

2. FINDINGS OF TURBOCHARGER MODEL TE0659, PART NUMBER 406610-9025, SERIAL NUMBER BK0170 – LEFT SIDE

NOTE

All observations reported herein are based on visual examinations with the unaided eye, unless otherwise noted.

Figure 1 is an illustrated parts breakdown for the TE0659 series of turbochargers.

2.1 General

- (a) The turbocharger had been removed from the engine prior to the examination (Figure 2).
- (b) The turbocharger rotating assembly was not free to rotate. White debris was observed on the compressor blades (Figure 3). No apparent damage was observed on the turbine (Figure 4) blades. Both the compressor and turbine appeared to have non-uniform circumferential clearances between the wheels and their respective adjacent static structures.
- (c) Rotational scoring was noted on the turbine housing adjacent to the turbine wheel shroud line edge, near the exducer (Figure 5).
- (d) The nameplate identified Garrett / AlliedSignal as the original manufacturer and that the unit had been overhauled by the Consolidated Fuel Systems, FAA approved repair station. Additionally, the nameplate included Customer part number (Cust P/N) '632729-11', AlliedSignal part number (PN) '406610-9025', and serial number (Serial No.) 'BK0170' (Figure 6).

2.2 Compressor Section

- (a) The compressor housing (Figure 7) was fire damaged with the outlet flange and relief valve port being consumed by fire. The inlet flange was partially melted and a clamp was still attached. Ash and corrosion was observed on external surfaces of the compressor housing.
- (b) The compressor wheel appeared to be off-centered when viewed from the air inlet port (Figure 8). Also, debris was observed within the air inlet opening (compressor impeller shroud).
- (c) Following disassembly, ash and debris were observed within the compressor housing (Figure 9).
- (d) To facilitate examination, a hammer with a punch and prybars were utilized to separate the compressor housing from the backplate assembly. During separation, three compressor blades (inducers) were deformed (Figure 10).
- (e) Scuff marks caused during disassembly from the impeller blades were observed on the compressor housing (Figure 11).

- (f) The compressor backplate was mostly intact (Figure 12). Ash and soot was observed on the backplate.
- (g) The compressor wheel and backplate were removed from the center housing together with a hydraulic press. The backplate exhibited thermal damage and distortion (Figure 13).
- (h) Ash / soot was observed on the compressor wheel front face (Figure 14).
- (i) Light radial streaking was observed on the rear face of the compressor wheel (Figure 15).
- (j) The clamp attaching the compressor housing to the compressor backplate was intact (Figure 16).

2.3 Center Section

- (a) Prybars were utilized to separate the turbine housing from the center section after the bolts were removed.
- (b) The inlet oil tube was removed from the center section to facilitate examination. The gasket was present, but tore during separation of the tube from the Center Section. Rust was observed within the oil inlet (Figure 17).
- (c) The oil drain tube was removed from the center section to facilitate examination. The gasket was present, but tore on separation of the tube from the Center Section (Figure 18). At that time, it was also noted that the safety wire was incorrectly installed on one of the turbine housing bolts (Figure 18).
- (d) The center housing was primarily intact (Figure 19 and Figure 20). There was rust and ash on the external surfaces of the center section. Large flakes of black debris, consistent with coked oil, were observed in the oil wetted area (Figure 21).
- (e) The oil seal between the center housing and compressor backplate was consumed by the post-crash fire (Figure 22).
- (f) The compressor backplate was thermally damaged and deformed (Figure 23). The outboard thrust bearing (Figure 24) within the compressor backplate was corroded.
- (g) The thrust spacer, thrust collar, and inboard thrust bearing were intact but corroded and dry (Figure 25). The piston rings on the thrust spacer were intact. A puller tool (Figure 26) was used to remove the thrust spacer and thrust collar (Figure 27) from the turbine wheel shaft.
- (h) The inboard thrust bearing and locating (anti-rotation) pins (Figure 28) appeared to be intact. The thrust bearing was corroded.

- (i) A borescope was utilized to look at the center section oil wetted area. A loose, flakey debris consistent with coked oil was observed within the passages (Figure 29). Some of the debris was collected and submitted for material analysis.
- (j) Due to the inability to remove the turbine shaft from the center housing, the center housing was cut in half in an effort to minimize the disassembly damage to the bearings and shaft (Figure 30 - Figure 34). Debris was noted between the center housing and wheel shroud; the debris was more prominent on the bottom (scavenge side) of the turbocharger. The debris appeared to be consistent with coked oil and corrosion deposits from the center housing.

The debris was collected and submitted for material analysis.

- (k) Once the center housing was cut, the turbine wheel assembly and bearings were removed. A buildup of hardened debris (Figure 35 and Figure 36) was noted within the oil gallery in an area 90 degrees from its normally installed orientation; suggesting it may have occurred after the accident.
- (l) Slight damage to the bearings occurred during the cutting process and removal from the center housing.
- (m) The lubrication holes in both bearings, adjacent to the oil supply in the ‘as received’ rotational orientation (Figure 37), were full of a blackish-brown debris. The other holes were clear. No evidence of rotational scoring or heat damage were present on the OD of the bearings.
- (n) The compressor and turbine journal bearings were intact and marked to orientate their positions on the shaft (Figure 38). Neither were free to be removed from the shaft. Both compressor and turbine journal bearings were marked as Part Number 4922-0 (Figure 39).
- (o) While installed on the shaft, the outside diameter (OD) of the journal bearings were measured with calibrated calipers and found to be near or within the service limits (reference Table I and Appendix I).

Table I. Journal Bearing Diameters.

Parameter	Compressor	Turbine
Measured Bearing OD (inches)	0.9770	0.9780
Minimum OD Service Limit (inches)	0.9780	0.9780
Measured Bearing ID (inches)	N/A – bearings cut	N/A – bearings cut
Maximum ID Service Limit (inches)	0.6272	0.6272
Bearing Part Number	4922-0*	4922-0*

* “-0” indicates that the turbine shaft is standard size

- (p) To facilitate removal of the bearings by cutting, the turbine was cut from the shaft (Figure 40). Once exposed, the inside diameters of the turbine and compressor bearings (Figure 41) did not exhibit evidence of rotational scoring or heat damage.

2.4 Turbine Section

- (a) The turbine housing was intact. There was oxidation and corrosion on external surfaces of the turbine housing (Figure 42). Rotational score marks were noted on the turbine housing shroud surface (Figure 43) with corresponding rotational score marks to the turbine wheel (Figure 44).
- (b) The turbine wheel shroud was cut to facilitate removal of the turbine wheel assembly. There was oxidation on all surfaces of the turbine wheel shroud. There was debris on internal surfaces of the wheel shroud (Figure 33).
- (c) There were rotational score marks on the surface of the wheel shroud adjacent to the back face of the turbine wheel (Figure 45), with corresponding rotational score marks on the back face of the turbine wheel (Figure 46).
- (d) The turbine wheel and the turbine shaft were intact prior to cutting.
- (e) The bearing journal surfaces of the turbine shaft were intact (Figure 47). The OD of the bearing journals were measured with calibrated calipers and found to meet service limits (reference Table II and Appendix I). The turbine shaft threads and locknut were undamaged.
- (f) The piston ring, located at the base of the turbine shaft, was intact (Figure 48). A black residue and corrosion deposits were noted at the base of the turbine wheel.

