Report of Incident Investigation on

Helium Balloon Ride at Ocean Park

Electrical and Mechanical Services Department

30 August 2012

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Executive Summary

On June 28, the Helium Balloon Ride at the Ocean Park carrying seven passengers and one pilot on board landed to the planter around 29 m away from the landing platform, causing injuries to six persons.

The Electrical and Mechanical Services Department (EMSD) completed an investigation on the cause of the incident. The findings indicated that the incident was caused by the loss of helium as a result of the opening of the rip panel. The rip panel is located near the top of the balloon and is used for quick deflation of the balloon at ground in case of emergency (e.g. typhoon) to avoid hazard.

In summing up the results of inspection and tensile testing, the EMSD came to believe that the thermal and mechanical cyclic effects of the balloon during operation had reduced the adhesion of the covering strips, and caused the formation of local detachments. The tensile strength of the joint was thereby weakened. These detachments were extended upon further operation cycles, resulting in splitting at the joint. As a result, helium gas leaked from the opening and caused this incident. The Ocean Park previously identified and rectified local detachments formed at the corner edge of the covering strip during periodic inspection; however, if any detachment formed in the central part of the covering strip, it would be rather difficult to detect during periodic inspection.

To prevent recurrence of similar incident, it is recommended that the Ocean Park and the balloon manufacturer to work out a comprehensive method to inspect the rip panel joint.

Report of Incident Investigation on
Helium Balloon Ride at Ocean Park

A. Objective

1. This report presents the results of the investigation by the Electrical and Mechanical Services Department (EMSD) on the incident of the Helium Balloon Ride at the Ocean Park on 28 June 2012.

B. Background of the Incident

2. On 28 June 2012, the Helium Balloon Ride at the Ocean Park, carrying seven passengers and one on board operator (pilot), was descending (retrieving by the winch) from about 60 m above the ground at around 3:48 pm (please refer to Figure 1a and Figure 1b).

3. At around 20 m above the ground, the balloon was descending faster than the retrieving speed of 0.65 m/s (please refer to Figure 1c) and gradually landed to the planter around 29 m away from the normal landing platform (please refer to Figure 1d) with the remaining buoyancy provided by the residual helium.

4. Four passengers and the operator in the gondola sustained minor injuries while a female guest on the pathway near the landed gondola sustained head injury.

