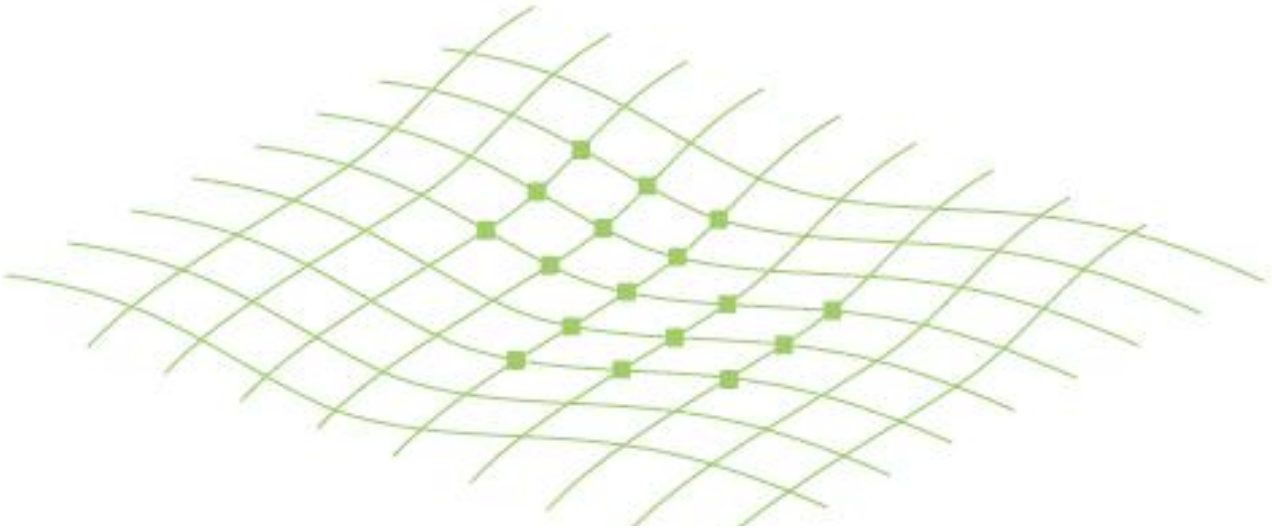
BRITISH COLUMBIA SAFETY AUTHORITY

THE EXCALIBUR GONDOLA INCIDENT

December 16, 2008



Safety Authority

Prepared by:	**Provincial Safety Manager, Passenger Ropeway and Amusement Devices**
Date:	**July 12, 2010**
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Table of Contents

Executive Summary

In the early afternoon of December 16, 2008 the lower section of Tower #4 of the Lower Excalibur Gondola passenger ropeway cracked resulting in the top section completely separating from the lower section of the tower. The top of the tower then fell to the ground in an upright position supported by the communication cables attached to the top of the top section.

At the time of the failure the Excalibur lift was carrying a total of forty-three passengers. Following efforts taken to secure the lift, these passengers were immediately evacuated by ski patrol staff and local emergency services. Twelve passengers were injured. Their injuries ranged from a fractured vertebra and concussion (reportedly the most serious injury) to bruises and contusions.

The Excalibur lift was also damaged as a result of the tower failure. Six of a total of thirty-three cabins were damaged to various degrees. Several of the ropeway sheaves, which are fitted to the top of the towers to carry the lift rope were damaged and the lift rope itself suffered minor damage.

Intrawest the owner and Blackcomb Skiing Enterprises Ltd. the operator of the Lower Excalibur Gondola passenger ropeway, informed the Provincial Safety Manager in accordance with regulations. The Provincial Safety Manager requested the site to be secured and dispatched a Safety Officer as a first step in starting a formal investigation of the incident. The operating permits for both the lower and upper Excalibur Gondola lifts were suspended pending investigation and repairs.

The BC Safety Authority initiated an investigation into the failure incident consisting of the following primary activities or elements:

- A review of the various metallurgical tests and examinations undertaken by Acuren, which was commissioned by Intrawest, on the section of the tower where the crack initiated and subsequently failed,
- A review of Intrawest's inspection and maintenance records for the lower Excalibur Gondola lift was undertaken,
- Analysis of all documents obtained during the on site investigation including witness's statements,
- A review of various codes and standards that apply to the design, inspection, maintenance and operation of this type of Gondola lift,
- An independent analysis of the Acuren findings undertaken by Pol-X West,
- A root cause analysis of the incident undertaken by a multi-disciplinary team within the BC Safety Authority, and
- Identification of recommendations to prevent future occurrences.

Tower #4 was designed by the manufacturer to be sealed to prevent water ingress and exposure to oxygen to inhibit corrosion of the inside of the tower tubes. However, over the 14 years since the Excalibur lift was installed, water did enter the tower inner cavity

collecting in the lower section. The water accumulated above a column of concrete that was poured into the lower section of the tower during its installation. Although tests for water accumulation were conducted during periodic inspections of the tower, the test, called a resonance or dead blow hammer test, did not detect the water in the tower. The test method is dependent on the tester's knowledge of the tower's "as built" construction such as the level of concrete within the tower cavity as well as, previous test experience and adequate test instructions. The use then, of the hammer blow test to confirm the presence of water within a tower is not always definitive. The records of inspections carried out on Tower #4 and results of the resonance testing undertaken were vague making an accurate assessment of the reliability of the testing difficult.

Between December 13 and December 16, 2008 a cold front dropped temperatures in the Whistler-Blackcomb area to as low as -15°C, well below the seasonal average of -3.2°C. The water inside the lower tower section froze causing a column of ice to form on top of the concrete. As the water froze, the ice expanded. The ice then began imparting a longitudinal force onto the splice coupling plate, as well as an axial force directly onto the weld of the splice coupling plate.