Table II. Turbine Shaft Bearing Journal OD.

Parameter	Compressor	Turbine
Bearing Journal OD (inches)	0.6255	0.6255
OD Service Limit (inches)	0.6251 minimum	0.6251 minimum

2.5 Controls

2.5.1 Wastegate, Part Number 470780-9016, Serial Number NHR0114, Customer Number 5050154-16

- (a) According to TP25-0111-3, Aircraft Turbocharger and Control Reference with Troubleshooting Guide, Revised 4/1/93 the appropriate wastegate for the Left Position on a 1980 and newer Cessna 335 aircraft is AID Part Number 470780-15 / Customer PN 5050154-15.
- (b) The exhaust bypass valve (wastegate) assembly was intact, and coated with coked oil, ash, and soot (Figure 49 and Figure 50).

- (c) Upon removal of the crushed wastegate exhaust port, a piece of fibrous gray debris (appeared to be insulation) was observed falling from the wastegate exhaust port (Figure 51).
- (d) The wastegate butterfly valve was found in the open position (Figure 52).
- (e) The wastegate assembly nameplate (Figure 53) indicated that the unit was factory overhauled in August 1984 (based on pre-fix of the Serial Number).
- (f) The oil drain line was removed from the wastegate assembly. Upon removal of the tube, a gray gelatinous substance was observed in the drain tube fitting (Figure 54). Some residual oil was noted within the drain tube.
- (g) The wastegate assembly was connected to the Test Set Part Number 481070-1 to facilitate functional testing (Figure 55).
- (h) The wastegate assembly was found to be functional when tested using Test Set Part Number 481070-1, Serial Number OKOI06, in accordance with the test requirements specified in Document No. TP15-0104-01 (Appendix II). Test results are described in the following paragraphs:
 - (1) The 'Actuator Functional Test' checks specified in TP15-0104-01 were completed. The pressures recorded are shown in the 'Test Point 1' through 'Test Point 4' rows of Table III.

All measurements of Test Point 1 – 4 were within specification.

Table III. Wastegate Functional Test Results.

TP15-0104-01 Check	Requirement	Value Recorded
Dimension 'A' (fully closed)	0.010 to 0.025 inch	Not measured
Dimension 'B' (fully open)	0.975 to 1.100 inch	Not measured
P2 Pressure, Restriction Test	24 to 36 psig	Not Tested
P2 Pressure, Test Point 1	19 psig maximum	17 psig
P2 Pressure, Test Point 2	52 psig maximum	48 psig
P2 Pressure, Test Point 3	33 psig minimum	38 psig
P2 Pressure, Test Point 4	3 psig minimum	11 psig

2.5.2 Absolute/Pressure Ratio Controller, Part Number 470782-3 (Assumed), Serial Number Unknown

- (a) The absolute/pressure ratio controller assembly (controller) was partially consumed by fire and could not be tested (Figure 56 and Figure 57).
- (b) The nameplate was not returned with the controller.

2.5.3 The Pressure Relief Valve, Part Number 470930-1 (Assumed)

- (a) The pressure relief valve was not returned with the turbocharger.

3. FINDINGS OF TURBOCHARGER MODEL TE0659, PART NUMBER 406610-9025, SERIAL NUMBER XKO14123 – RIGHT SIDE

NOTE

All observations reported herein are based on visual examinations with the unaided eye, unless otherwise noted.

Figure 1 is an illustrated parts breakdown for the TE0659 series of turbochargers.

3.1 General

- (a) The turbocharger had been removed from the engine prior to the examination (Figure 58 and Figure 59).
- (b) The turbocharger was connected to various exhaust ducting.
- (c) The turbocharger rotating assembly was not free to rotate.
- (d) The pressure relief valve remained attached to the compressor housing but was covered in what appeared to be soot and dirt.
- (e) All the turbine wheel blades were bent opposite the direction of rotation at the exducer (Figure 60). Two blades were fractured with portions separated and missing. The turbine wheel appeared to be off-center within the turbine housing.
- (f) The compressor housing assembly was dented.
- (g) The nameplate on the turbocharger included Customer part number (Cust P/N) '632729-11', Garrett part number (PN) '406610-9025', and serial number (Serial No.) 'XKO14123'.
- (h) The nameplate (Figure 61) indicated that the unit was factory overhauled in November 1994 (based on pre-fix of the Serial Number).

3.2 Compressor Section

- (a) The compressor housing was intact (Figure 62). There was soot on the external surfaces of the compressor housing.
- (b) Rotational scoring was noted at the inducer of the compressor housing (Figure 63) with corresponding scoring damage noted to the compressor wheel.
- (c) Removal of the pressure relief valve from the compressor housing disclosed a buildup of material on the valve poppet that matched the diameter of the compressor housing attachment bore (Figure 64). A rock was noted to be present within the apparently extruded poppet material (Figure 65).

- (d) The compressor wheel was intact (Figure 66) but exhibited rotational scoring at the inducer (Figure 67) with corresponding scoring to the compressor housing. The compressor wheel was covered with black debris.
- (e) The compressor backplate was intact (Figure 68). There was soot and dirt on the compressor backplate. There was residual oil in the bearing bore of the compressor backplate (Figure 69).
- (f) The clamp attaching the compressor housing to the compressor backplate was intact.

3.3 Center Section

- (a) The center housing was intact (Figure 70 and Figure 71). There was a buildup of black debris noted in the area between the center housing and the wheel shroud. The debris appeared to be a mixture of coked oil as well as center housing corrosion deposits.

The black debris was collected and submitted for material analysis.

- (b) There was residual oil on the bearing bores and internal surfaces of the center section. The center housing oil passages were undamaged and unobstructed
- (c) The oil seal between the center housing and compressor backplate was intact but remained attached to the compressor backplate (Figure 68).
- (d) The thrust spacer (Figure 72), thrust collar and inboard thrust bearing (Figure 73) were intact and appeared to be undamaged. The locating (anti-rotation) pins for the thrust bearing were intact and engaged with the inboard thrust bearing.
- (e) The compressor bearing slid out of its bore easily. QDC contact cleaner and M1 lubricant were used to remove debris to facilitate removal of the turbine bearing from the center housing. The compressor (Figure 74) and turbine (Figure 75) journal bearings were intact.
- (f) Both compressor and turbine journal bearings were marked as Part Number 4922-0. The lubrication holes on both journal bearings were undamaged and unobstructed. The OD and ID of the journal bearings were measured with calibrated calipers and found to be within service limits (reference Table IV and Appendix I).

