

National Transportation Safety Board

Office of Research and Engineering

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COCKPIT VOICE RECORDER

Specialist's Factual Report

March 6, 2026

WARNING

The reader of this report is cautioned that the summary of a cockpit voice recorder audio recording is not a precise science but is the best product possible from a National Transportation Safety Board group investigative effort. The summary or parts thereof, if taken out of context, could be misleading. The summary should be viewed as an accident investigation tool to be used in conjunction with other evidence gathered during the investigation. Conclusions or interpretations should not be made using the summary as the sole source of information.

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A. ACCIDENT

Location: Philadelphia, PA
Date: January 31, 2025
Time: 1807 Local
Airplane: Learjet 55, Med Jets, S.a. De C.v., XA-UCI

B. COCKPIT VOICE RECORDER SPECIALIST

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C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, XA-UCI, was operating as Title 14 *Code of Federal Regulations* (CFR) Part 129: Foreign. The event aircraft was manufactured in March 3, 1982 and was operating such that it was not required to be equipped with a cockpit voice recorder (CVR).

Aircraft operated under Title 14 *Code of Federal Regulations* (CFR) 129 are required to follow the operating rules of their country of registry. ICAO Annex 6 Standards and Recommended Practices require that aircraft between 5700 and 27000 kg, manufactured after January 1, 1987, should be equipped with a CVR that records a minimum of the last 30 minutes of aircraft operation. There is an ICAO recommendation to require *'All turbine-engine aeroplanes, for which the individual certificate of airworthiness was first issued before 1 January 1987, with a maximum certificated take-off mass of over 27,000 kg that are types of which the prototype was certificated by the appropriate national authority after 30 September 1969 should be equipped with a CVR'*.

D. DETAILS OF THE INVESTIGATION

A CVR group was not convened. The NTSB Vehicle Recorder Division received the following CVR:

Recorder Manufacturer/Model:	Fairchild A-100A
Part Number:	93-A100-83
Recorder Serial Number:	25033

1.0 Recorder Description

This model CVR, the Fairchild A-100A, records a minimum of 30 minutes of analog audio on a continuous loop tape in a four-channel format: one channel for each flight crew, one channel for a cockpit observer, and one channel for the cockpit area microphone (CAM).

1.1 Recorder Damage

Upon arrival at the laboratory, it was evident that the CVR had sustained severe structural damage as shown in figures 1 - 4. The CVR had also sustained extreme fluids exposure including water, fuel, and biohazard as it sat for multiple days at the 6-foot level of an impact crater after firefighting and recovery efforts were completed. The CVR was first soaked in fresh RO/DI¹ water in multiple stages to slowly reduce the initial contamination while mitigating any further degradation of the recording medium (figure 2). Due to extreme deformation to the recorder, the outer case was removed using a variety of cutting tools, chisels, and other mechanical means to expose the internal crash case (figure 5).

Deformation of the entire recorder, the unknown character of internal damage to the Recorder Assembly,² and the uncertain condition of the magnetic tape, precluded entry in the normal manner by removing the armored Cover Assembly of the Thermal Box³ and Inside Cover Assembly.⁴ Instead, exemplars of other A-100A recorders in various states of disassembly were set up for reference to aid in a controlled teardown of the internal tape drive from the opposite face of the Drive Unit Assembly.⁵

To preserve the state and position of the magnetic tape within the tape transport, all material from the Belt Cover⁶ through the Motor Plate Assembly⁷ and up to the Drive Unit Assembly was carefully removed while restricting the movement of all shafts leading into the tape transport. Once this damaged material was cleared,

¹ RO/DI water refers to water that has been purified through both reverse osmosis (RO) and deionization (DI) processes, removing nearly all dissolved solids, organic compounds, and ions to produce extremely high-purity water.

² See Recorder Assembly, 93A247, Figure 14, A-100A Component Maintenance Manual 23-70-01Rev 3: Mar 04.

³ Part #380, Figure 14.

⁴ Part #280, Figure 14.

⁵ See Drive Unit Assembly, 93A246, 9300A026, Figure 16, A-100A Component Maintenance Manual 23-70-01Rev 3: Mar 04.

⁶ Part #240, Figure 14.

⁷ Part #400, Figure 14,

the Drive Unit Assembly including the Reel Cover Assembly⁸ and Bridge Assembly⁹ were removed as a unit from the deformed and broken crash case. These three Assemblies will be collectively referred to as the *transport mechanism* in the narrative that follows (figure 6).

Impact damage was observed to both the Reel Cover Sub-Assembly¹⁰ and the Erase Coil Assembly (figures 7 - 8). One splice¹¹ in the magnetic tape material was immediately observable on the data side of the tape in the area of the pinch roller near the Playback Head Assembly (figures 9, 18, 19). A second splice was also observed approximately 2 inches from the first, but on the opposite (non-data) side of the tape (figures 10, 20-22). The magnetic tape was found to be otherwise contiguous and unbroken before removal from the recorder.