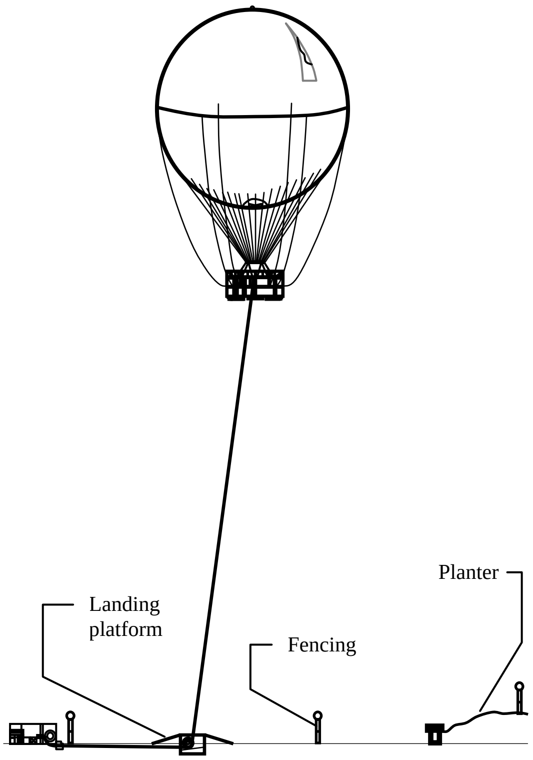

Figure 1a – Helium Balloon at 60 m

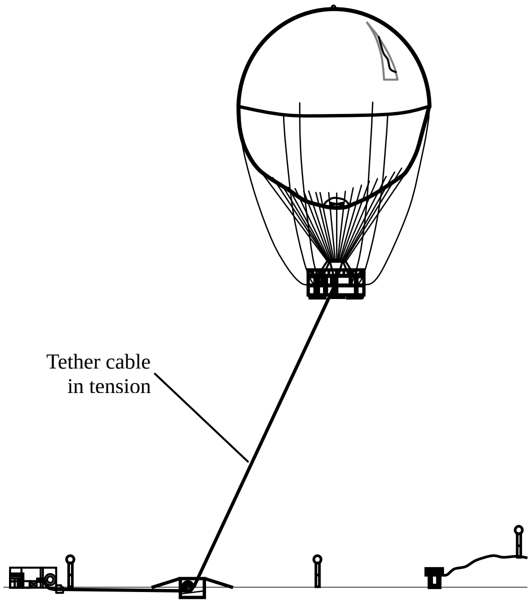

Figure 1b – Balloon descending at 0.6 m/s

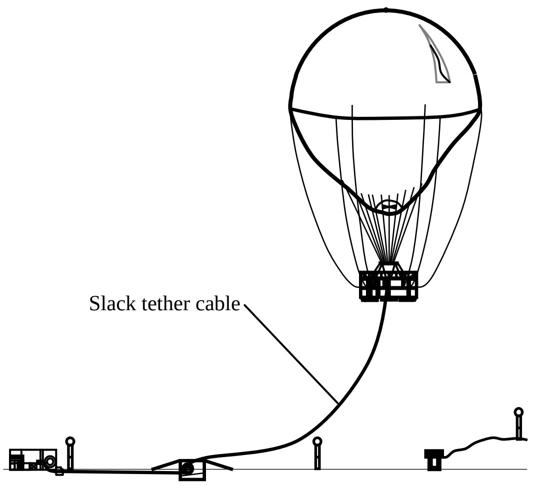

Figure 1c – Balloon descending at higher speed at around 20 m above ground

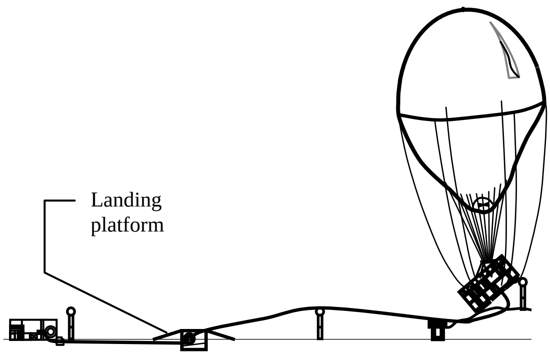

Figure 1d – Gondola landed on planter

C. Approach of investigation

5. The EMSD conducted an investigation with a view to identifying the root causes of the incident and recommending enhancement measures to prevent recurrence of similar incidents.

6. The approach of the investigation is outlined as follows:

a. to inspect the components of the Helium Balloon Ride;

b. to analyse CCTV footage;

c. to conduct examination and specific laboratory tests on the balloon envelope and rip panel with support from an independent material expert;

d. to review and analyse relevant records, in particular the maintenance records and operational log records of the Helium Balloon Ride; and

e. to interview and collect statements from parties involved.

D. Technical information of the Helium Balloon Ride at Ocean Park

7. The Helium Balloon Ride consists of the following major components (please refer to Figure 2 and Figure 3):

a. Balloon envelope – The fabric of the balloon envelope comprises a textile base in the middle layer made of rip-stop polyamide specially coated on both sides. The inside is coated with anti-static rubber membrane, ensuring low helium porosity while the outside is coated with chlorosulfonated polyethylene (CSP) to protect the fabric from ultraviolet radiation. The diameter of the envelope is 22.46 m making a total volume of 5 950 m^3. It is separated into two compartments by a membrane, namely the helium compartment and the ballonet. The helium compartment is around 4 300 m^3 in volume to provide the buoyancy to the balloon and its payload and when the envelope is inflated, it forms a spherical shape. The ballonet is used to pressurize the helium in the envelope and to maintain the spherical shape of the envelope under wind. Ballonet expands and contracts to compensate the changes in helium volume due to varying temperature and altitude. The ballonet fan which drives air into the ballonet is located at the bottom of the envelope.

