AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

CASE WHERE A SLUNG LOAD CARRIED EXTERNAL TO THE AIRCRAFT WAS RELEASED UNINTENTIONALLY AERO ASAHI CORPORATION BELL 412 (ROTORCRAFT), JA9584 ABOUT 1,150 FT OVER KIRYU CITY, GUNMA PREFECTURE AT ABOUT 11:00 JST, DECEMBER 22, 2021

August 8, 2025
Adopted by the Japan Transport Safety Board
Chairperson RINOIE Kenichi
Member TAKANO Shigeru
Member MARUI Yuichi
Member SODA Hisako
Member TSUDA Hiroka
Member MATSUI Yuko

1. PROCESS AND PROGRESS OF THE AIRCRAFT SERIOUS INCIDENT INVESTIGATION

1.1 Summary of the Serious Incident	On Wednesday, December 22, 2021, while flying over forests, Kiryu City, Gunma Prefecture, a Bell 412, JA9584, operated by Aero Asahi Corporation, dropped ready-mixed concrete from a bucket hanging outside the rotorcraft.
1.2 Outline of the Serious Incident Investigation	The occurrence covered by this report falls under the category of "case where a slung load carried external to the aircraft was released unintentionally" as stipulated in Article 166-4, item (xvi) of the Regulation for Enforcement of Civil Aeronautics Act of Japan (Order of Ministry of Transport Regulation No. 56, 1952), and is classified as a serious incident. On December 22, 2021, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and two other investigators to investigate this serious incident. An accredited representative of Canada, as the State of Design and Manufacture of the engine involved in this serious incident, participated in this investigation. Comments on the draft Final Report from parties relevant to the cause of the serious incident and the relevant State were invited.

2. FACTUAL INFORMATION

2.1 History of the Flight	According to the statements of the pilot, the onboard mechanic, and the ground operator, the history of the flight is summarized as follows: On December 22, 2021, a Bell 412, JA9584, operated by Aero Asahi

Corporation, made a transport of ready-mixed concrete supplies nine times, using two buckets alternately, from the operation site of the Kiryu Outdoor Activities Center in Kiryu City, Gunma Prefecture (at an altitude of about 1,000 ft (about 305 m), hereinafter referred to as “the operation site”) to the unloading site about 6.2 km away, with the pilot sitting in the right seat and the onboard mechanic responsible for guiding the rotorcraft and operating the bucket sitting in the left rear seat, and then, at about 10:58 Japan Standard Time (JST: UTC + 9hrs, unless otherwise stated all times are indicated in JST on a 24-hour clock), a bucket was attached to the rotorcraft for the 10th (This was the fifth transport using this bucket.)transport.

The bucket of ready-mixed concrete had been prepared by the ground operator, and the pilot and the onboard mechanic confirmed with the load gauge on the cockpit instrument panel that the total weight of the bucket was about 1,000 kg.

The onboard mechanic checked the external condition of the bucket and reported to the pilot that there were no abnormalities.

The rotorcraft climbed while increasing the speed to about 65 kt, and flew towards the unloading site at an altitude of about 1,150 ft (about 350 m).

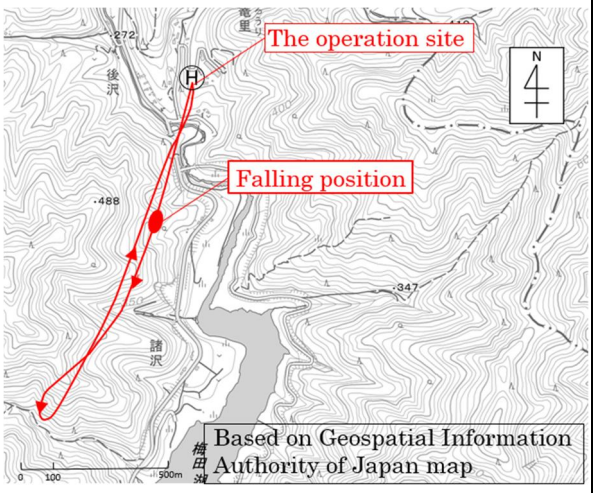

Figure 1: Estimated Flight Route

At about 11:00, the pilot checked the cargo mirror and saw that there was no-ready-mixed concrete in the bucket and the opening in the bottom plate of the bucket.