Table IV. Journal Bearing Diameters.

Parameter	Compressor	Turbine
Measured Bearing OD (inches)	0.9785	0.9795
Minimum OD Service Limit (inches)	0.9780	0.9780
Measured Bearing ID (inches)	0.6260	0.6260
Maximum ID Service Limit (inches)	0.6272	0.6272
Bearing Part Number	4922-0*	4922-0*

* “-0” indicates that the turbine shaft is standard size

3.4 Turbine Section

- (a) The turbine housing was intact. There was oxidation and corrosion on external surfaces of the turbine housing (Figure 76). During disassembly, 5 of the 6 turbine housing attachment bolts fractured near the bolt head. The sixth bolt had to be cut to facilitate removal of the turbine housing.
- (b) Rotational score marks were noted on the turbine housing shroud surface (Figure 77) with corresponding rotational score marks to the turbine wheel (Figure 78).
- (c) There was debris on internal surfaces of the turbine wheel shroud (Figure 70). There were rotational score marks on the surface of the wheel shroud adjacent to the back face of the turbine wheel (Figure 79), with corresponding rotational score marks on the back face of the turbine wheel (Figure 80).
- (d) The turbine wheel blades were bent opposite the direction of rotation with two blades missing material.
- (e) The bearing journal surfaces of the turbine shaft were intact (Figure 81). The OD of the bearing journals was measured with calibrated calipers and found to be slightly below service limits (reference Table V and Appendix I). The turbine shaft threads and locknut were undamaged.
- (f) The piston ring, located at the base of the turbine shaft, was intact. Black residue was noted at the base of the turbine wheel.

Table V. Turbine Shaft Bearing Journal OD.

Parameter	Compressor	Turbine
Bearing Journal OD (inches)	0.6250	0.6250
OD Service Limit (inches)	0.6251 minimum	0.6251 minimum

3.5 Controls

3.5.1 Wastegate, Part Number 470780-9015, Serial Number XK035880, Customer Number 50501154-15

- (a) According to TP25-0111-3, Aircraft Turbocharger and Control Reference with Troubleshooting Guide, Revised 4/1/93 the appropriate wastegate for the Right Position on a 1980 and newer Cessna 335 aircraft is AID Part Number 470780-16 / Customer PN 5050154-16.
- (b) The exhaust bypass valve (wastegate) assembly was covered with corrosion, ash and soot (Figure 82 and Figure 83). The wastegate appeared discolored due to thermal exposure.
- (c) Upon removal of the wastegate actuator supply and return oil lines, black debris (appeared to be coked oil) was noted within the lines and fittings.

- (d) The wastegate butterfly valve was found in the open position.
- (e) The wastegate assembly nameplate (Figure 84) indicated that the unit was factory overhauled in November 1994 (based on pre-fix of the Serial Number).
- (f) An attempt was made to functionally test the wastegate but it would not actuate.

3.5.2 The Pressure Relief Valve, Part Number 470930-9004, Serial Number OBR-0114, Customer Number C482002-0103

- (a) The pressure relief valve nameplate (Figure 85) indicated that the unit was factory overhauled in February 1985 (based on pre-fix of the Serial Number).
- (b) The pressure relief valve was covered in, what appeared to be soot and dirt (Figure 86). The valve and poppet appeared to be heat damaged.
- (c) An attempt was made to functionally test the valve however, it would not open.
- (d) An attempt was made to manually actuate the valve. When pressure was initially applied to the poppet, it made a sound similar to becoming unstuck. A repeated attempt to functionally test the valve disclosed that it still would not actuate.

3.5.3 Absolute/Pressure Ratio Controller, Part Number 470948-1, Serial Number EL0108, Customer Number C165002-0102

- (a) The nameplate (Figure 87) indicated that the unit was manufactured December of 1975 (based on pre-fix of the Serial Number).
- (b) The absolute/pressure ratio controller assembly (controller) was covered with oil, soot and dirt but appeared to be intact (Figure 88).
- (c) Residual oil was noted in the port with the broken fitting (Figure 89) which was removed to facilitate testing of the unit.
- (d) The unit was functionally tested (Figure 90) using Test Set Part Number 481070-1, Serial Number OKO106, in accordance with the test requirements specified in Document No. TP15-0104-01 (Appendix III). Test results are described in the following paragraphs:
 - (1) The 'Case Leakage Test' and 'Test Setup' procedures specified in TP15-0104-01 were completed. No anomalies were observed.
 - (2) The 'Friction Test' procedure specified for the absolute controller section in TP15-0104-01 was completed. The pressure differential recorded is shown in the 'Friction Test (Absolute Section)' row of Table VI.
 - (3) The 'Calibration' procedure specified for the absolute controller section in TP15-0104-01 was completed. The pressure recorded is shown in the 'Calibration (Absolute Section)' row of Table VI.

- (4) Test Setup Changes' procedures specified in TP15-0104-01 were completed. No anomalies were observed.
- (5) The 'Friction Test' procedure specified for the pressure ratio controller section in TP15-0104-01 was completed. The pressure differential recorded is shown in the 'Friction Test (Pressure Ratio Section)' row of [Table VI](#).
- (6) The 'Calibration' procedure specified for the pressure ratio controller section in TP15-0104-01 was completed. The pressures recorded are shown in the 'Calibration (Pressure Ratio Section)' rows of [Table VI](#)
- (7) The 'Both Sections, Seat Leakage Test' procedure specified in TP15-0104-01 was completed. The pressure recorded is shown in the 'Seat Leakage Test (Both Sections)' row of [Table VI](#)

Table VI. Controller Functional Test Results.

TP15-0104-01 Check	Requirement	Value Recorded
Friction Test (Absolute Section)	0.5 inHg maximum	0.12 inHg
Calibration (Absolute Section)	9.0 to 19.0 psig	10.0 psig
Friction Test (Pressure Ratio Section)	0.5 inHg maximum	0.25 inHg
Calibration (Pressure Ratio Section) steps 1-3	32.0 to 52.0 psig	51 psig
Calibration (Pressure Ratio Section) steps 4-7	50 psig minimum	62 psig
Seat Leakage Test (Both Sections)	50 psig minimum	54 psig

4. ANALYSIS AND CONCLUSIONS

4.1 Material Analysis ([Appendix IV](#))

- (a) As denoted within the factual sections of this report, three different material samples were collected from areas of the turbochargers and submitted for material analysis with the following findings:
 1. LH center housing debris, Section 2.3(i):

“Energy dispersive X-ray (EDX) spectra produced from the analysis of the debris collected from the oil gallery of the center housing on the LH turbocharger showed high carbon, lead, and bromine concentrations. It is reported that AVGAS 100LL fuel can contain lead and bromine.”
 2. Debris from LH Behind Turbine Heat Shield, Section 2.3(j)

“EDX analysis spectra produced from the LH turbocharger debris located behind turbine heat shield (wheel shroud) exhibited high concentrations of

oxygen, carbon, and iron with lead and silicon and traces of bromine, manganese, and nickel. The iron-rich material containing manganese and nickel was characteristic of a low alloy steel. The alloy could not be definitively determined.”