b. Net – The net consists of a series of interlinked ropes, formed into a diamond pattern, which are sized to fit over the envelope. The net contains all the buoyancy generated in the envelope and the bottom of it is connected onto the load ring in order to transfer the buoyancy into the load ring.

c. Load ring – The load ring is constructed from tubular stainless steel. It acts as a junction for the major system components. While the net transfers all the buoyancy generated by the balloon into the upper side of the load ring, a gondola is suspended from the lower outer side of the ring. A tether cable is also attached to the lower side of the ring.

d. Gondola – The gondola is a welded aluminium framework. It is spaced to create a narrow walkway, sufficiently wide to allow people to pass each other but narrow enough to deter bunching of the passengers at one side of the gondola. The sides above the handrail and the top face of the framework are covered by mesh which provides restraint of the passengers whilst affording good visibility.

e. Cable and winch system – The tether cable is attached to the lower inner side of the ring and a load cell which is fitted at the bottom of the load ring and the top of the winch cable to measure the load applied to the tether cable with the readout located in the control panel. The other end of the tether cable is connected to the winch house and the altitude of the balloon is controlled by the electric winch at constant ascending and descending speeds of 0.8 m/s and 0.65 m/s respectively.

f. Rip panel – The rip panel is of triangular shape and serves for quick emptying of the balloon. It starts at a distance of approximately 4 m from the north pole of the balloon and runs with a panel over a length of approximately 7 m towards the equator (please refer to Appendix 1 for the details of the rip panel and its operation).

