

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



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MAINTENANCE

Specialist's Factual Report

April 29, 2024

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A ACCIDENT

Location: Santa Ana, California
Date: August 20, 2023
Time: 2315 Pacific Daylight Time (PDT)
 0615 coordinated universal time (UTC)
Airplane: Boeing 737-890

B MAINTENANCE GROUP

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Group Member	James Williams Aircraft Mechanics Fraternal Association (AMFA) Seattle, WA
Group Member	Captain Craig Boxrucker Air Line Pilots Association (ALPA) Seattle, WA
Group Member	Mike Waschak Sunvair Valencia, CA

C SUMMARY

On August 20, 2023, about 2315 Pacific daylight time (PDT), Alaska Airlines flight 1288, a Boeing 737-890, sustained damage when the left main landing gear collapsed after landing on runway 20R at John Wayne-Orange County Airport (SNA), Santa Ana, California. The 112 passengers and crew evacuated the airplane via stairs onto taxiway E with no injuries. The flight was operating under the provisions of 14 Code of Federal Regulations Part 121 as a scheduled domestic passenger flight from Seattle, Washington, to SNA.

D DETAILS OF THE INVESTIGATION

1.0 Aircraft

The airplane was built by The Boeing Company on December 14, 2008 (Certificate of Issue) and subsequently delivered to Alaska Airlines on December 16, 2008. The airplane was registered as N516AS, Serial No 39044. At the time of the accident, the airplane accumulated 53,207:34 Hours and 15,854 Cycles.

2.0 Alaska Airlines

2.1 Maintenance

A post-accident review of the landing gear system maintenance records was conducted. No discrepancies with the left MLG were recorded for the period between February 2023 and the accident. Alaska Airlines routine maintenance (i.e. brake and tire replacements) were conducted during this time.

A review of the maintenance history of the left MLG after installation (July 17, 2018) on the airplane showed the following:

1. On 11/24/2020. Maintenance personnel wrote up a defect (G1526272) where the key washer was not properly installed on the trunnion pin. After further review, the defect was a non-issue since the retainer tab was engaged properly per Boeing Drawing 144A1650 Rev A, Flag Note 7.
2. On 11/27/2020, Maintenance personnel wrote up a defect (G1526274) for the left-hand main landing gear pin forward fitting external surface area contains server spots of bare metal. Maintenance personnel restored the finish to the area in accordance with B737-00 AMM 51-21-99.

2.2 Alaska Airlines Landing Gear Maintenance Program

MPD TASK NUMBER	ALASKA ID	TASK	DESCRIPTION	FREQUENCY THRESHOLD / REPEAT		ACCOMPLISHED
32-010-01	N8005001	RST	Clean exposed surfaces of the left main landing gear shock strut.	50 FC	50 FC	2/27/2024
32-010-02	N8005001	RST	Clean exposed surfaces of the right main landing gear shock strut.	50 FC	50 FC	2/27/2024
32-020-01	74732002	SVC	Service the left main landing gear shock strut.	4000 FC	4000 FC	9/25/2023
32-020-02	74732003	SVC	Service the right main landing gear shock strut.	4000 FC	4000 FC	12/17/2022
32-030-01	78732002	LUB	Lubricate the left main landing gear assembly.	560 FC 90 DY	560 FC 90 DY	12/19/2023
32-030-02	78732003	LUB	Lubricate the right main landing gear assembly.	560 FC 90 DY	560 FC 90 DY	12/19/2023
32-040-01	161A1100-(XX) LM PNC	RST	Restore the left main landing gear assembly.	21000 FC 10 YR	21000 FC 10 YR	7/17/2018
32-040-02	161A1100-(XX) RM PNC	RST	Restore the right main landing gear assembly.	21000 FC 10 YR	21000 FC 10 YR	7/17/2018
32-050-01	161A1100-(XX) LM PNC	DIS	Discard the left main landing gear life limited parts.	75000 FC	75000 FC	Accomplished at each landing gear vendor visit
32-050-02	161A1100-(XX) RM PNC	DIS	Discard the right main landing gear life limited parts.	75000 FC	75000 FC	Accomplished at each landing gear vendor visit
32-110-00	N8132006	DET	Perform a detail visual inspection of the landing gear selector valve.	8000 FC	8000 FC	12/17/2022
32-150-00	74732005 74732006	DET	Perform a detail visual inspection of the left and right main landing gear extension and retraction mechanism. (Includes retraction actuators, up lock actuators, down lock actuators, up lock mechanism, and down lock mechanism).	6600 FC	6600 FC	12/17/2022
32-220-00	74232000	FNC	Perform a functional check of the left and right main landing gear manual extension system and alternate extension bypass valve.	36 MO	36 MO	12/17/2022
32-230-00	N8132001	FNC	Remove the main landing gear wheel well protection retract pressure fuse for functional test.	25000 FH	25000 FH	12/22/2018
32-240-00	74132000	OPC	Operationally check the landing gear transfer valve.	12000 FH	12000 FH	12/17/2022
32-250-00	74132005	DET	Perform a detail visual inspection of the forward and aft brake control linkages and cable quadrants.	6600 FC	6600 FC	12/17/2022