3. RH Debris Between Heat Shield and Center Housing, Section 3.3(a)

“EDX analysis produced from the RH turbocharger debris between the heat shield (wheel shroud) and center housing exhibited spectra similar to that of the LH turbocharger debris from the same location, but it contained higher nickel concentrations.”

No spectra were produced from Fourier Transform Infrared (FTIR) analyses of the three debris samples to identify an organic material. The organic bonds measured by FTIR analysis techniques may have been broken due to combustion/charring.

- (b) According to ASTM specification D910 – 17a¹, a lead and bromine mixture is a mandatory antiknock additive for aviation gasolines. These constituent elements will eventually coalesce with the engine oil, either from combustion byproducts within the engine cylinders or due to incomplete combustion of the aviation gasoline.

All three debris samples consistently contained carbon, lead and bromine which is believed to be remnants of the engines’ oil that had been coked/charred either during normal operation or in the post-crash fire. To illustrate, the debris collected from interior of the LH turbocharger center housing (Section 2.3(i)) had been located within the known oil wetted/lubricated section of the turbocharger. The other 2 samples were collected from non-oil wetted areas but also contained carbon, lead and bromine. In these areas, the leakage of oil past the piston ring and the center housing sealing area could allow for oil accumulation between the center housing and the wheel shroud.

4.2 Analysis

Some of the measured items within the turbochargers were slightly outside the service limit criteria. However, these exceedances did not appear to have affected the operation of either the left or right turbocharger.

Based on the as received position markings, the left and right wastegate assemblies were installed in the opposite (reversed) positions. Honeywell did not perform any assessment to determine the operational impact, if any.

- (a) The left turbocharger was rotating at the time of impact, as evidenced by rotational scoring to the turbine components.
- (b) The left wastegate assembly was found to be functional when tested.

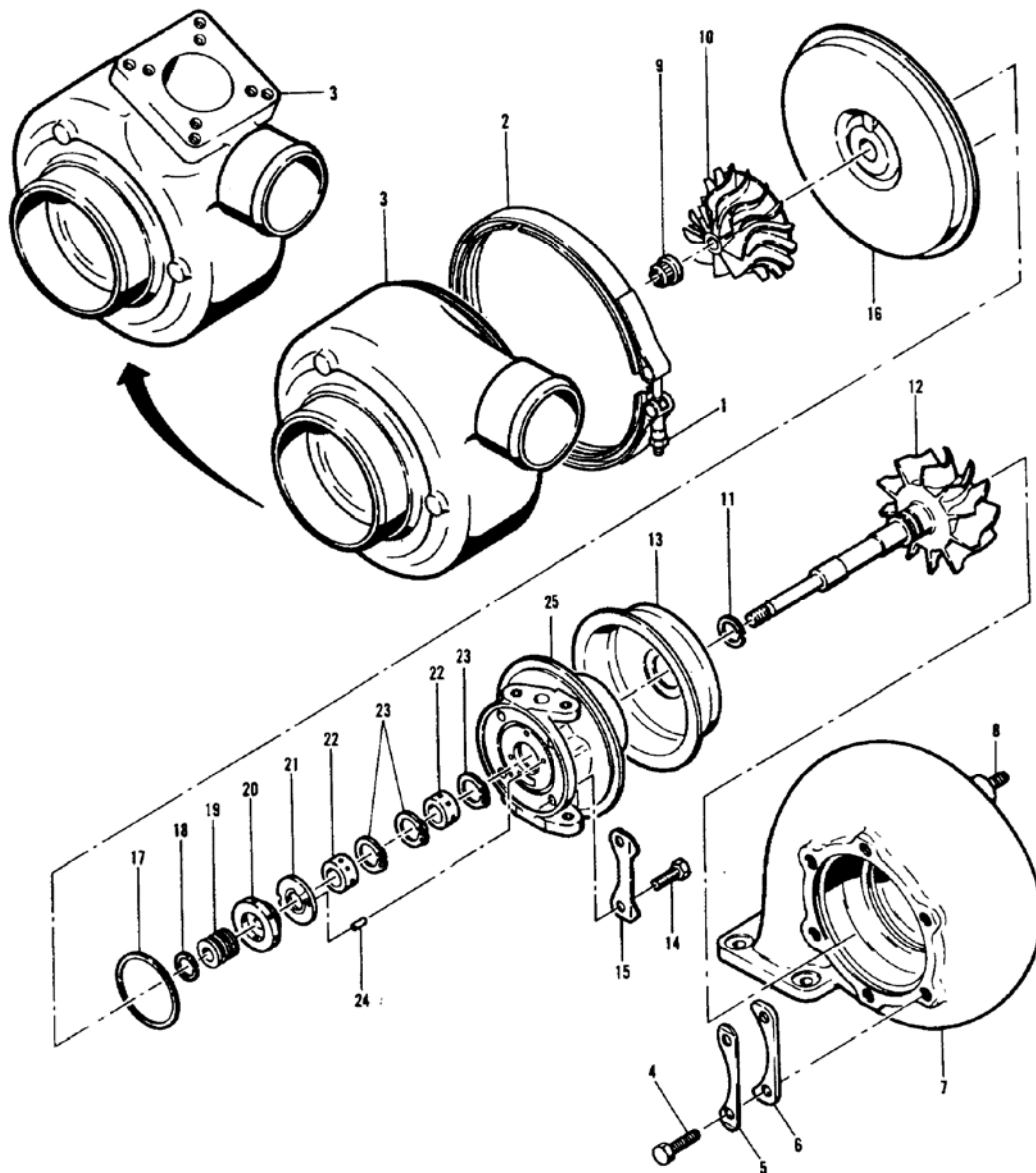
¹ ASTM International (2017). Designation: D910 – 17a, Standard Specification for Leaded Aviation Gasolines. Retrieved August 22, 2019 from <https://compass.astm.org/download/D910.35709.pdf>

- (c) The right turbocharger was rotating at the time of impact, as evidenced by rotational scoring to the turbine and compressor components.
- (d) The right wastegate assembly was thermally damaged and could not be tested.
- (e) The right pressure relief valve was thermally damaged and could not be tested.
- (f) The right absolute/rate controller assembly (controller) was found to be functional when tested.

4.3 Conclusions

The teardown and inspection of the turbochargers and associated controls disclosed that:

- (a) The left turbocharger was rotating at impact. No pre-accident conditions were identified which would have interfered with normal operation of the left turbocharger or the associated controls.
- (b) The right turbocharger was rotating at impact. No pre-accident conditions were identified which would have interfered with normal operation of the right turbocharger or the associated controls.