After removal from the recorder, the transport mechanism containing the magnetic tape was soaked for several more days in 7-gallon buckets of RO/DI water occasionally agitated and changed daily until evidence of fuel sheen on the surface of the water was reduced to a minimum (figure 11). Portions of the transport mechanism were slowly removed during this soaking process to aid in cleaning and contaminant diffusion while maintaining support and protection for the magnetic tape medium. This included the removal and replacement of the damaged Reel Cover Assembly with a structurally sound Reel Cover Sub-Assembly.

The transport mechanism was then transferred to a wide Pyrex beaker of RO/DI water and the magnetic tape was cut between the central exit from the Reel and Tape Assembly¹² and the tape recording heads, releasing the tape from the transport mechanism. A leader was spliced to the end threaded past the Bridge Assembly (figure 12) and the opposite end was tucked back into the center of the tape reel. The leader material was then carefully reeled onto the Reel and Tape Assembly while still in the Pyrex beaker (figure 13).

The Reel and Tape Assembly containing the magnetic tape was then removed from the transport mechanism and placed onto one of a pair of spindles mounted in a large tub filled with RO/DI water using a standard 5-1/2 in plastic take-up reel acting as a top-cover until the tape could be wound onto the first take-up reel (figure 14). The tape medium was soaked for four more days while performing a gentle pass of

⁸ See Reel Cover Assembly, 9300A039, Figure 15, A-100A Component Maintenance Manual 23-70-01Rev 3: Mar 04

⁹ See Bridge Assembly, 9300A088, Figure 17, A-100A Component Maintenance Manual 23-70-01Rev 3: Mar 04

¹⁰ Part #10, Figure 15.

¹¹ Splice - Refers to the process of physically joining two segments of magnetic audio tape by cutting and securing the ends together with splicing tape, creating a continuous playback path without an audible gap.

¹² Part #25, Figure 14.

the tape surface across swatches of 100% cotton batting¹³ between water changes as the tape was very slowly wound to another open-style take-up reel while continuously under RO/DI water. A leader was attached to the opposite end of the tape at the end of the first pass. The tape was rewound as loosely as possible during each pass, to maximize the ability for contaminants to diffuse away from the surface of the tape while soaking between turns (figure 15). Evidence of spotty but generally present grey gel-like material smelling of jet fuel appeared on the batting at times emanating from both sides of the tape. This abated very slowly, but not completely, before transitioning to the drying phase.

For the drying phase, the tape was rewound extremely loosely¹⁴ onto a new dry open-style take-up reel (figure 16). The tape was then baked out in stages:

- 4 hours in a vacuum ½ ATM and 28 degrees C.
- Overnight in a desiccant drying cabinet
- 8 hours in a vacuum ½ ATM and 28 degrees C
- Overnight and the next day in a desiccant drying cabinet

The smell of jet fuel was still evident after this procedure as the tape was inspected for any remaining visible deposits while very, very slowly rewinding it onto another open-style take-up reel. The tape was then allowed to dry further in a commercial portable fume hood running 24/7 for 3 days. The odor of jet fuel was significantly reduced by the end of this procedure. The tape was then slowly rewound by hand to another take-up reel and inspected. The second as-found splice (observed on the tape prior to NTSB re-work) was repaired to eliminate overlap observed on magnetic tape medium. This take-up reel was moved to a NAGRA¹⁵ set in free-spooling mode and hand re-wound onto another take-up reel using tension just high enough to keep the NAGRA tension gauge arms activated during the respooling procedure (figure 17). The tape was then very carefully cycled again on the NAGRA in dual reel playback mode to even out the tape tension throughout the reel prior to attempting a normal playback for digitization of the recording.

A normal dual-reel playback was initiated and the output observed using a software-based real-time spectrum analyzer and the NAGRA playback speed variator adjusted to match frequency with the continuous 400Hz ships-power supply hum recorded on one of the audio channels.

Normal playback was then re-initiated to digitize all four channels of 30-minute audio recorded on the tape. Fidelity of recorded audio was good, save periodic

¹³ Pellon WZ-45.

¹⁴ Loosely enough that when the take-up reel was held perpendicular to the ground, the tape would droop like gelatin from the circular to an oval.

¹⁵ NAGRA T Audio - A reel to reel magnetic tape playback mechanism.

approximately ½ second long dropouts observed across all four channels of the entire 31-minute, 36-second recording.

It is noteworthy that the NAGRA heads and capstans required cleaning immediately after playback due to deposits left behind from the tape. The tape was read-back again several weeks later as a test, with little apparent degradation to the recording.



Figure 1. Damaged exterior view of CVR prior to initial soaking.



Figure 2. Damaged exterior of CVR during initial soaking.



Figure 3. Damaged exterior view of CVR after initial soaking.



