaluation of the DCV at Valve Research was witnessed by Todd Fox, Antonio (Technical Support Engineer, Piaggio Aero) and Claudio Somaini (Engine Product Support, Piaggio Aero).

3.0 As-Received Inspection

The unit was received in good condition. There was no visual damage to the external surfaces of the DCV.

3.1 Investigation Procedure

The investigation procedure was to disassemble the DCV and evaluate the condition of the internal components and capture the particle lodged in the spool/body as well as any other contamination or FOD.

The solenoid assembly section (6033-1) was removed first. The breakaway torque on the four screws (5-40 X ½) that secure the solenoid was 6.5 to 8.5 in/lbs. The solenoid did not move away from the body section (3010-13) as the

screws were loosened. This indicates that the spool was jammed in the body by the particle identified in the CT scan, which prevented the spring force to be transmitted to the solenoid assembly. All components in the solenoid assembly appeared normal and in good condition.

The endplate (4552) was removed from the body. The breakaway torque on the four screws (5-40 X 3/8) that secure the solenoid was 6.5 to 8.5 in/lbs. As the screws were loosened the endplate backed-off the body due to the force exerted by the spring (LC-026B-08SS).
The O-ring (MS28775-017) had some fraying on the parting line.

After removing the solenoid assembly and endplate from the body assembly it was confirmed that the spool was jammed in the body. The spool had to be forced (hand pressure) out of the body. There was a slight witness mark on the edge of the spool that was in contact with the particle. The body was flushed with a filtered solvent to extract and capture the particle. The particle was put on a Millipore filter patch and placed in an analyslide petri dish for future analysis.

3.2 Investigation Findings

It was determined that the particle lodged between the spool and body prevented the DCV from functioning properly and was attributable to the failure. The particle was taken to a subcontract service (QC Metallurgical, Inc.) for analysis.
Images taken by QC Metallurgical suggest the particle measured 3.3 mm long, 1 mm wide, and 0.5 mm thick. The particle was not mounted or metallurgic ally prepared so the measurements are approximations. SEM analysis indicated the chip is consistent with a 9000 series steel. Ref. Addendum A

The particle was taken by Todd Fox (NTSB) for additional analysis. Images taken by the NTSB suggest the particle measured approximately 2.9 mm long, 0.98

mm wide and an unknown depth. NTSB analysis of the composition of the particle indicates it is consistent with 93xx or 33xx steel. EDS testing determined that the composition was approximately 94% Fe, 3% Ni, 2% Cr, and d0.5% Mn. Other trace elements identified (Al, Mg, Si) are likely related to the particle being in close contact with aluminum component within the DCV. Ref. Addendum B

3.3 Root Cause

Contamination introduced into the DCV during operation in the aircraft system.

4.0 Corrective Action

Not Valve Research responsibility. The material identified that the particle is composed of (93xx or 33xx) is not a material used in the DCV. Additionally, this material is not procured by Valve Research or used in any other product produced by Valve Research. Corrective action to be determined by Eaton and/or Piaggio Aero.

4.1 Corrective Action Implementation Plan

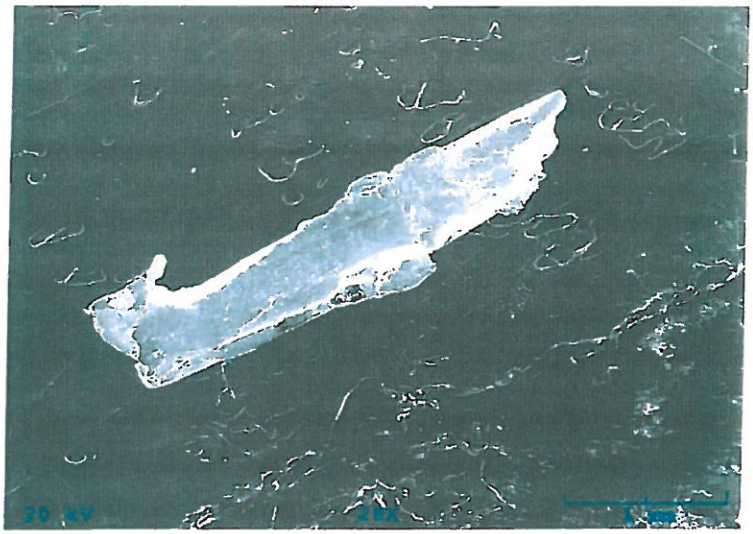
None at this time.