32-260-00	N8132006	DET	Perform a detail visual inspection of the brake metering valves.	8000 FC	8000 FC	12/17/2022
32-270-01	N8005001	GVI	General visual inspection (GVI) the left brake wear pins for minimum extension.	50 FC	50 FC	2/27/2024
32-270-02	N8005001	GVI	General visual inspection (GVI) the right brake wear pins for minimum extension.	50 FC	50 FC	2/27/2024
32-290-00	N8132002	OPC	Perform an operational check of the alternate brake system and alternate brake selector valve.	15000 FC	15000 FC	11/26/2013
32-300-00	72132003	SVC	Check brake accumulator precharge pressure, service as required.	1500 FH	1500 FH	12/19/2023
32-310-00	N8132000	OPC	Operationally check the brake accumulator isolation valve.	12500 FC	12500 FC	11/26/2013
32-330-00	N8132006	DET	Perform a detail visual inspection of the parking brake mechanical control path.	8000 FC	8000 FC	12/17/2022
32-340-00	74132006	FNC	Perform a functional bleed down check of the parking brake system and brake accumulator precharge pressure.	4000 FC	4000 FC	12/17/2022
32-420-00	N8132003	OPC	Perform an operational check (bite check) of the proximity switch electronics unit.	25000 FH	25000 FH	12/22/2018
32-430-00	72332000	VCK	Perform a visual check of the tail skid crushable cartridge for evidence of a tail strike.	480 FC	480 FC	12/19/2023
32-440-00	74120000 74120001 74120002	DET	Perform a detail visual inspection of the exposed portions of the landing gear system control cables.	6600 FC 36 MO	6600 FC 36 MO	12/17/2022
32-450-00	N8120009 N8120010 N8120011 N8120012 N8120013	DET	Perform a detail visual inspection of the internal portions of the landing gear control system cables.	10400 FC 6 YR	10400 FC 6 YR	12/22/2018
32-460-00	N8120006 N8220005	DET	Perform a detail visual inspection of the internal portions of the landing gear systems control cables that are over the center wing section BS 540 to BS 663.75 or cables that require special access.	36000 FC 12 YR	36000 FC 12 YR	12/22/2018

32-720-01	161A1100-(XX) LM PNC	GVI	Inspect left main landing gear assembly, including outer cylinder, inner cylinder, axle, torsion links, side strut, lock links and retraction linkage. Landing gear removal is required.	10 YR	10 YR	7/17/2018
32-720-02	161A1100-(XX) RM PNC	GVI	Inspect right main landing gear assembly, including outer cylinder, inner cylinder, axle, torsion links, side strut, lock links and retraction linkage. Landing gear removal is required.	10 YR	10 YR	7/17/2018
32-804-01	N8900000	ZONAL (GV)	Perform an external zonal inspection (GV) of the left main landing gear and landing gear doors. Inspection is accomplished from the ground, without the use of stands or ladders.	120 DY 745 FC	120 DY 745 FC	12/19/2023
32-806-01	74732000	ZONAL (GV)	Perform an external zonal inspection (GV) of the left main landing gear and landing gear doors. (EZAP)	6600 FC 36 MO	6600 FC 36 MO	12/17/2022
32-808-02	N8900000	ZONAL (GV)	Perform an external zonal inspection (GV) of the right main landing gear and landing gear doors. Inspection is accomplished from the ground, without the use of stands or ladders.	120 DY 745 FC	120 DY 745 FC	12/19/2023
32-810-02	74732001	ZONAL (GV)	Perform an external zonal inspection (GV) of the right main landing gear and landing gear doors. (EZAP)	6600 FC 36 MO	6600 FC 36 MO	12/17/2022
32-ASA-01	78232000	FNC	Perform a functional check of the landing gear control cable tension.	18000 FC 5 YR	18000 FC 5 YR	12/12/2020
32-ASA-03	N4232000	RST	Restore (clean) the landing gear control lever slide mechanism.	4800 FC	4800 FC	12/17/2022
32-ASA-06	N4232001	FNC	Perform an adjustment of the manual extension system access door switch.	3 YR	3 YR	12/17/2022
32-ASA-08	N8005001	VCK	Check the main landing gear wheel tie-bolts for installation.	3 DY	3 DY	2/27/2024