Figure 4. Damaged exterior of CVR after initial soaking.



Figure 5. Damaged exterior of CVR being removed using cutting tools.



Figure 6. Transport mechanism removed from the damaged A-100A (s/n 25033).

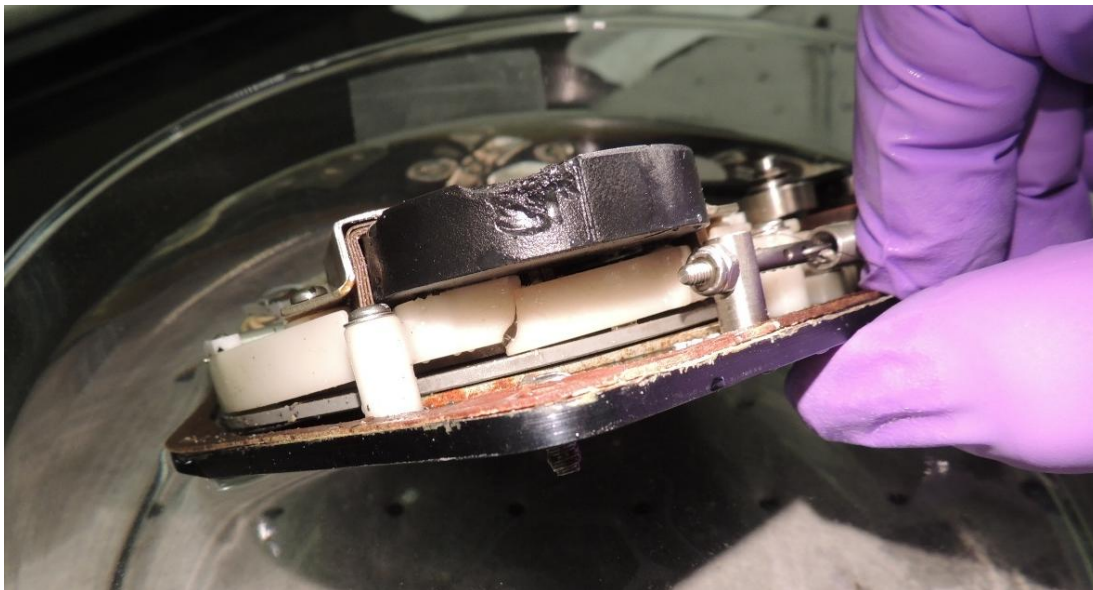


Figure 7. Transport mechanism showing internal damage due to impact forces.



Figure 8. Transport mechanism showing internal damage due to impact forces.

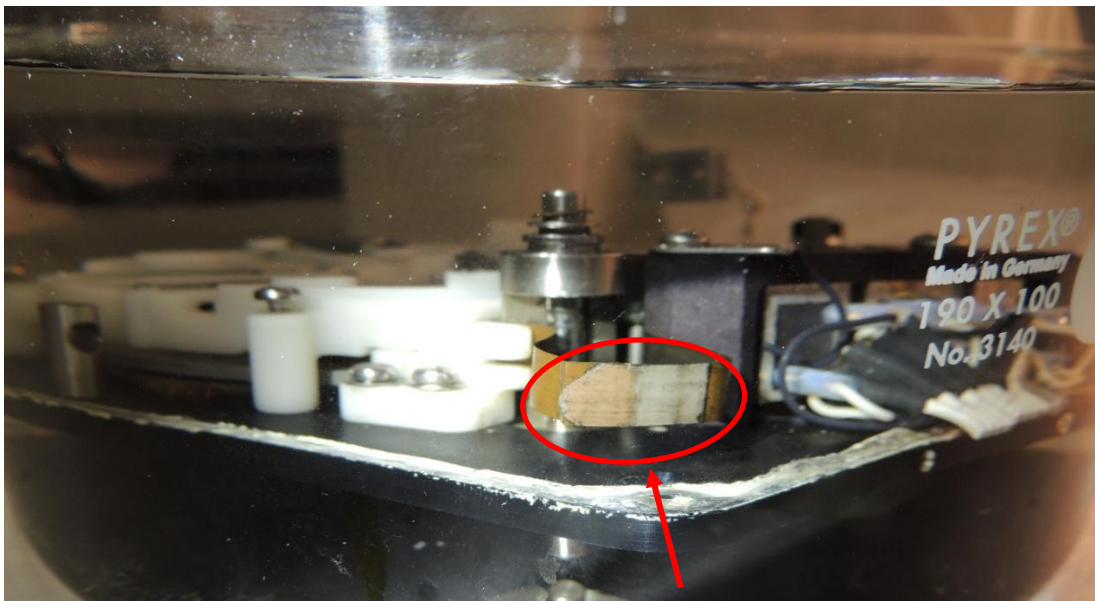


Figure 9. Transport mechanism showing an existing splice to data side of magnetic tape.