At this time, the load gauge showed about 190 kg. And the weight of the bucket was 135 kg.

The pilot reduced the speed of the rotorcraft and had the onboard mechanic check the bucket, and it was found that there was no ready-mixed concrete with the bucket door (hereinafter referred to as “the door”) slightly open, therefore the pilot judged that the ready-mixed concrete had fallen.

The rotorcraft returned to the operation site, unloaded the bucket on the ground, then conducted an aerial search for where the ready-mixed concrete had fallen, but was unable to find it, and at 11:07, the rotorcraft landed at the operation site.

The company conducted an aerial and ground search to identify the ready-mixed concrete falling location, and identified the location on December 24, 2021.

The serious incident occurred in the mountains about 540 m of south-southwest of the operation site (36° 29’ 13” N, 139° 24’ 40” E) at about 11:00: on December 22, 2021.

The fallen ready-mixed concrete weighed about 800 kg, but the fall did not

	cause any damage to people or objects on the ground. In addition, there was no influence on the flight such as imbalance in the rotorcraft until it landed at the operation site.
2.2 Injuries to Persons	None
2.3 Damage to the Aircraft	None
2.4 Personnel Information	Pilot; Age 51 Commercial pilot certificate (Rotorcraft) March 14, 2007 Pilot competence assessment/confirmation Expiration date of piloting capable period: May 20, 2023 Ratings and limitations: Type rating for Bell 212: March 24, 1997 Class 1 aviation medical certificate Validity: November 27, 2022 Total flight time 7,177 hours 12 minutes Flight time in the last 30 days 24 hours 24 minutes Total flight time on the type of aircraft 350 hours 17 minutes Flight time in the last 30 days 0 hour 00 minute
2.5 Aircraft Information	Aircraft type: Bell 412 Serial number: 33030 Date of manufacture: May 19, 1981 Airworthiness certificate: No. TOU-2021-011 Validity: April 30, 2022 When the serious incident occurred, the weight and the position of the center of gravity of the rotorcraft were within the allowable range.
2.6 Meteorological Information	According to the statements of the pilot, at the time of the serious incident, there was a north-northwesterly wind of approximately 8 to 10 m/s (there was a variation in wind direction and velocity due to the influence of the topography), with a visibility of more than 10 km and no clouds, a temperature of 8 °C and an altimeter setting (QNH) of 29.96 inHg.
2.7 Additional Information	(1) Bucket Condition The rotorcraft was transporting ready-mixed concrete by hanging a sling assembly, hook and bucket (total length about 20 m), in that order, from the cargo hook attached to the lower fuselage (see Figure 2). The ground operator carried out an operational check on the bucket used for each transport of ready-mixed concrete, and it was confirmed that there was no abnormality until the start of the 10th transport. The door operation from the rotorcraft can be made by using the open/close