- | | | |
|-----------------------|-------------------------|----------------------------|
| 1. LOCKNUT | 10. COMPRESSOR WHEEL | 19. THRUST SPACER |
| 2. V-BAND COUPLING | 11. PISTON RING | 20. THRUST COLLAR |
| 3. COMPRESSOR HOUSING | 12. TURBINE WHEEL ASSY. | 21. INBOARD THRUST BEARING |
| 4. BOLT | 13. WHEEL SHROUD | 22. BEARING |
| 5. LOCKPLATE | 14. BOLT | 23. RETAINING RING |
| 6. CLAMP | 15. LOCKPLATE | 24. PIN |
| 7. TURBINE HOUSING | 16. BACKPLATE ASSEMBLY | 25. CENTER HOUSING |
| 8. STUD | 17. SEAL RING | |
| 9. LOCKNUT | 18. PISTON RING | |

Figure 1. Illustrated Parts Breakdown for Model TE0659 Turbochargers.



Figure 2. Turbocharger, as Received.



Figure 3. Turbocharger Compressor Inlet.



Figure 58. Right Turbocharger System.



Figure 59. Right Turbocharger System.

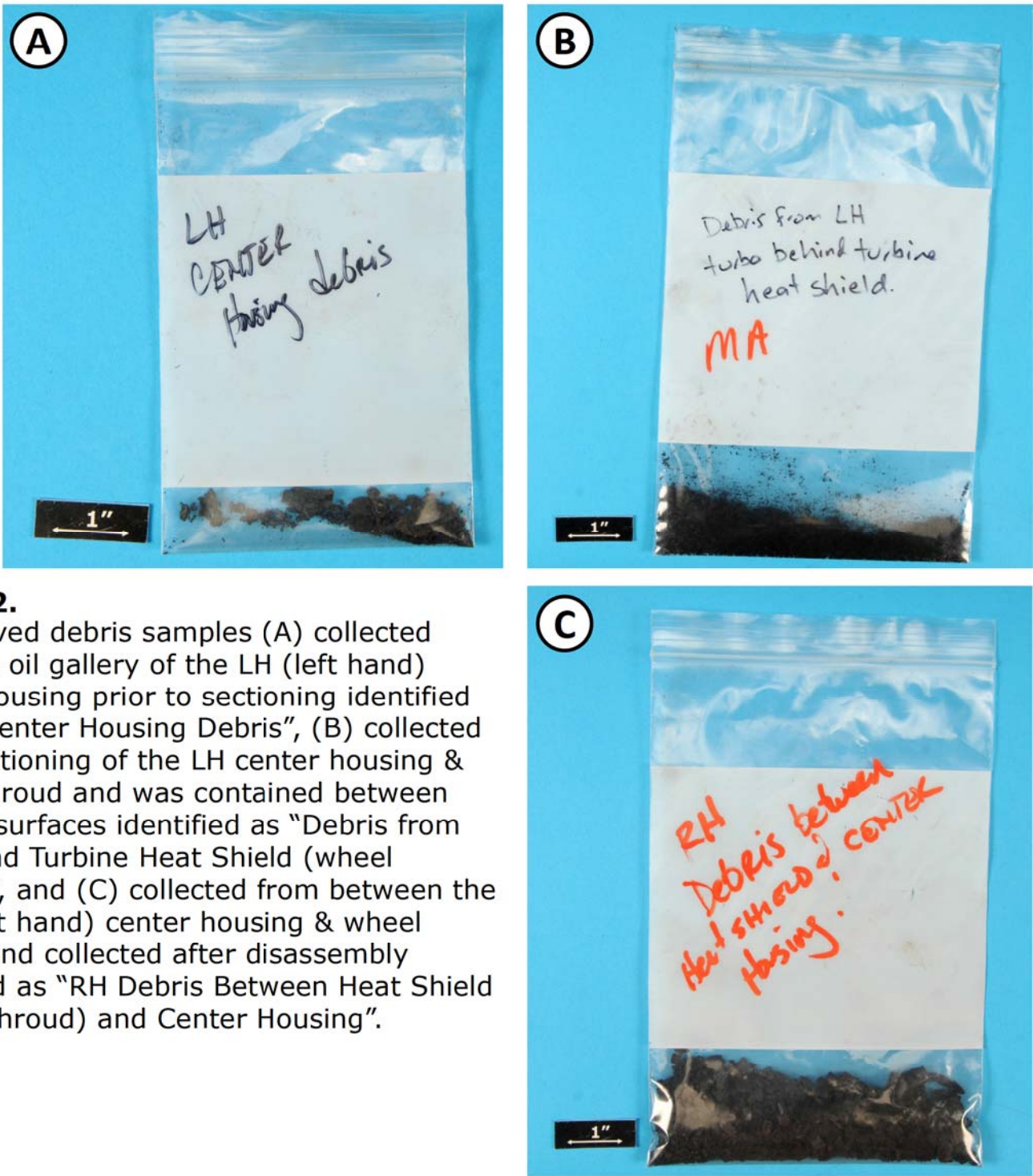
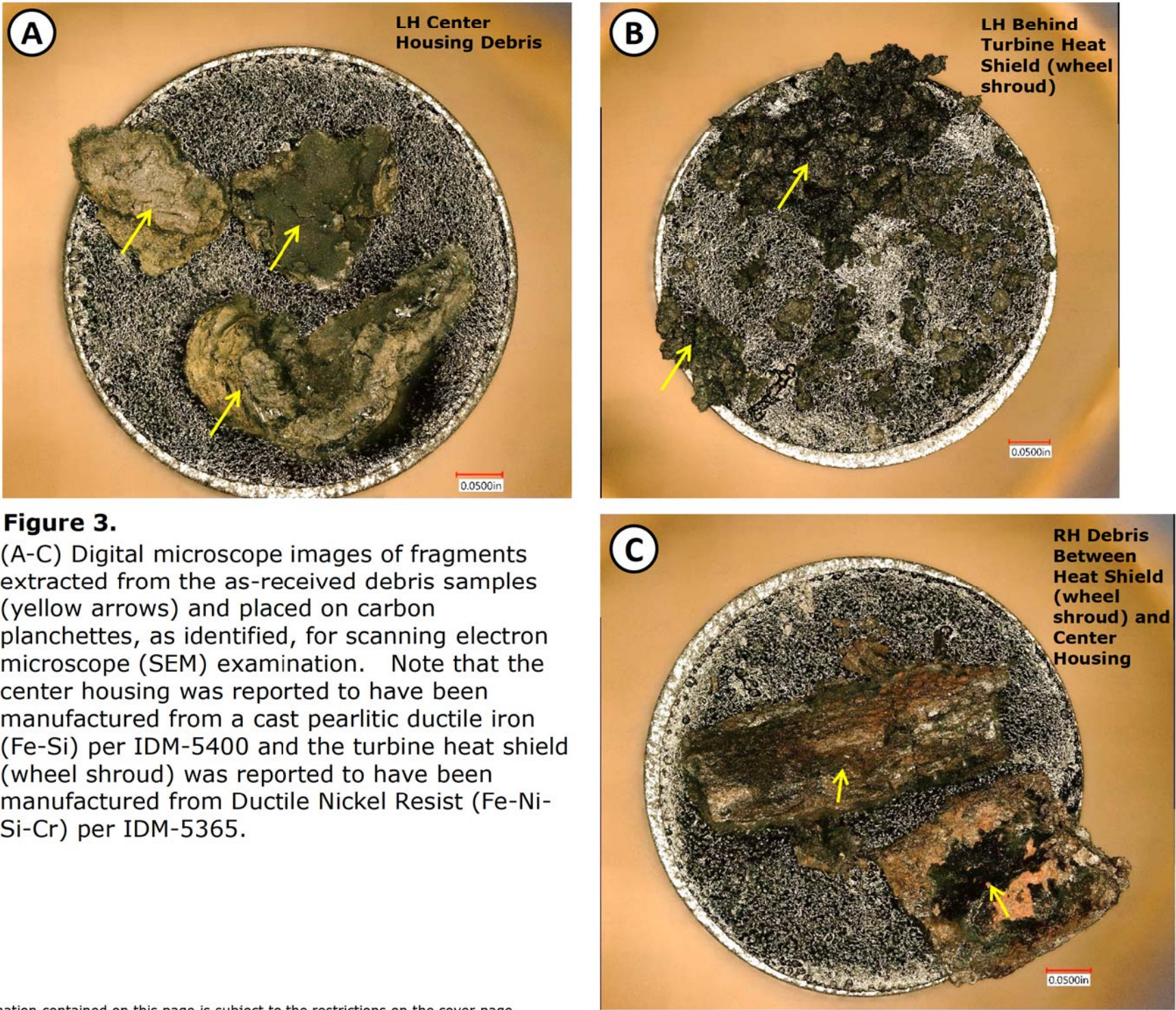
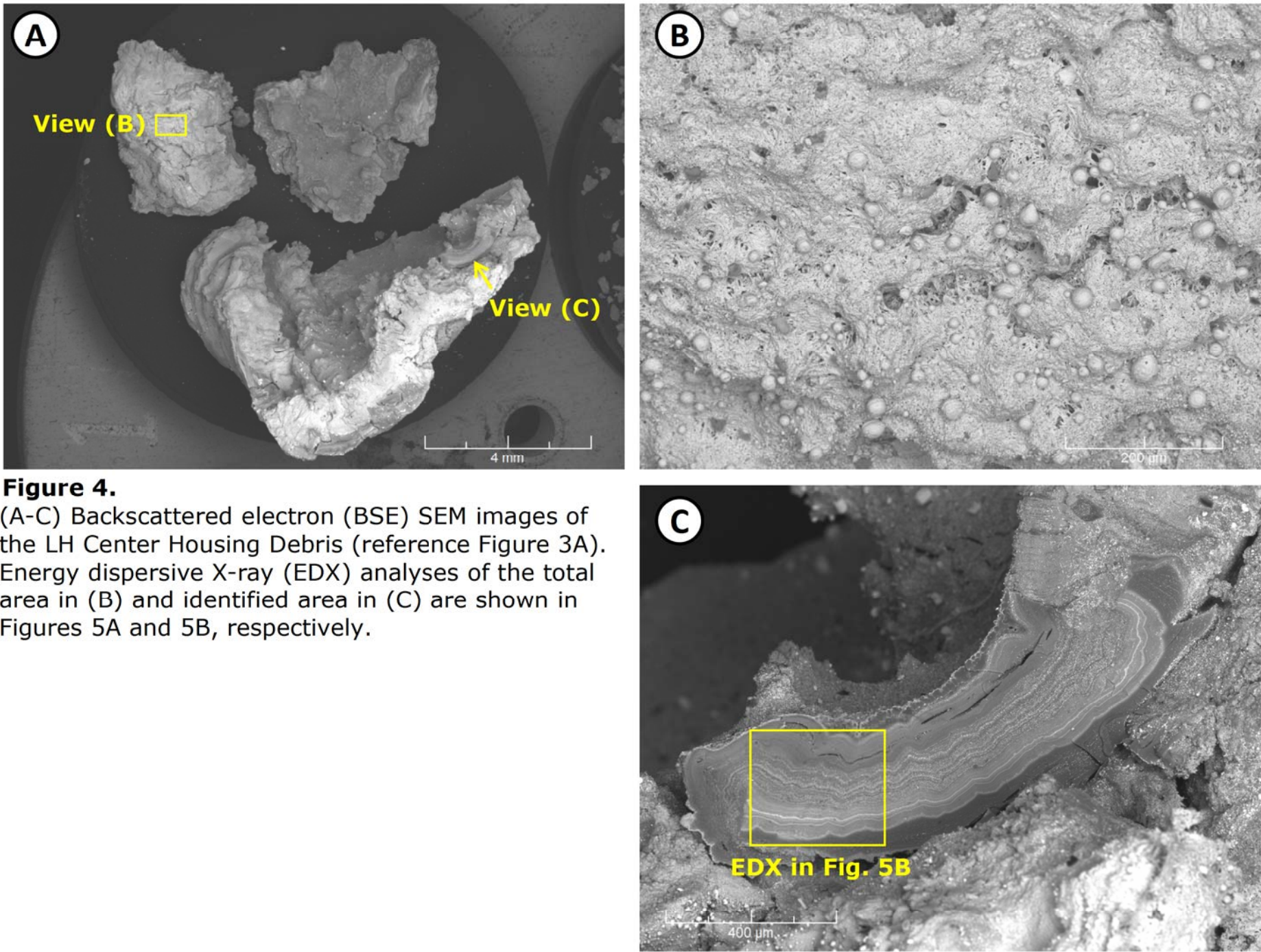