2.3 FAA Airworthiness Directive (AD)

FAA issued AD 2019-01-03 which supersedes AD 2016-18-01 which applied to certain Boeing 737-600, -700, -700C, -800, -900, and -900ER series airplanes. AD 2016-18-01 required repetitive lubrication of the forward and aft trunnion pin assemblies of the right and left main landing gears (MLGs); repetitive inspection of these assemblies for corrosion and chrome damage, and related investigative and corrective actions if necessary; and installation of new or modified trunnion pin assembly components, which terminated the repetitive lubrication and repetitive inspections. Since issuance of AD 2016-18-01, it was determined that rotatable parts were not addressed in that AD, and it was therefore necessary to include all airplanes of the affected models in the applicability. AD 2019-01-03 retains the requirements of AD 2016-18-01, adds airplanes to the applicability, and prohibits the installation of a MLG or MLG trunnion pin assembly under certain conditions.

According to Alaska Airlines records, the AD was terminated during both Left and Right MLG Restoration in July 2018 (see Attachment 1).

3.0 Left Hand Landing Gear

The LH MLG was installed on the accident airplane on July 17, 2018. The airplane had 36,691:46 Hours and 11,144 Cycles at landing gear installation.

The LH MLG had accumulated a total of 53,558:53 total hours and 15,826 cycles since new. At installation, the landing gear had 37,043:05 total hours and 11,116 cycles. The landing gear had been on the accident airplane for about 16,516 total hours and 4,710 cycles since its installation.

The nameplate on the LH MLG shock strut identified as follows:

P/N 161A1100-53
S/N MAL05621Y2721
Sunvair JUL 01, 2018

The Aft Trunnion Pin from the LH MLG was identified as P/N 161A1192-13; Serial Number (S/N) E5514. Both the LH MLG and the aft trunnion pin was overhauled at the same time by Sunvair Inc. in Valencia, CA on July 5, 2018 (see Attachment 2).

4.0 Sunvair Inc.

A review of the general Sunvair Overhaul Process is below with some specifics regarding this accident:

According to Sunvair personnel, the receiving department checks that Sunvair has the current Component Maintenance Manual (CMM) from Boeing when inducting parts. Each landing gear was placed on racks, and a Bill of Materials was created for each section. In general, service bulletins (SB) to be implemented during the overhaul would come from Customer/Airline building specifications. This was typically the latest revision; however, the vendor may request an older version. The trunnion pin does have an applicable SB (737-32-1448 rev 1) pertaining to its different maintenance profile. Sunvair confirmed that the necessary service bulletin requirements had been complied with on the part. The lubrication portion would have to be completed by the operator at the time of assembly on the aircraft. The Air Carrier was ultimately responsible for compliance with applicable Airworthiness Directives (AD).

The trunnion pins were not normally replaced in service since this required removing the entire MLG from the airplane. As such, the cycles of the aft trunnion pin were typically identical to those of the landing gear assembly. The trunnion pins were typically overhauled at set time/cycle intervals. Sunvair repairs and overhauls these pins for several commercial operators as well as private aircraft operators. Currently, one operator customer had requested that these pins be replaced with new at each overhaul, however, this was a new request and Sunvair had not scrapped any in their possession to date. Sunvair has noticed that the trunnion pins installed in 737-900ER aircraft do not exhibit the degree of wear typically seen on 737-800/-900 landing gear.