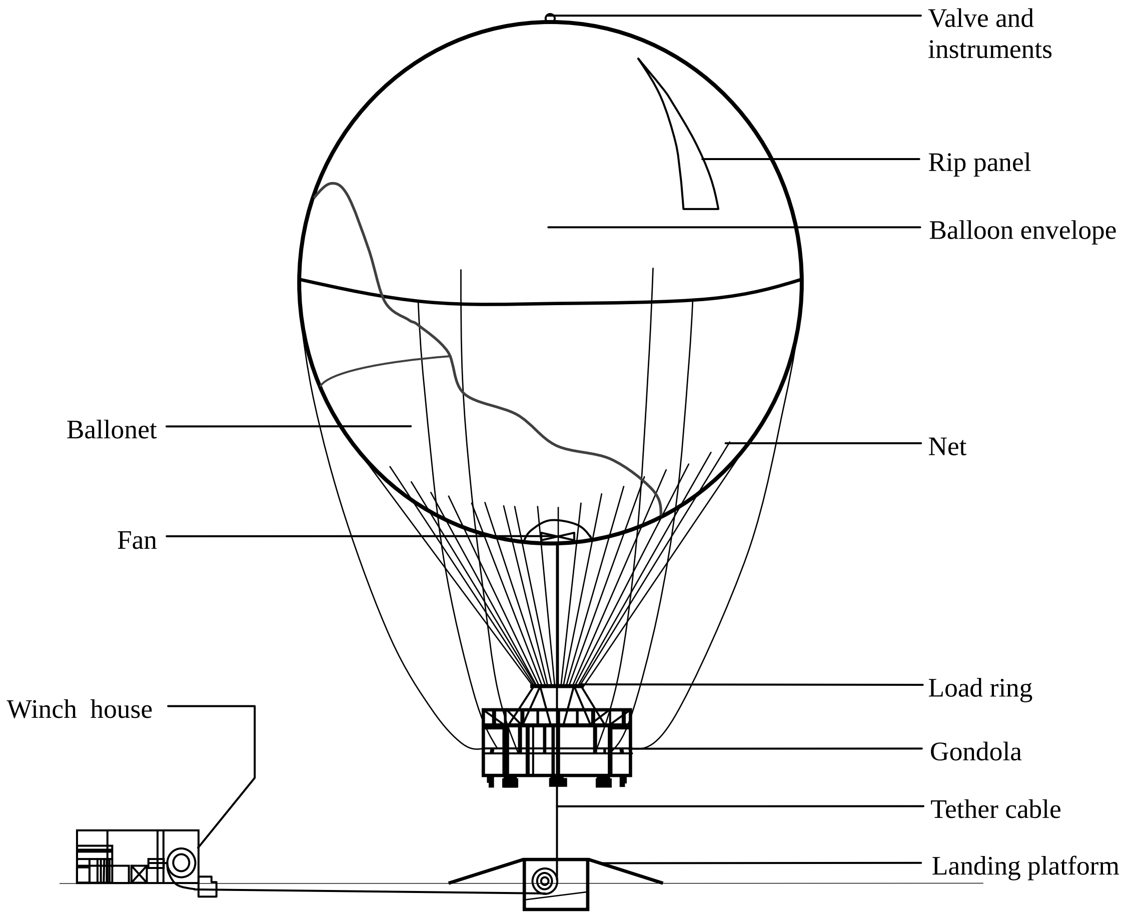

Figure 2 – Schematic diagram of Helium Balloon Ride

8. The Helium Balloon Ride can carry a maximum of 30 persons (including the pilot). Depending on the wind speed, the allowable carrying capacity may vary. In order to maintain sufficient buoyancy to withstand the wind effect, fewer passengers will be carried by the balloon under high wind situation.

9. The maximum height the balloon can reach is determined by the length of the tether cable and the normal operating height of the Helium Balloon Ride at the Ocean Park is 60 m. For each flight cycle, the gondola with pilot and passengers on board will be lifted up to 60 m above ground and will stay at that height for around one minute before descending back to the landing platform.

10. If very high wind speeds are forecast (110 km/h or more) or if the movement of the balloon is too vigorous under heavy storm (due to broken mooring ropes or damaged tether system), it is required to empty the balloon by use of the rip panel. This deflation must be done before the wind increases too much in order to prevent damage to the envelope. The opening of the rip panel is controlled by the rip panel rope (red command rope). The operator can pull the rip panel rope in order to open the rip panel.

Figure 3 – Photo of Helium Balloon Ride

E. Observations and findings

11. According to the operation log retrieved from the on-board control computer, the pressure of helium inside the envelope started to drop when the balloon was at a height of around 60 m above ground at around 3:48 pm. That implied the leaking of helium started at that altitude.

12. Within the next 20 seconds, the balloon began to descend at normal speed of around 0.6 m/s.

13. At a height of around 20 m above ground, the descending speed increased to around 1.2 m/s which indicated that the buoyancy force given by the remaining helium in the envelope was less than the overall weight of the balloon, and the tether cable became slack.

14. Due to the wind effect, the balloon was dragged off from the landing platform and landed to the planter at around 29 m away from the landing platform.

15. As revealed in the operation log, the balloon was operating under the design operating conditions (including the temperature and pressure of helium) during the flight cycle concerned. The recorded maximum wind speed before and during the flight cycle concerned was 8 m/s which was below the permissible maximum operating wind speed of 13 m/s.

16. Besides, prior to the flight cycle of the incident, around 40 flight cycles were made on the day of the incident. No significant pressure drop was recorded before the incident which indicated that there was no noticeable leakage of helium before the incident.

17. The tether cable and the winch system were inspected after the incident. No irregularity was found on them.

18. Inspection of the balloon envelope was conducted on site. Apart from the cuts made by the staff of Ocean Park immediately after the incident for releasing the remaining helium inside the envelope (which could be distinguished by the nature of the incisions), the only noticeable opening on the envelope was found in the rip panel.

19. According to the design of the rip panel, the rip panel tongue is adhered to the balloon envelope by means of covering strips on the external surface (please refer to Appendix 1 for the details of the rip panel and its operation).

20. It was however found that the right-hand edge of the rip panel tongue was detached from the right covering strip and split from the right-hand rip panel joint (please refer to Figure 4) and the air tightness of the balloon could not be maintained. It is believed that the helium escaped from this opening leading to a loss of buoyancy.