Figure 2.
As-received debris samples (A) collected from the oil gallery of the LH (left hand) center housing prior to sectioning identified as "LH Center Housing Debris", (B) collected after sectioning of the LH center housing & wheel shroud and was contained between the two surfaces identified as "Debris from LH Behind Turbine Heat Shield (wheel shroud)", and (C) collected from between the RH (right hand) center housing & wheel shroud and collected after disassembly identified as "RH Debris Between Heat Shield (wheel shroud) and Center Housing".





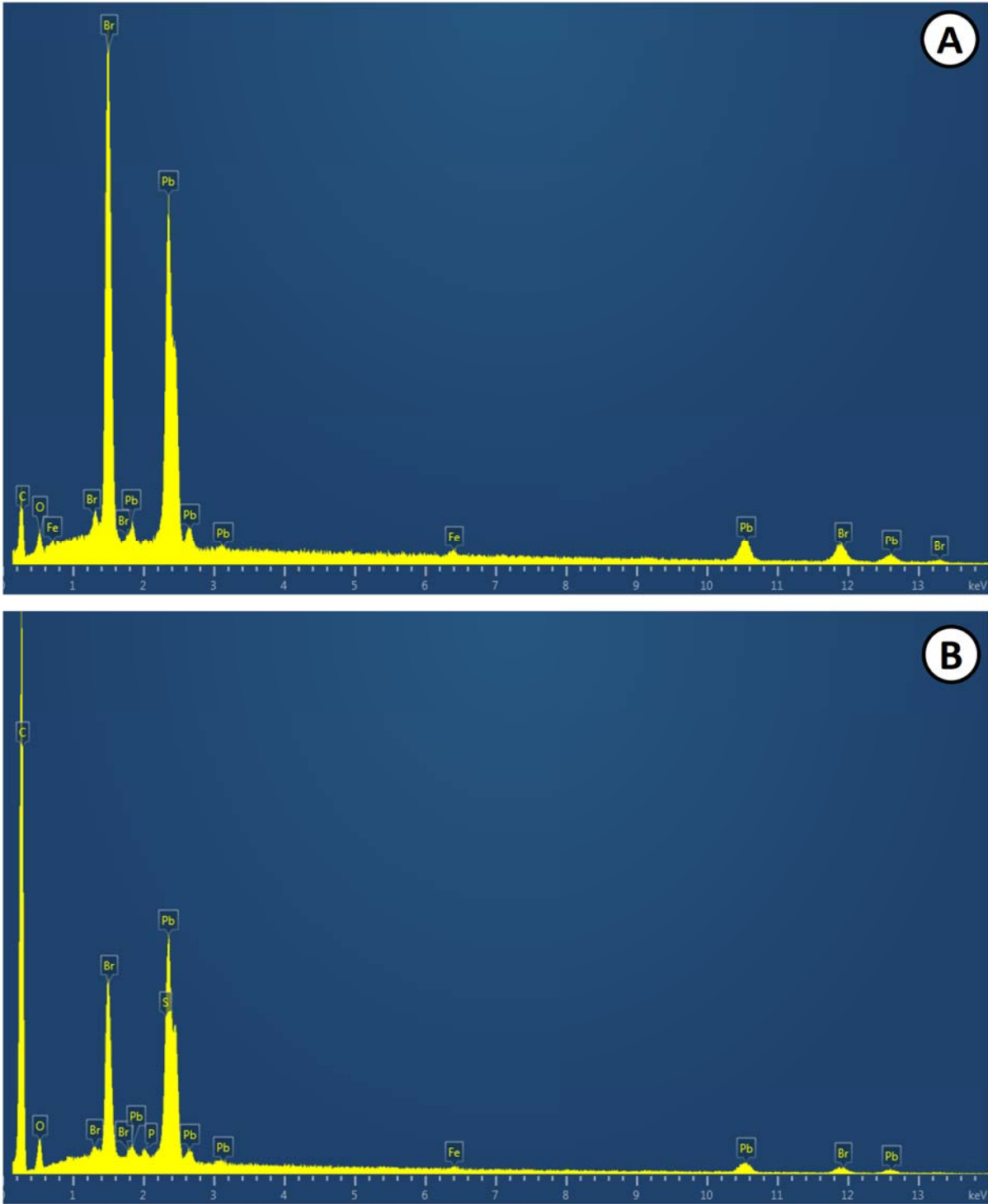


Figure 5.

(A, B) EDX spectra produced from the analysis of the areas identified on the LH Center Housing Debris in Figures 4B and 4C, respectively, showing high lead and bromine concentrations. The source of the bromine and lead was likely the AVGAS 100LL fuel which contains lead and bromine.

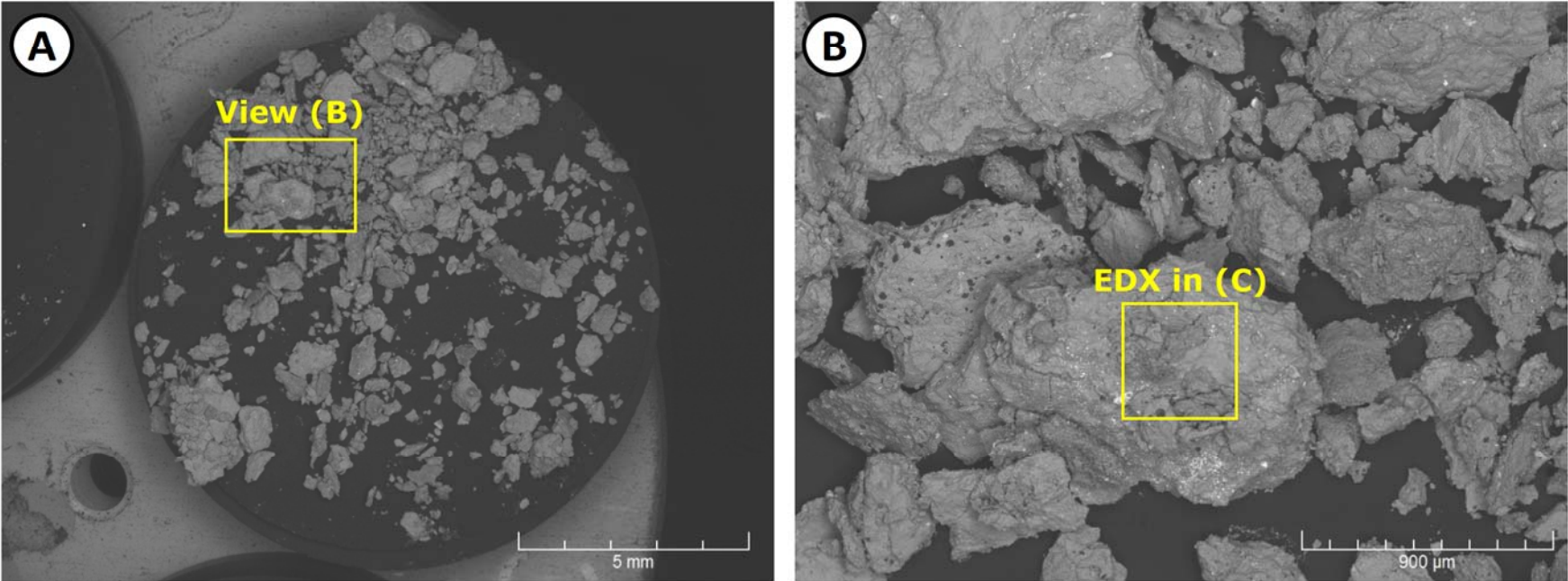
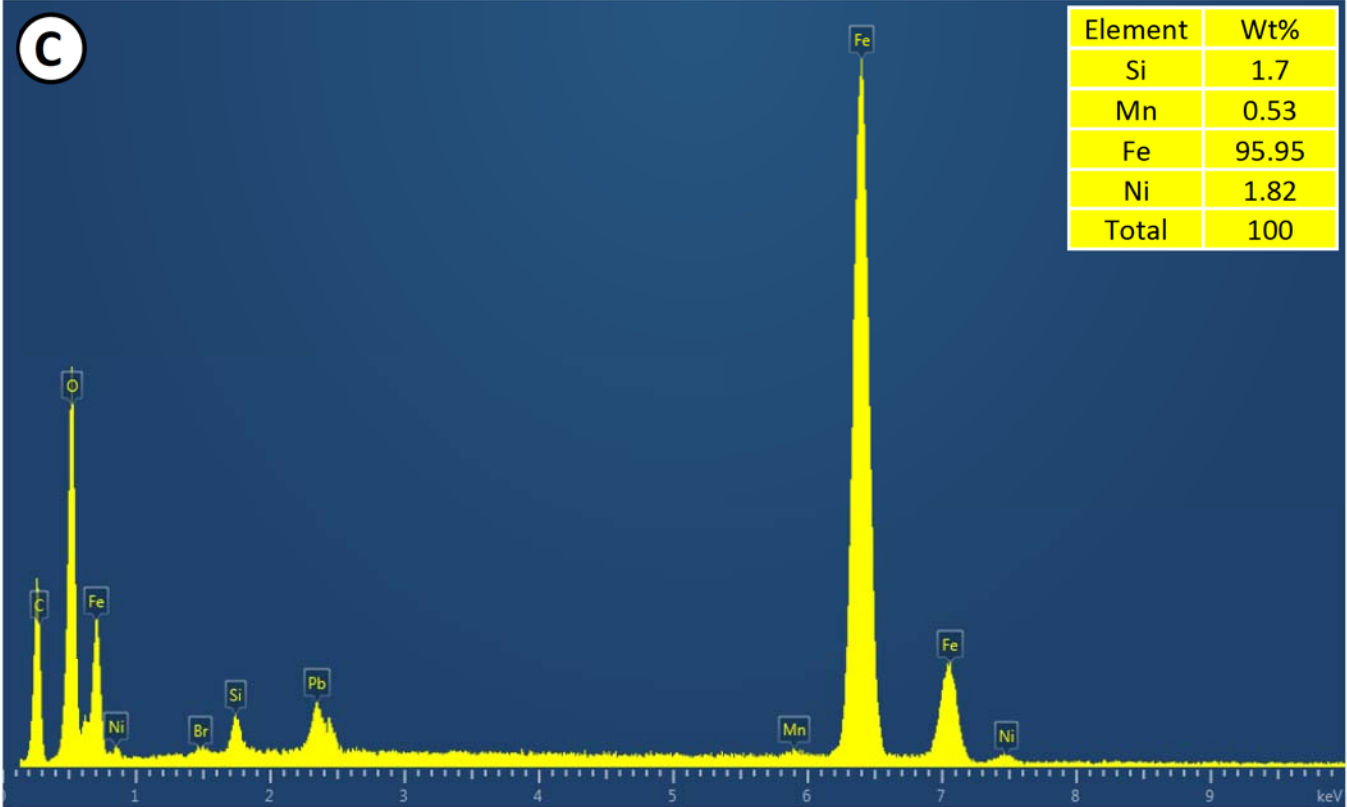