Turnaround times (TAT) for the landing gear assemblies were typically 40 to 45 days per contract period for each year. Sunvair operated on three shifts, though the majority of work was performed on the first shift. The facility operated 5 days a week, though there were often 'skeleton crews' on the weekends, particularly at the ends of months. The facility, a non-union shop, currently employed 187 people. The floor workers receive 3 breaks, including a 30-minute lunch, and typically worked no more than 10-hour shifts. If they were to work 12 or more hours, the State of California requires a second lunch break.

After stripping the chromium electroplating and performing the temper etch inspection, some parts that do not need machining (grinding) were shot peened and replated and then continued on the rework process. For NDT inspections, Sunvair performs an upfront stress relief treatment and magnetic particle inspection (MPI), as well as a final MPI near the end of the rework process.

If a part was machined / ground during repair, a temper etch, fluorescent penetrant (FPI), and MPI was performed, as mandated by the applicable manufacturers CMM, along with stress relief and shot peening. Shot peening was performed in house or subcontracted as necessary. There were no requirements for eddy current inspection during the normal overhaul process of the OEM's landing gear or the affected trunnion pin.

During the repair process, the cooling fluid for the machining equipment was checked daily by refractometer before the start of the primary shift. Gages were

calibrated annually, using a color-coated sticker system that allows for easy identification of the month for calibration. Operators inspected gages prior to each shift. The gages inspected include the tachometer, wheel diameter, and spindle speed. The speeds were checked monthly and were recorded on each work traveler. Due to the manual nature of the machining equipment, operators must stay with the equipment during an entire run. If issues arise during an operation, the inspector will be informed immediately.

Post-grinding, the first check was a visual one, looking for chatter marks, pass indications, and adherence to dimensional tolerances. If such a discrepancy was found, a nonconformance report was not necessarily created, and the engineers make a judgment call as to the next steps. For significant issues the part was rerouted to include all necessary processing. Minor issues may be returned to the machine shop for rework under their original traveler operation. Boeing does allow rework of a part with an indication from a temper etch inspection, and typically Sunvair operators will see if additional grinding (no more than to the minimum diameter) could remove the indications. The Nital etch tanks, like all those in the plating shop, were elevated above the shop floor, and were located adjacent to each other and rinse tanks to more quickly batch process parts. Typical dunk times for etching are 30 and 60 seconds per step.

Post chromium electroplating and grinding of the chrome plate to final diameter, an inspector ensured that each step had been signed off. They verify each value reported by each operator was within stated tolerances. Post plating inspections involved visually looking for evidence of heat damage or defects in the chromium electroplating, such as mud-cracking or 'chicken wire' cracks. MPI was performed to look for cracks in the base metal.

The Investigative team had the opportunity to review training records for Sunvair Technicians. Inspectors and grinders were primarily trained with on-the-job training (OJT), though some were sent to formal classes so they can have certification "in-hand." Inspector and operator OJT training also included extensive testing, such as the 20+ question exam for temper etch inspectors.

According to Sunvair, some of technicians who worked on the overhaul of the subject aft trunnion pin have since left the company for various unrelated reasons. This included the temper etch inspector and the operator of the post-plating grinding machine. Sunvair records showed there were two other aft trunnion pins (Part Number: 161A1192-11 S/N: E0396 and E0347) worked on the same grinding machine the month after the Alaska Airlines Trunnion pin. Sunvair also stated that the two aft trunnion pins were not re-worked by the same operator of the Alaska Airlines trunnion pins.

According to Sunvair, all Landing Gear records are kept for a period of 10 years.

Sunvair Safety Action:

After notification of the accident, Sunvair reviewed their Trunnion Pin Overhaul process and added a Florescent Penetrant Inspection to the pin's repair procedure, even though it was not specified by the original equipment manufacturer (OEM), to detect potential grinding issues after the final grinding was complete following chromium plating. Other NDT options have been considered as a supplement method that could aid in finding such defects, but they have not been incorporated within OEM repair requirements.

E ATTACHMENTS

Attachment 1 - Alaska Airlines AD Record

Attachment 2 - Sunvair Inc. Overhaul Records

Submitted by:

Pocholo Cruz
Aerospace Engineer