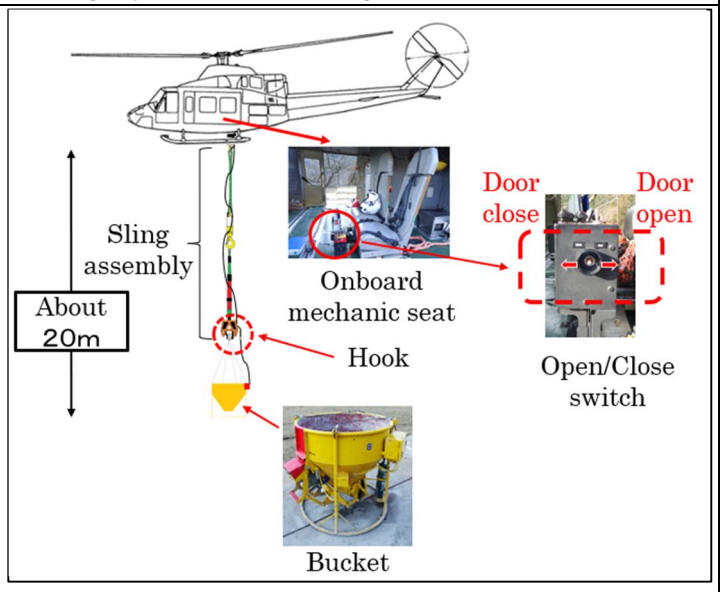

Figure 2: Bucket Slinging Status

switch (hereinafter referred to as "the switch") on the operation panel at the foot of the left rear seat, where the onboard mechanic was sitting.

(2) Open/Close Mechanism of the Door

As shown in Figure 3, the door can open and close as the carbon dioxide pressure activates a rod connected to the opening/closing cylinder. In the door closing condition, the fulcrum is inserted inwards (bucket side) to be the over-centered condition, which acts as a locking mechanism, and the door is locked as the locking cylinder extends downward by the carbon dioxide pressure and would not be opened by the load of the ready-mixed concrete in the bucket. The door opens when the locking cylinder is contracted to disengage the lock, the opening/closing cylinder extends towards the OPEN side of the door, the fulcrum is moved outwards and the over-center locking mechanism is also disengages, thus the door opens via a rod connected to the door.