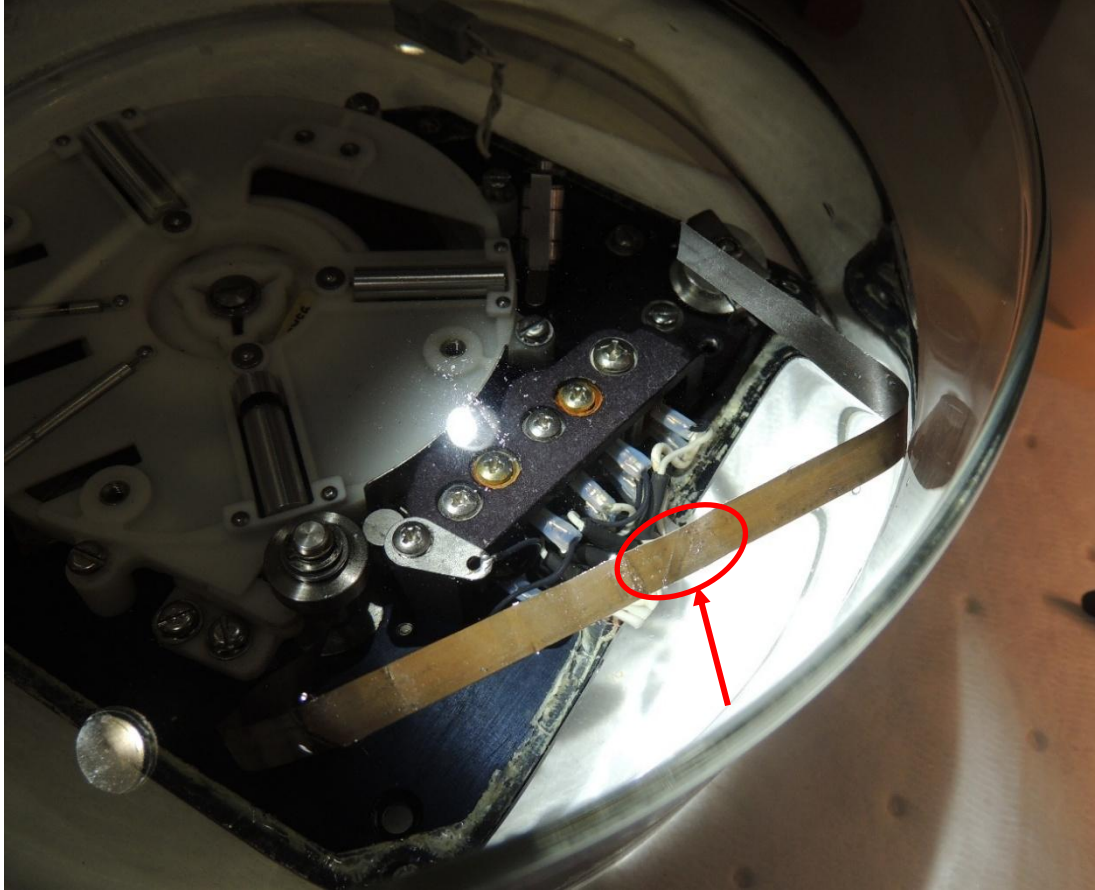


Figure 10. Transport mechanism showing an existing splice to non-data side of magnetic tape.