Figure 6.
(A, B) BSE SEM images of the LH Behind Turbine Heat Shield (wheel shroud) Debris, reference Figure 3B. (C) EDX spectrum produced from the analysis of the area in (B) showing a high concentration of oxygen, carbon, and iron with lead and silicon and traces of bromine, manganese, and nickel. The iron rich material containing manganese and nickel was characteristic of a low alloy steel. The weight % composition shown has the carbon, oxygen, lead and bromine removed from the analysis to aid in identification of the alloy. The alloy could not be determined. The lead and bromine were likely contributed by the AVGAS 100LL.



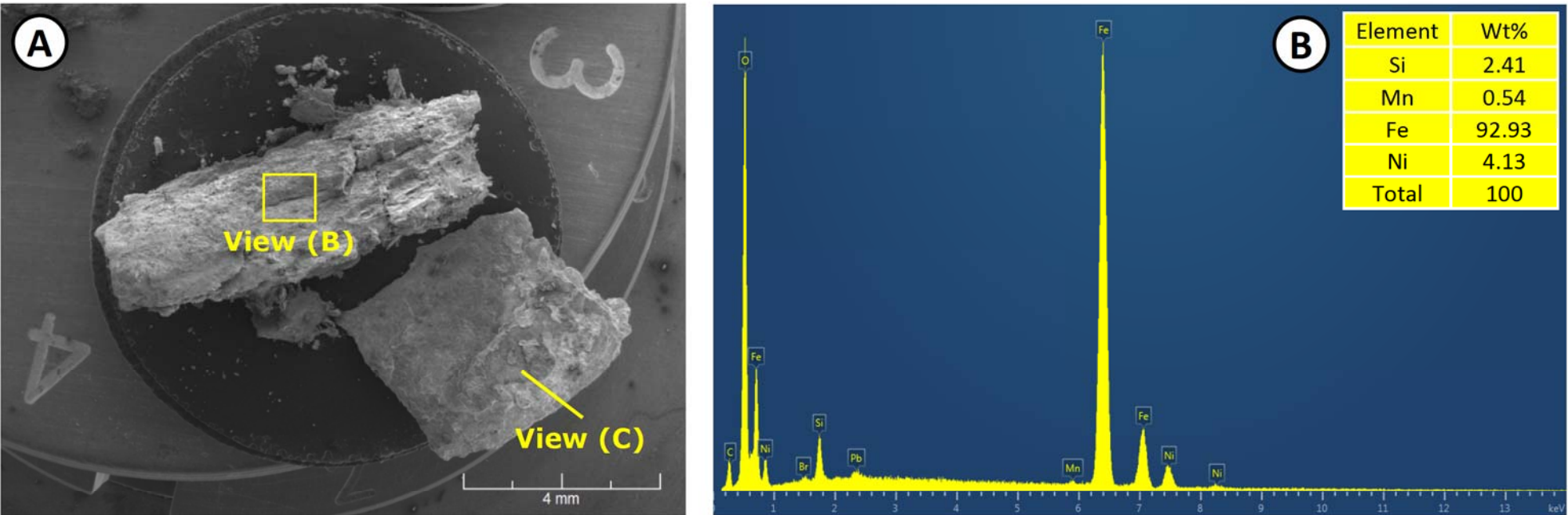


Figure 7.
(A) BSE SEM image of the RH Debris Between Heat Shield (wheel shroud) and Center Housing Debris, reference Figure 3C. (B, C) EDX spectra produced from the analysis of the areas in (A) showing high concentrations of oxygen and iron with carbon, silicon, and nickel, and traces of bromine, manganese, and lead. The iron rich material containing manganese and nickel was characteristic of a low alloy steel with elevated nickel concentrations. The weight % composition in the upper right corners have the carbon, oxygen, lead, and bromine removed from the analysis to aid in identification of the alloys. The alloys could not be determined. The lead and bromine were likely contributed by the AVGAS 100LL.