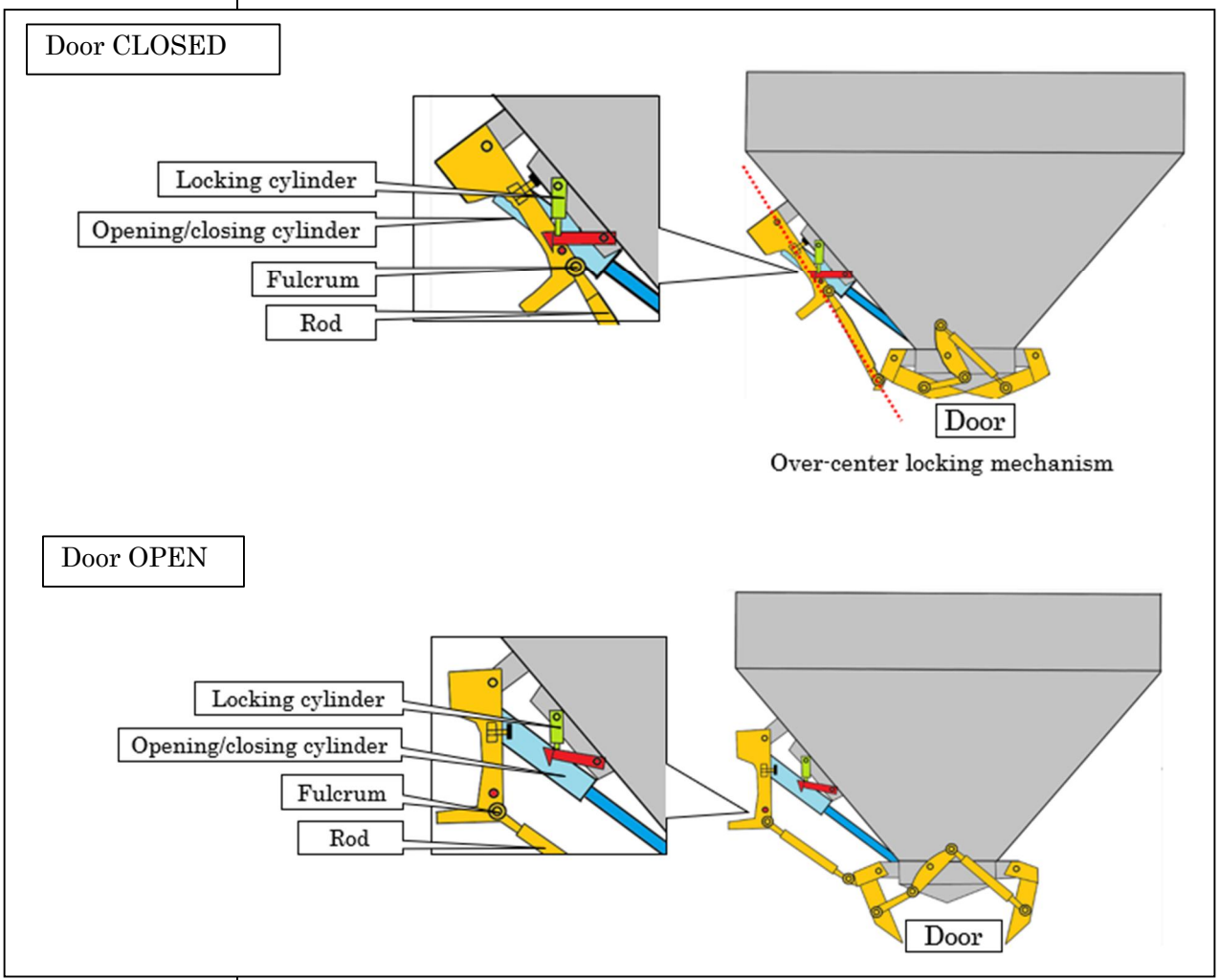

Figure 3: Summary Diagram of Opening/Closing of the Door

(3) Operation of Cylinders and Valves

The outline of the cylinder and valve operation is as follows (see Figure 4):

a. The opening/closing cylinder and the locking cylinder are designed to contract by switching the flow path of carbon dioxide gas for cylinder operation supplied to each cylinder, and to switch the OPEN/UNLOCK position and the CLOSE/LOCK position.

b. In the default position, the opening/closing cylinder is held in the CLOSE

	position when the gas for cylinder operation flows from the carbon dioxide bomb to the CLOSE side, but when the control gas is supplied from the air operation valve, the flow path of the gas for cylinder operation is switched to the OPEN side and the cylinder extends to the OPEN position. c. The locking cylinder is supplied with gas for cylinder operation via the air operation valve from the gas bomb. When gas is supplied to the "LOCK" side, the cylinder extends to the "LOCK" position and when gas is supplied to the "UNLOCK" side, the cylinder contracts to the "UNLOCK" position. d. In the air operation valve, the spool in the valve is held in the CLOSE position by spring force by default. When the spool is in the CLOSE position, the gas for control flow path to the opening/closing cylinder is closed and the gas for cylinder operation is supplied to the LOCK side of the locking cylinder. Accordingly, the open/close cylinder is hold in the CLOSE position and the lock cylinder in the LOCK position, respectively. When the spool in the air operation valve is supplied with control gas from the solenoid valve, it moves from a default CLOSE position to the OPEN position. When the spool is set to the OPEN position, the opening/closing cylinder is supplied with control gas and the gas for opening/closing cylinder operation flows to the OPEN side, at the same time the locking cylinder is supplied with the gas for cylinder operation to the UNLOCK side. Accordingly, the opening/closing cylinder is set to the OPEN position, and the locking cylinder is set to the UNLOCK position, resulting in the opening the door. e. It is designed so that the solenoid valve is supplied with carbon dioxide gas from the gas bomb and when the operation switch on the onboard mechanic's seat is moved to the OPEN position, the solenoid is energized to push the spool in the valve, thereby supplying the control gas to the air supply path to the air operation valve. f. The solenoid valve is equipped with the exhaust path to discharge the exhaust air generated during spool operation into the atmosphere. On the other hand, the air operation valve is equipped with the exhaust outlet to discharge the exhaust from the locking cylinder to the atmosphere, but not the outlet to discharge the control gas supplied from the solenoid valve, therefore it is designed to discharge the control gas via the air supply path in between the solenoid valve from the exhaust path of the above solenoid valve.