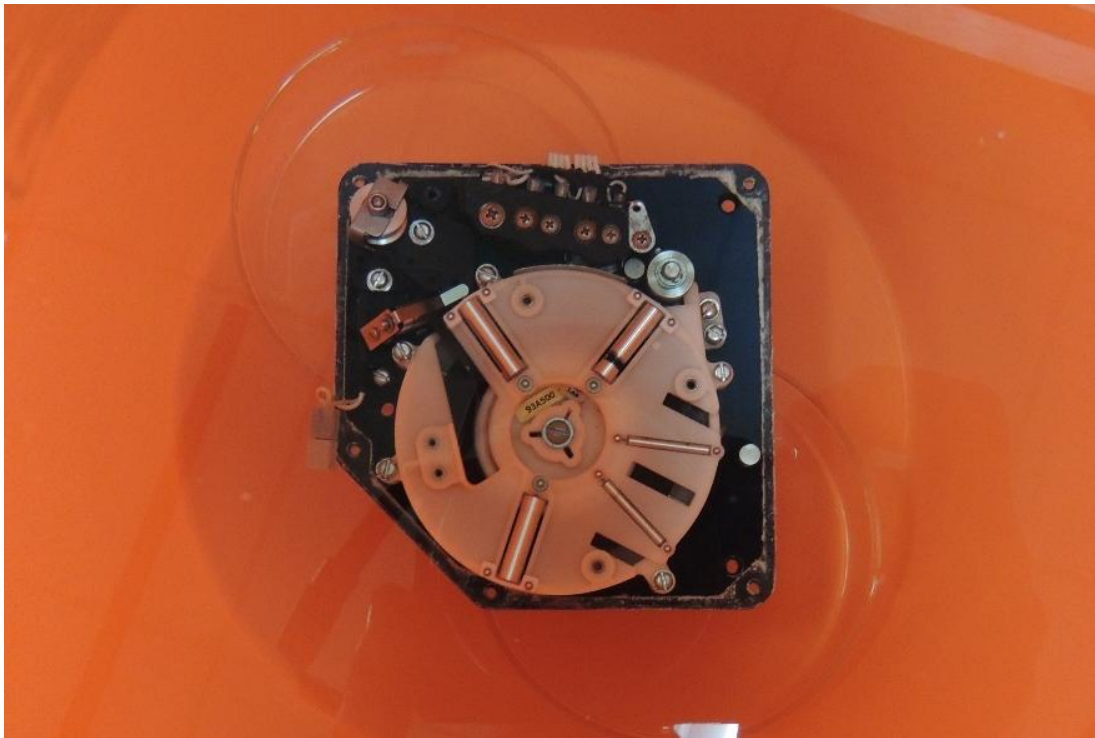


Figure 11. Transport mechanism in process of staged soaking and cleaning.



Figure 12. Leader tape spliced to outer end CVR tape after initial cutting and splicing.

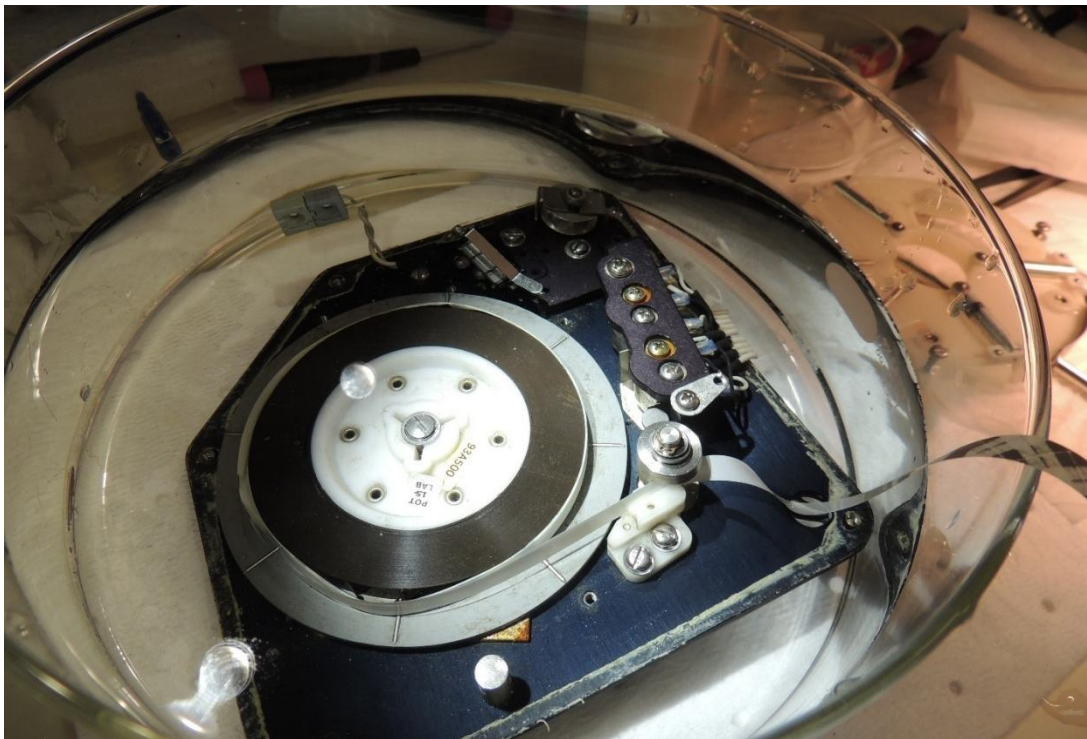


Figure 13. Leader tape end of the CVR tape being re-wound onto the transport.