21. The balloon envelope and rip panel concerned had been put into operation for over 3 years at the Ocean Park. During the commissioning of the balloon envelope, pressure test was conducted to check for leakage of helium and no irregularity was recorded. Besides, apart from the routine maintenance carried out by the maintenance staff, the balloon had been inspected annually by the manufacturer and no irregularity was observed and reported in the past inspections (the last inspection was carried in February 2012).

22. The airworthiness of this particular type of balloon has been certified by the Direction Générale de l'Aviation Civile (DGAC, the French Civil Aviation Authority) and the designs and specifications of the Helium Balloon Ride have been approved by the EMSD.

23. Besides, the rip panel is a typical design for gas balloons for emergency deflation. Around 40 nos. of this type of balloon have been fabricated by the manufacturer and operated worldwide, no similar incident was recorded.

24. The tensile tests conducted had shown that the factory-bonded rip panel joint could provide sufficient strength.

25. Upon inspection of the opening of the rip panel, it was found that the right-hand edge of the rip panel tongue completely detached from the rip panel joint (please refer to Figure 5b) while the left-hand side remained intact. This indicated that the split on the right-hand side was not caused by the pulling action of the red command rope as such action would have torn both sides of the rip panel joint at the same time. The finding was consistent with the statement taken from the pilot on board that no one had touched the command ropes during the course of the flight cycle. Therefore, the manual operation of the rip panel is excluded from the cause.

26. There were areas with signs of local detachments found at the left covering strip despite the fact that the left covering strip was basically intact.

Figure 4 – Failure in right-hand rip panel joint (the orientation is reversed as viewed from inside of envelope)

Figure 5a – Detachment in left covering strip at the edge (circled in blue)

Figure 5b – Some detachments in left covering strip at the centre (circled in red)

Right covering strip detached from the rip panel tongue (circled in green)

27. These local detachments were found at the centre as well as the edge of the left covering strip (please refer to Figure 5a and Figure 5b). It was suspected that such local detachments might also be present at the right covering strip before the incident.

28. The rip panel joint was subject to expansion and contraction as well as thermal effect during operation[1] and the adhesion between the covering strip and the rip panel joint could be degraded by these cyclic effects, hence these local detachments were formed.

29. Subject to the thermal and mechanical cyclic effects throughout the repeated flight cycles, it is likely that the size of these local detachments grew progressively (please refer to Figure 6).

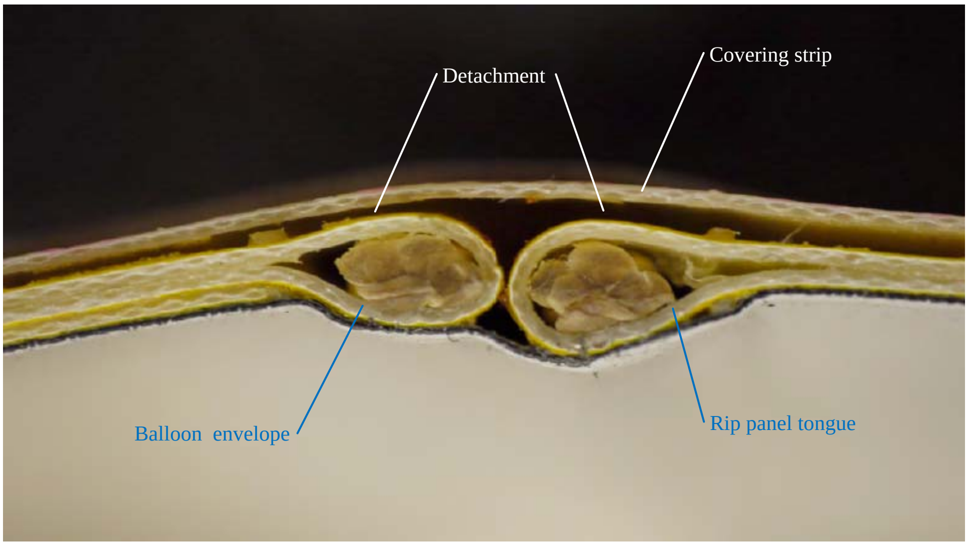

Figure 6 – Cross section of the rip panel joint with detachment of covering strip

30. According to the inspection and maintenance records, there was an occasion where local detachment at the corner edge was found during routine inspection and rectified according to the instruction from the manufacturer. However, it is considered that when the balloon is inflated, these detachments in particular those at the centre would be rather difficult to detect.