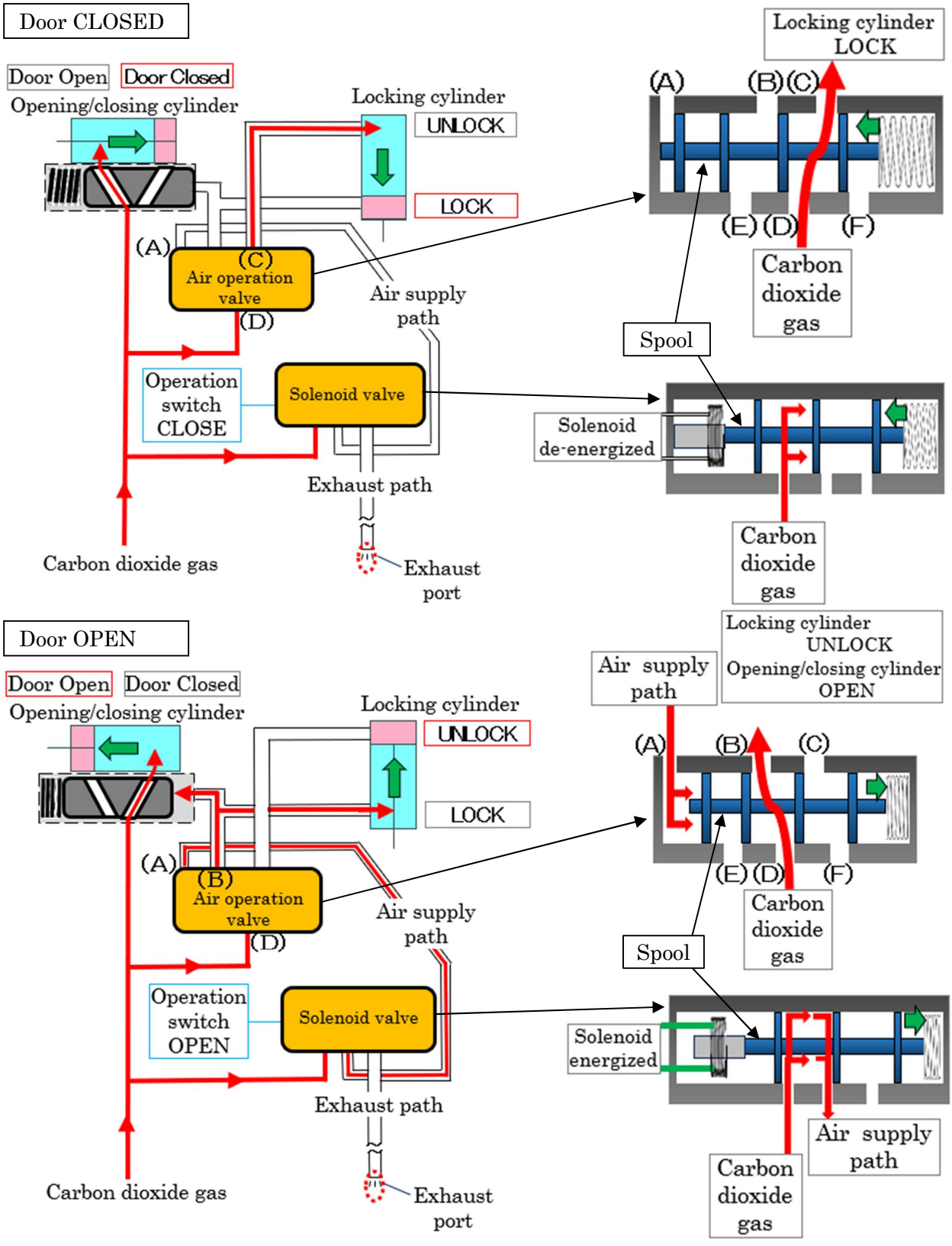

Figure 4: Summary Diagram of the Operation of Cylinders and Valves

(4) Condition of the Bucket after the Serious Incident

After the major incident, the opening/closing cylinder was operating in the CLOSE position, but the door was approximately 3 cm open.