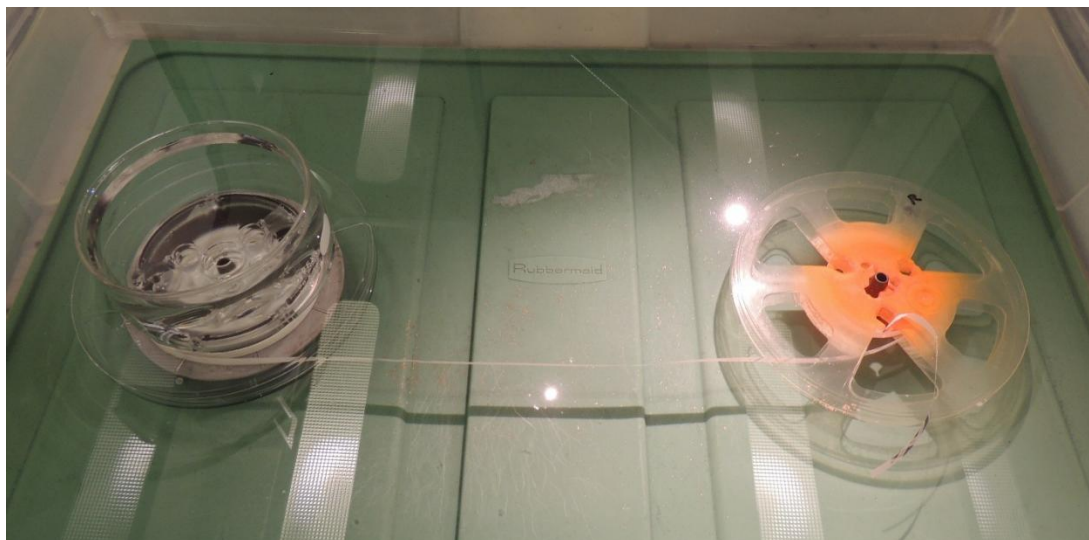


Figure 14. Setup for the second stage tape cleaning process.

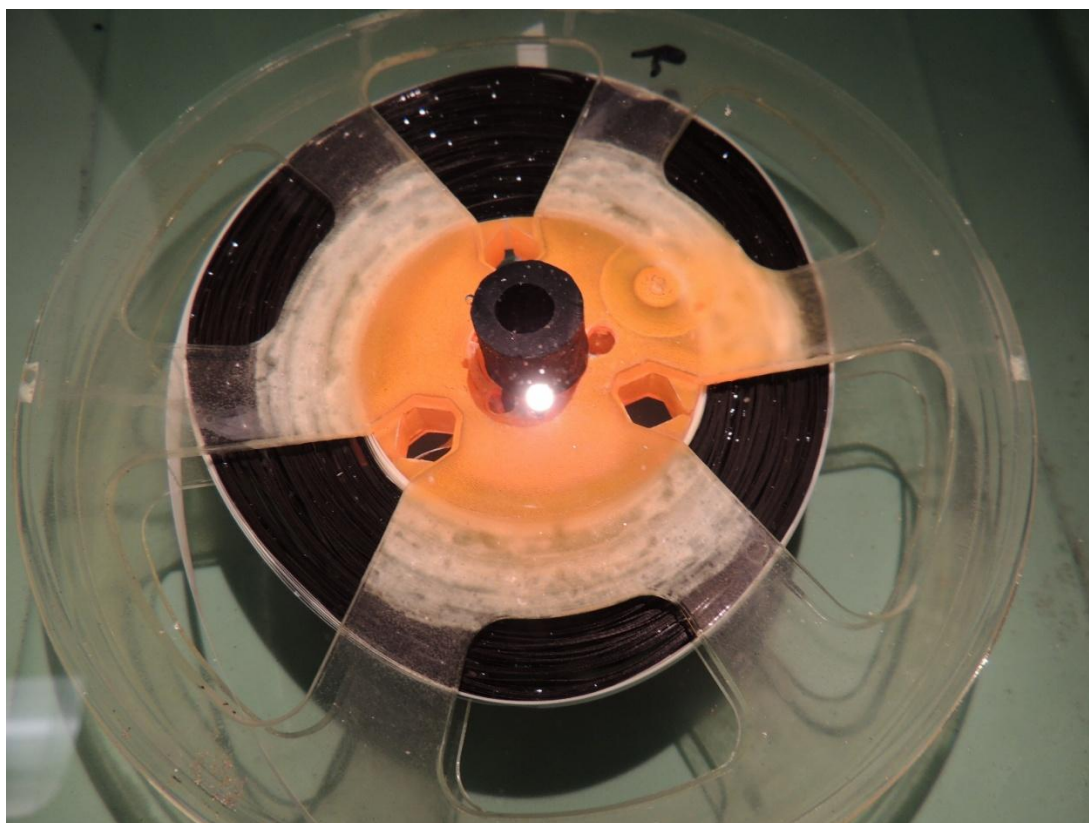


Figure 15. Tape loosely wound on take-up reel during the second stage cleaning process.