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[1] According to the operation log, the temperature of the helium could reach as high as 59ºC when the ambient temperature was at around 30ºC on the day of the incident. Furthermore, the pressure inside the helium compartment varied with the change in altitude during operation. As the stress acting on the balloon envelope was proportional to this internal pressure, the balloon envelope and the rip panel joints had been subject to expansion and contraction as well as thermal effect during operation.

F. Conclusions

31. In view of the above, it was concluded that the loss of helium of the Helium Balloon Ride on 28 June 2012 was resulted from the opening of the rip panel joint.

32. The opening of the rip panel was probably attributable to the detachments of the covering strip. It is likely that the formation of these local detachments could be due to thermal and mechanical (i.e. expansion and contraction) cyclic effects during operation.

33. Subject to the thermal and mechanical cyclic effects throughout the repeated flight cycles, the size of these local detachments progressively grew. The rip panel joint strength was therefore further weakened and resulted in splitting at the joint.

G. Recommendations

34. Taking into account of the above findings, it is recommended that the Ocean Park and the balloon manufacturer to work out a comprehensive method to inspect the rip panel joint.

35. The EMSD will consider allowing the resumption of operation of the balloon only when the effectiveness of the improvement measures is confirmed.

Electrical and Mechanical Services Department
30 August 2012

Appendix 1

Rip panel and its operation

A1. As the rip panel was found split during the inspection of the balloon envelope on site which appeared to be the cause of the opening of the rip panel joint, the description of it is presented in the following paragraphs (please refer to Figure A1).

A2. The rip panel is of triangular shape and serves for quick emptying of the balloon. It starts at a distance of approximately 4 m from the north pole of the balloon and runs with a panel over a length of approximately 7 m towards the equator.

Figure A1 – Photo of the rip panel (rip panel joint indicated by dotted line)

A3. The detachable part of the rip panel is called the rip panel tongue. The rip panel tongue is sized to fit exactly into the rip panel. The rip panel joints are covered and bonded with specific cement by three 100 mm wide fabric covering strips (using the same fabric of the balloon envelope) on the sides and bottom as well as one 200 mm wide fabric covering strips on the top (please refer to Figure A2 and Figure A3a).

A4. According to the information provided by the manufacturer, the balloon envelop and the rip panel tongue were aligned and kept in place by three 40 mm wide adhesive backing tapes in order to facilitate the bonding of the covering strips by specific cement during fabrication (please refer to and Figure A2 and Figure A3b). The backing tapes are not designed to carry the load in the rip panel joints.