No abnormalities were found during the visual inspection of the bucket components, the switch-to-bucket continuity check, the door operation check, the carbon dioxide gas leakage check and others carried out after the serious incident.

(5) Validation of the Bucket

After the serious incident, the validation of the bucket was carried out as follows:

a. Validation of vibration and impact

Instead of ready-mix concrete, about 870 kg of stone gravel was placed in the bucket, and the locking cylinder was set to the UNLOCK status, however, but the door did not open, even though vibrations and impacts were applied to the bucket while it was locked by the over-center locking mechanism.

When it was switched to the OPEN side for one second, the door opened slightly and continued to open under the weight of the stone gravel, and the stone gravel flowed out vigorously, but with less stone gravel, the door was closed.

b. Validation of exhaust path

A validation was carried out assuming a malfunction with a clogged exhaust port. When the exhaust port was clogged in an environment with temperatures above 10 °C, the door did not open. However, as the outside air temperature at the time of the serious incident was 8 °C, when the exhaust port of the bucket placed in a low temperature environment (below 5°C) was clogged, the locking cylinder and the opening/closing cylinder were activated and the door opened. When the exhaust port was opened the door was closed.

(6) Disassembly Investigation of Bucket Components

Disassembly investigation of each cylinder and valve associated with the door operation revealed that the grease normally applied in the solenoid valve had solidified and adhered to them, and other minute foreign objects were also adhering to the spool.

The composition of the minute foreign objects could not be identified (see Table 1).

Table 1: Results of Disassembly Investigation of Components

Name of components	Results of disassembly investigation	Results of function testing
Opening/closing cylinder	No abnormalities	Normal operation
Locking cylinder	No abnormalities	Normal operation.
Solenoid valve	The grease normally applied in the solenoid valve had solidified and adhered to them, and other minute foreign objects were also adhering to the spool.	Normal operation.
Air operation valve	No abnormalities	Normal operation.

(7) Operations Manual of the Bucket Manufacturer

The bucket manufacturer's instruction manual described the checks before use and the points to be observed during use, but not the inspection method required for continuous use of the bucket, such as the periodic checking of the valves and others.

(8) Ensure Safety in the Transport of Ready-mix Concrete

The company's Flight Operations Procedures for Cargo Transport stipulate that when transporting ready-mix concrete, the rotorcraft should select a flight route that avoids flying over houses, roads, railways and others and that, even in an emergency, does not endanger people or objects on the ground. During the transport of ready-mixed concrete at the time of the serious incident, the pilot complied with the company's procedures to ensure safety and there was no damage to people or objects on the ground.

3. ANALYSIS

(1) Regarding the door's operation

The JTSB concludes that regarding the door opening, it is certain that, although the switch was not operated during the flight, the door opened and the contents of the bucket, ready-mixed concrete, dropped, since the switch on the operation panel had a guard and the onboard mechanic did not operate the switch.

The door is designed be locked by the locking mechanism unless the switch is not operated, therefore, it is possible that when the spool of the air operation valve was temporarily switched, just as when the switch was operated, the locking cylinder and the opening/closing cylinder were operated, causing the door to open.

(2) Air Leakage in Solenoid Valve and Clogged Exhaust Path

The JTSB concludes as follows:

As indicated in 2.7. (5) b., it was confirmed that when the exhaust port was clogged at low temperatures, the locking cylinder and the opening/closing cylinder were operated to open the door.