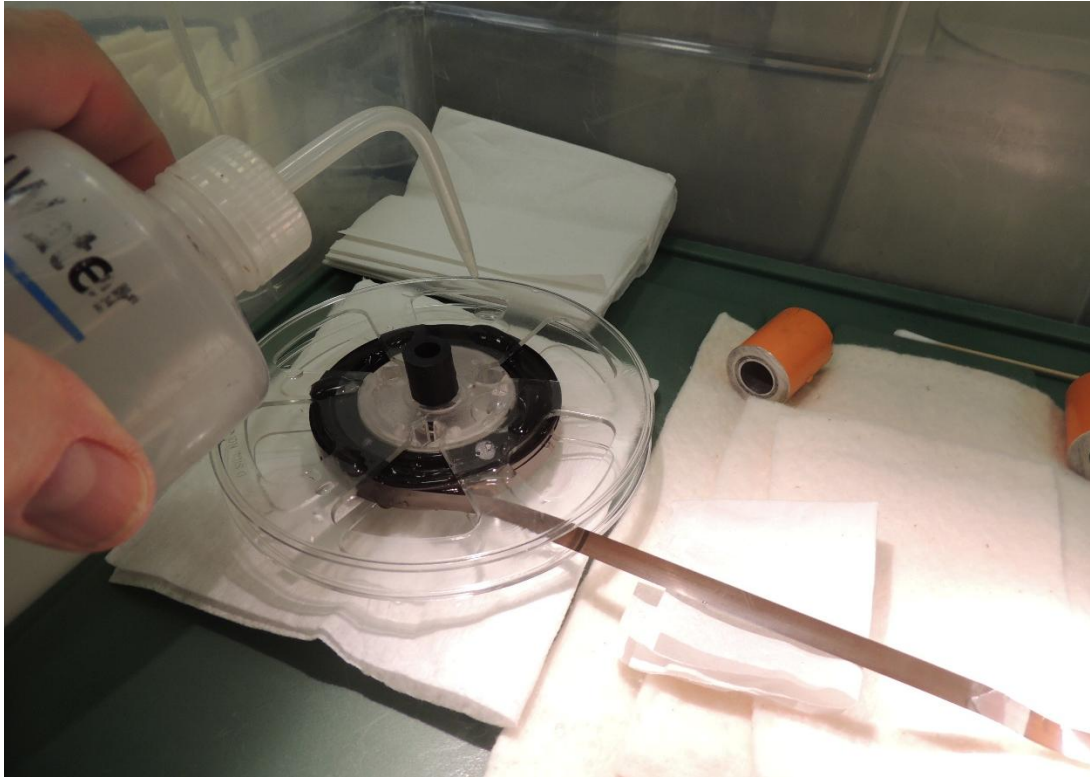


Figure 16. Tape being wound onto a dry take-up reel after the second stage cleaning process.



Figure 17. Tape being hand-wound in free-spooling mode after drying to take up slack.



Figure 18. First pre-existing splice viewed from the data side of the tape.



Figure 19. First pre-existing splice viewed from the non-data side of the tape.



Figure 20. Second pre-existing splice viewed from the data side of the tape.



Figure 21. Second pre-existing splice viewed from the data side of the tape (closeup).



Figure 22. Second pre-existing splice viewed from the non-data side of the tape.

1.2 Audio Recording Description

Each channel's audio quality is indicated in Table 1.¹⁶ Channel number 4 did not contain any audio information.

Table 1. Audio Quality

Channel Number	Content/Source	Quality	Duration
1	HOT Microphone	Fair to Good	<<30 min>>
2	CAM	Fair to Good	<<30 min>>
3	HOT Microphone	Fair to Good	<<30 min>>
4	Other	N/A	<<30 min>>

The recording consisted of four channels of audio information, however none of the audio was pertinent to the accident investigation. The audio was consistent with landing and subsequent ground operations at Houston Hobby Airport prior to the accident flight.

1.3 Timing and Correlation

No timing correlation was performed. Times are expressed in elapsed time into the recording.

1.4 Description of Audio Events

The entire CVR recording on all four channels was modulated by periodic dropouts (no audio data) of recorded audio approximately ½ second long.

All times are given in the format MM:SS, where MM stands for the number of elapsed minutes, and SS, the number of elapsed seconds.

The recording began with aircraft X-Ray Alpha Uniform Charlie India (XA-UCI) landing at Hobby Airport and subsequently taxiing to the Wilson FBO.

Approximately 11:00 into the recording, the CVR recorded electronic whining sounds followed by sounds consistent with three power cycle signatures.

Approximately 14:00 into the recording, the CVR recorded ATIS Uniform at Hobby Airport, followed by XA-UCI requesting and receiving clearance to MMTO airport using the Patreon 5 departure.

Approximately 18:00 into the recording the CVR recorded high amplitude *whining* sounds with prominent harmonics at 400 Hz for approximately 30 seconds.

¹⁶ Appendix A comprises the CVR Quality Rating Scale.