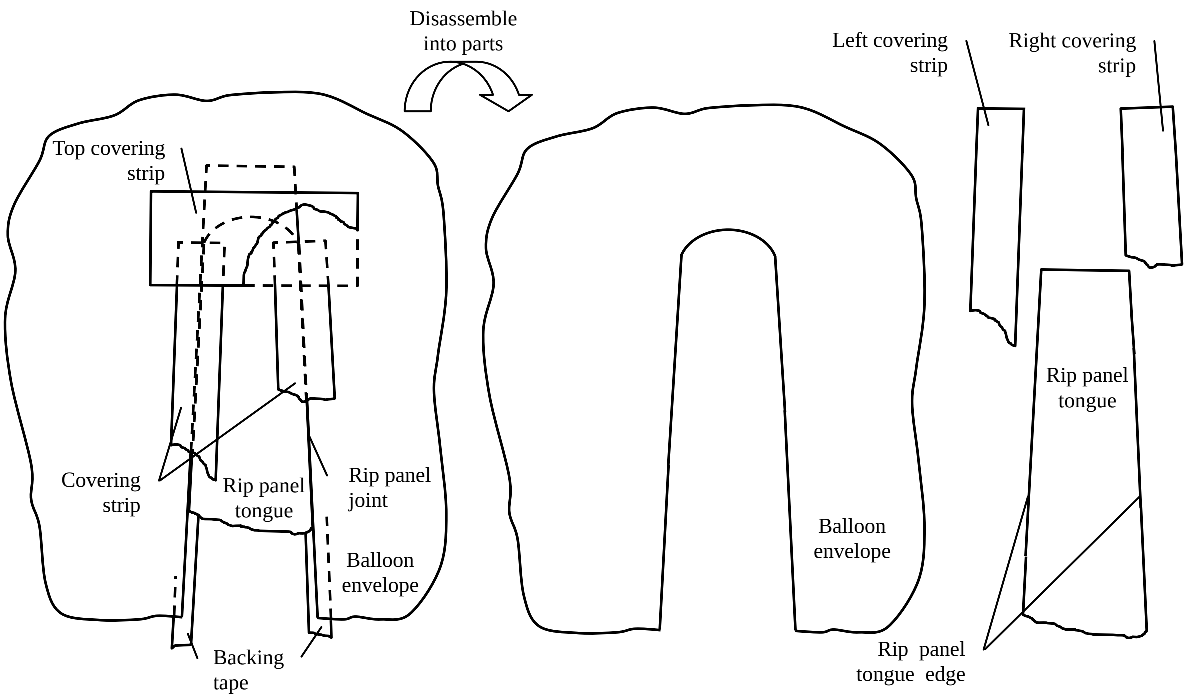

Figure A2 – Fabrication of the rip panel

Figure A3a – Photo of the covering strips

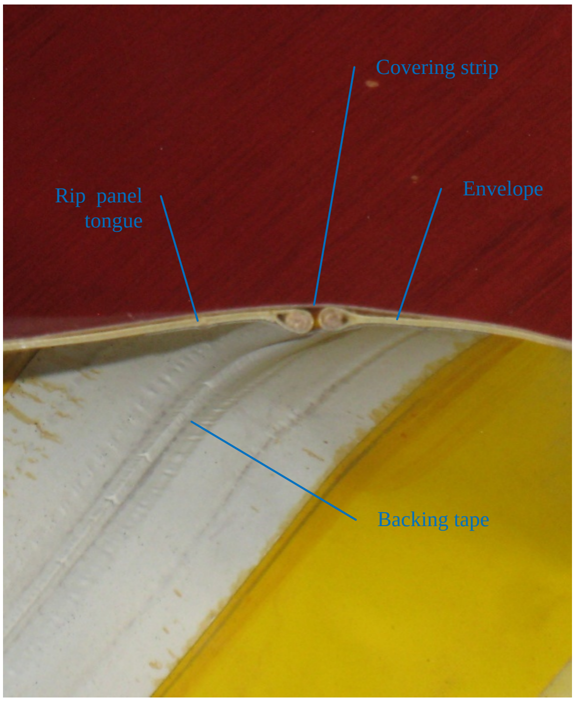

Figure A3b – Cross-section of the rip panel joint

A5. At the top end of the rip panel tongue, a steel ring is sewed on with a while belt which in turn is connected to the red command rope. The steel ring is fixed to the patch of the rip panel using backing tapes to prevent unintentional opening and at the same time to ensure the command rope can be operated at a force of 200 N.

A6. If very high wind speeds are forecasted (110 km/h or more) or if the movement of the balloon is too vigorous under heavy storm (due to broken mooring ropes or damaged of the tether system), it is required to empty the balloon by use of the rip panel. This deflation must be done before the wind increases too much in order to prevent damage to the envelope. The opening of the rip panel is controlled by the rip panel rope (red command rope). The operator can pull the rip panel rope in order to open the rip panel. The backing tapes attaching the steel ring of the rip panel tongue to the patch will break first. The backing tapes at the two long sides of rip panel tongue will then be torn and the rip panel tongue will fall into the inside of the balloon.