As shown in Figure 5, it is possible that when in the exhaust path closing condition, if carbon dioxide gas to be supplied to the solenoid valve leaks to the side connecting to the exhaust path in the valve, the internal pressure of the exhaust path will increase and through the path connecting

the solenoid valve and the air operation valve, the carbon dioxide gas will be supplied to the air operation valve. It is therefore likely that this has caused to the spool of the air operation valve to be switched to the door OPEN side and the opening/closing cylinder and the locking cylinder to be operated, causing the door to open.

As shown in Table 1, the results of the disassembly investigation of the solenoid, it is possible that foreign objects, such as solidified grease and others had adhered and mixed into the exhaust path, causing the exhaust path to temporarily clog and the carbon dioxide gas to leak into the valve.

On the other hand, carbon dioxide gas was supplied to the air operation valve, therefore it is possible that it could have leaked into another path in the valve, but as the gas would be released to the atmosphere due to the mechanism of the valve, there would be no possibility of increasing the internal pressure of the air supply path.

Given the above, as a contributing factor to the air operation valve having moved to the door OPEN side, it is possible that the exhaust path has been clogged by the ingress of foreign matter, causing an air leak in the solenoid valve, however the details of the situation could not be clarified.

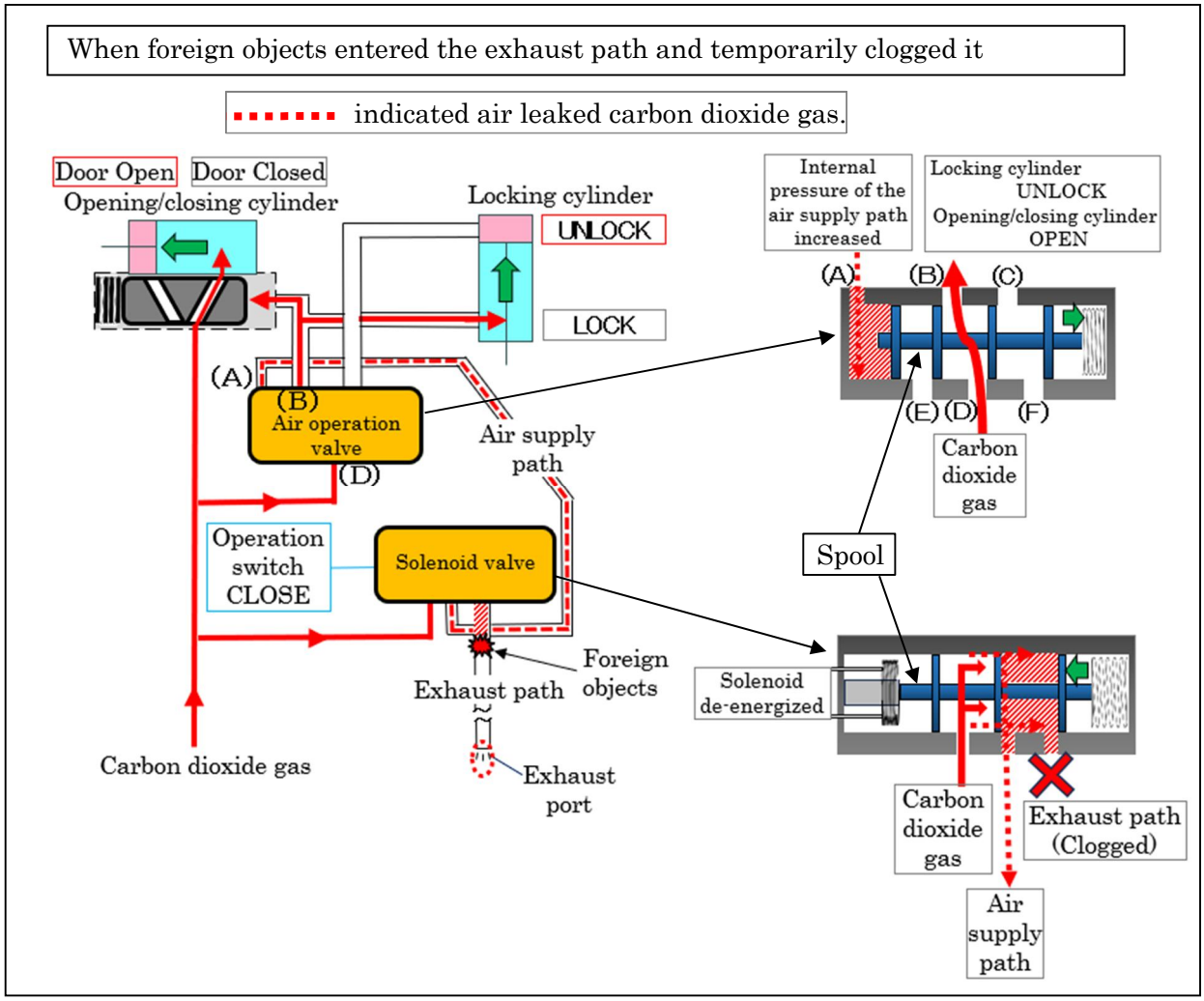

Figure 5: Situation when the Exhaust Path is Clogged (Summary Diagram)

(3) Periodical Inspection

The JTSB concludes that since the bucket is designed to control the locking cylinder as a safety device and the opening/closing cylinder through the same air operation valve, it is likely that the air operation valve may be opened due to a malfunction of the solenoid valve and the air operation valve. In addition, it is also possible that the clogged exhaust path would cause the air operation

valve to operate. Therefore, it is important to carry out maintenance and management, such as cleaning the inside of the pipes and checking the valves periodically, as foreign objects are mixed into the pipes or valves of the bucket used to transport ready-mixed concrete, which could possibly affect the operation of the valves.