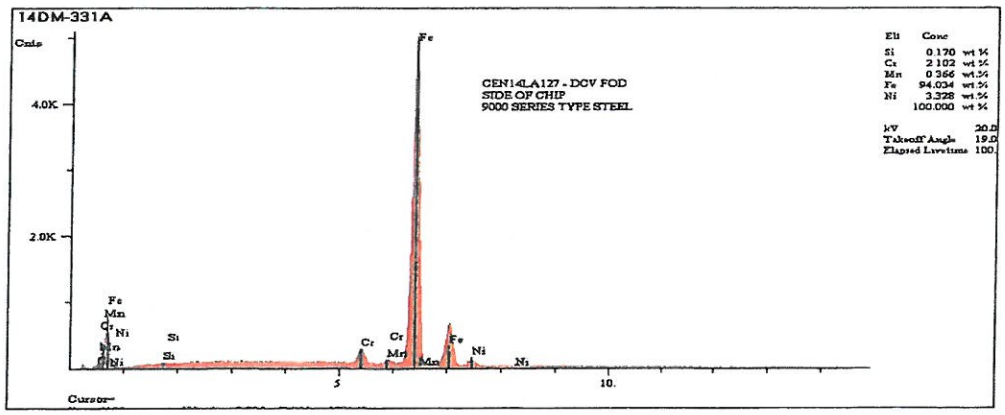
5.0 Additional Observations

None

ADDENDUM A

QC Metallurgical, Inc.
Testing & Consulting Services





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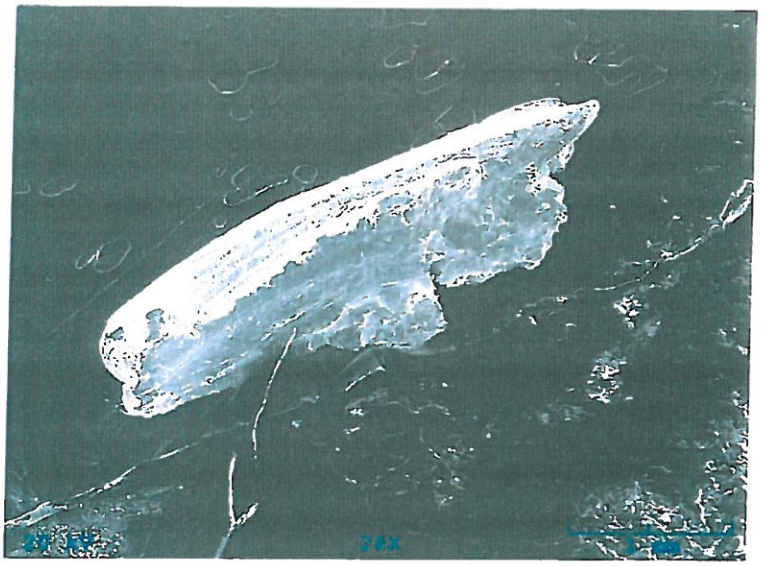
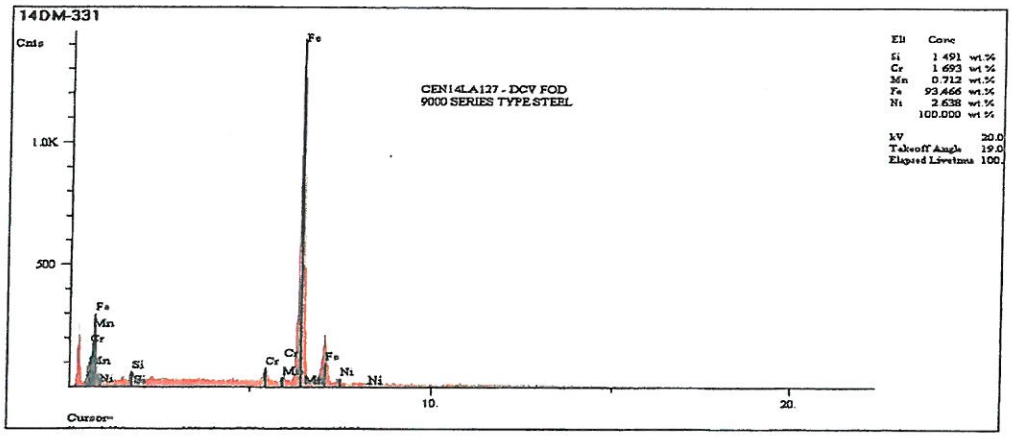
QC Metallurgical, Inc.