At approximately 22:13 into the recording, the CVR recorded a change from ATIS-U to ATIS-V at Hobby Airport, as follows:¹⁷

Hobby airport arrival slash departure information Victor one {three} five three Zulu wind two zero zero at {one one} - visibility niner. thunderstorm. few clouds at four thousand cumulo nimbus. niner {thousand} scattered, ceiling one four thousand overcast. temperature two seven dewpoint two six altimeter two {niner} eight four. remarks. lightning in the distance northeast. frequent lightning in-clouds northea{st} thunderstorm northeast moving southeast. {I-}L-S runway three one left approach in use. {primary de}parture runway two two. alternate departure run{way} may be assigned by ground control. notices to airmen runway one seven three five closed. taxiway golf two golf three kilo one kilo tw{o} taxiway charlie near southeast ramp closed. {taxi}way golf between runway - four and runway three five closed. taxiway kilo between F-C-I ramp and {runway} three five closed. bird activity in the vicinity Hobby airport. attention all aircraft hazardous weather {in}formation for the Houston area available from hazardous in-flight weather advi{sory s}ervice or flight-service station. when taxiing to ru{nway two} two do not make the right turn towards the runway until directed by tower. for C-P-D-L-C (lock) on (U-)K-U-S-A __ all aircraft taxi with transponder on. adv{ise on i}nitial contact you have information Victor.¹⁸

At approximately 27:36, while the aircraft was still on the ground, the CVR began recording intermittent electronic whining sounds over the next three minutes before recording sounds consistent with a severe slowdown and eventual jam of the CVR recording mechanism.

Erasure of the A-100A CVR is accomplished by pressing the Erase Button on the Voice Recorder Control Head for a minimum of 2 seconds to initiate a 5 second erasure cycle as the tape reel turns under the Erase Coil Assembly.¹⁹ A full erasure of CVR data for this unit would require the reel to turn at least one full rotation. Dropouts recorded across the length of the CVR recording are consistent with this function being activated while the tape was static and not turning in the transport mechanism.

The Normal Procedures, Before Starting Engines checklist for this aircraft calls out on Step 27: Cockpit Voice Recorder (CVR) ...CHECK.

Pressing the TEST button on the A-100A Voice Recorder Control Head for a minimum of 5-seconds starts an internal 600 Hz test tone generator that cycles sequentially through each of the 4 channels of the CVR. Each channel will receive this test tone for approximately 0.8 seconds. Monitoring circuitry receives this test tone and drives the Test Meter on the Voice Recorder Control Head, with the meter

¹⁷ Dropouts in the recorded audio that were filled in by a subsequent repeat of the same ATIS message appear in {}.

¹⁸ This corresponded closely with the following automated weather observation dated 19 September 2019: KHOU 191353Z 19011KT 9SM TS FEW040CB SCT090 OVC140 27/26 A2984 RMK AO2 LTG DSNT N-E SLP108 TSB48 FRQ LTGIC N-E TS N-E MOV SE P0000 T02720256

¹⁹ Installation & Operation Instruction Manual Model A100/A100A Cockpit Voice Recorder, Rev. 2, July 01/02, P/N: 165E2807-00.

reading rising to the green region on the meter and oscillating there as all 4 channels are tested in-turn. If the meter reading drops out of the green area during this time, that is considered a "NO-GO" indication. The 600 Hz test tone can also be audibly monitored by inserting a headset into the Headset Jack on the Voice Recorder Control Head.²⁰ An Audio sound spectrum of the CVR recording was reviewed in-detail. No signatures of a 600 Hz test tone was observed on any of the channels. This tone would be required to deflect the meter reading into the green indicating a positive test.

Submitted by:

Joseph Gregor
Recorder Specialist

²⁰ Installation & Operation Instruction Manual Model A100/A100A Cockpit Voice Recorder, Rev. 2, July 01/02, P/N: 165E2807-00.

APPENDIX A. CVR QUALITY RATING SCALE

The levels of recording quality are characterized by the following traits of the cockpit voice recorder information:

Excellent Quality Virtually all of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate only one or two words that were not intelligible. Any loss in the transcript is usually attributed to simultaneous cockpit/radio transmissions that obscure each other.

Good Quality Most of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate several words or phrases that were not intelligible. Any loss in the transcript can be attributed to minor technical deficiencies or momentary dropouts in the recording system or to a large number of simultaneous cockpit/radio transmissions that obscure each other.

Fair Quality The majority of the crew conversations were intelligible. The transcript that was developed may indicate passages where conversations were unintelligible or fragmented. This type of recording is usually caused by cockpit noise that obscures portions of the voice signals or by a minor electrical or mechanical failure of the CVR system that distorts or obscures the audio information.

Poor Quality Extraordinary means had to be used to make some of the crew conversations intelligible. The transcript that was developed may indicate fragmented phrases and conversations and may indicate extensive passages where conversations were missing or unintelligible. This type of recording is usually caused by a combination of a high cockpit noise level with a low voice signal (poor signal-to-noise ratio) or by a mechanical or electrical failure of the CVR system that severely distorts or obscures the audio information.

Unusable Crew conversations may be discerned, but neither ordinary nor extraordinary means made it possible to develop a meaningful transcript of the conversations. This type of recording is usually caused by an almost total mechanical or electrical failure of the CVR system.