In addition, it is probably desirable for the operation of the door and safety devices such as the locking mechanism to be controlled by different systems, respectively.

4. PROBABLE CAUSES

The JTSB concludes that it is certain that in this serious incident was that the rotorcraft, while flying with the bucket of ready-mixed concrete hanging outside, dropped ready-mixed concrete from a bucket because the door of the bucket opened unintentionally.

The door of the bucket opened inadvertently was likely because the exhaust path of the solenoid valve was temporarily clogged by foreign objects, causing the control carbon dioxide gas in the valve to leak into the exhaust path side, and the internal pressure in the exhaust path and the air supply path to increase, and the spool of the air operation valve was switched, causing the door to open, but this could not be clarified.

5. SAFETY ACTIONS

5.1 Safety Actions Required	When transporting ready-mixed concrete, the company's Flight Operations Procedures for Cargo Transport should be observed, and as indicated in the analysis, regular inspection and maintenance of the bucket should be carried out to prevent foreign objects from entering the air supply and exhaust paths and to enable early detection of foreign objects if they do enter, in order to prevent valve malfunction. In addition, design improvements are required to ensure that even if foreign objects enter the valve, the bucket will not open and the contents will not fall out.
5.2 Safety Actions Taken after the Serious Incident	(1) Safety Actions taken by the Company a. After the serious incident, the use of all of the gas-type buckets in the company was suspended. (December 22, 2021) b. All company employees involved in sling work were provided with education and training of cargo transport sling work on the subject of this serious incident. (February 18, 2022) c. The company and the bucket manufacturer conducted repair work for the air supply and exhaust paths of the bucket such as adding the independent exhaust path to each valve. (April, 2024) d. It was decided that after revising the bucket inspection list to include an additional item to check for dirt on the element inside the air filter or fogging of the inspection window before it is placed on site and then the bucket is put into service.