Testing & Consulting Services





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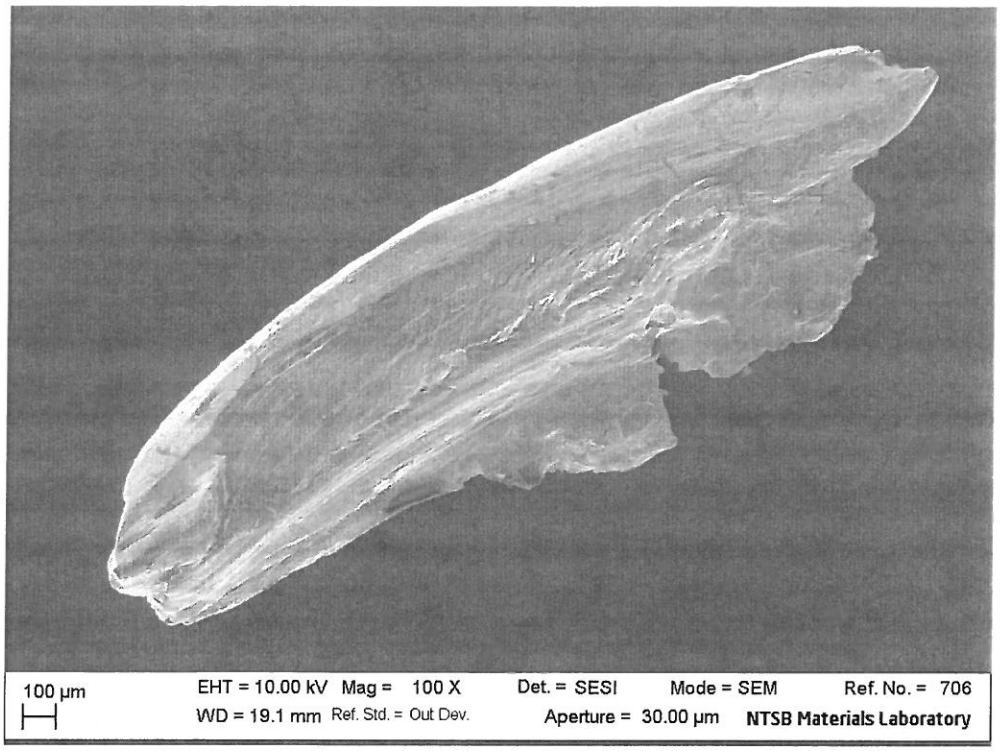
ADDENDUM B


100 µm
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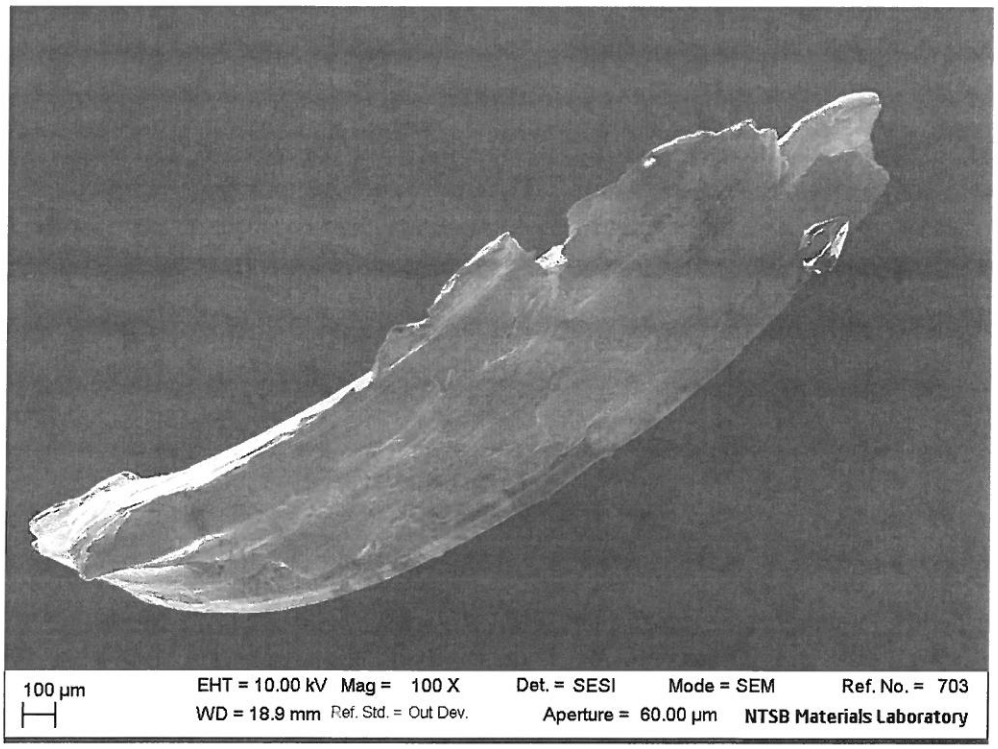
WD = 19.1 mm Ref. Std. = Out Dev. Aperture = 30.00 µm NTSB Materials Laboratory


100 µm
EHT = 10.00 kV Mag = 100 X Det. = SESI Mode = SEM Ref. No. = 703
WD = 18.9 mm Ref. Std. = Out Dev. Aperture = 60.00 µm NTSB Materials Laboratory

DIRECTIONAL CONTROL VALVE (Metallic Chip)