Acuren's report identified the failure mechanism as being a brittle fracture that started in the weld that joined the splice coupling plate to the lower tube section. Acuren also indicated that there were two other factors, which may have contributed to the fracture of the weld:

- Results of metallurgical tests of the steels used in the tower indicated reduced toughness at lower temperatures and therefore potentially more susceptible to brittle fracture, and
- A pre-existing crack within the weld may have contributed to the start of the December 16 brittle fracture.

The Provincial Safety Manager is of the view the forces created from the expansion of the ice were the primary contributors to the stresses that initiated the December 16 crack causing the tower to fail; the tower was not designed to withstand the forces of the expanding ice column. Other factors such as low temperature toughness, the pre-existing crack and stresses from independent loadings such as those that occur when a gondola passes through a tower's sheaves may have contributed to the failure stresses. However, based on the information available to the BC Safety Authority at the time of this Report the BC Safety Authority cannot definitely conclude whether such additional loadings did or did not contribute to the failure.

These findings have led to the BC Safety Authority to make the following recommendations as a means of reducing the risk of a similar failure occurring in the future:

1. All operators of passenger ropeway installations must assure towers are fitted with drain holes or have equivalent strategies in place to prevent the accumulation of water as required in the CAN/CSA Z98 standard.

2. Manufacturers must ensure the required inspection procedures, as described in the safety bulletins, clearly and effectively communicate all requirements to undertake an effective inspection.
3. Passenger ropeway contractors must verify the effectiveness of their internal communication processes to ensure that manufacturer's safety bulletins are followed correctly by staff and that the results of any inspections or tests are properly recorded and documented.
4. Manufacturers must ensure 'as built conditions' are properly documented and transferred to the owner/operator as an integral part of the installation process.
5. BCSA will submit the findings of this report to the CAN/CSA Z98 Technical Committee for review and discussion of possible code changes.
6. The BC Safety Authority shall improve their internal communication processes to ensure Safety Officers are aware of and understand the safety bulletins issued by manufacturers as well as improve the rigor of documenting this process.

Part 1 – The Site, Incident, and Impact

The Site, Whistler-Blackcomb Mountain

1. Whistler-Blackcomb Mountain is a resort operation owned by Intrawest ULC since March of 1997. Whistler Mountain Limited Partnership and Blackcomb Skiing Enterprises Ltd. each hold valid passenger ropeway contractor licenses with the latter being responsible for operation, maintenance and testing of the Lower Excalibur Gondola.

2. The Lower Excalibur Gondola passenger ropeway is an eight-passenger detachable gondola lift. A detachable gondola is a circulating passenger ropeway with fully suspended cabins that travel in one direction and detach/attach from the haul rope in each station. Detached cabins have a station speed below 1.0 M/S and a maximum line speed of 5.0 M/S when attached to the haul rope. Detached cabins are slowed in stations to permit easy loading and unloading of passengers.

3. The Lower Excalibur Gondola lift was constructed and installed by Doppelmayr Lifts in 1994. The passenger ropeway was registered by the Province of British Columbia in 1994 under registration number 140.021. The Province of British Columbia conducted the acceptance inspection for this installation on November 18, 1994.

4. Regular inspections were conducted on the Excalibur Gondola by the Government of British Columbia and the BC Safety Authority up until the failure of Tower #4 on December 16, 2008. These inspections included periodic visual examinations of line towers. No non-compliances in regard to structural integrity of the towers or other structural members were identified.

5. Prior to this incident, the Lower Excalibur Gondola operated for 14 years without a serious incident. Two non-serious incidents relating to the operation of the Lift and one involving a rope grip operating roller are the only incidents that were recorded during its entire operating history.

6. There are a total of nine line towers installed on the lower Excalibur lift. Three of the nine towers are of a two-piece design including Tower #4. The position of Tower #4 is adjacent to the east side of Fitzsimmons Creek.

7. The specifications for the steel tubes or pipe from which the lower and upper sections of Tower #4 were fabricated are identified in Table 1. Design details for lower and upper sections are identified on Drawings No. 19219 D 051500 rev. b and 20002605H006822 rev. b respectively. The original design of Tower #4 was for both the upper and lower sections to be sealed against the environment and more specifically against the ingress of water. The Tower #4 splice coupling plate connecting the two sections of the tower together is shown on Drawing No. 19230 D 051500 rev. b. The details of this splice coupling plate show a rectangular hole was cut in the plate to facilitate filling the lower section of the tower tube with concrete. Communications with Doppelmayr confirmed that the lower section of Tower #4 was designed to be filled with concrete to a height of 4 meters above the base. However, as a result of this investigation, Tower #4 was found to have concrete inside the lower tower section up to a level of 7.8 meters. No submitted drawings identified what the minimum level of concrete was or the actual level of concrete that was found within the lower section of Tower #4. The welding detail shown on the drawing for connecting the splice coupling plate to the lower section of Tower #4 requires a partial penetration butt/fillet weld. The weld detail also shows that the last 2mm are not penetrated. Doppelmayr's Chief Welding Engineer in Austria stated the following with regard to the weld details:

`*"Based on the drawings, the weld is not a full penetration weld, but a partial penetration weld with a weld size of 12.5 mm (weld size = thickness of tube). The interpretation that the joint was intended to be a full penetration weld is wrong, the weld shown on Detail A of drawing 19219D051500b is not a full penetration weld, but a partial penetration butt/fillet weld. It shows on the drawing that the last 2mm are not penetrated, therefore we don't think there was anything wrong with the welding."*

Table 1: Tower #4 Specifications

	Lower Section	Upper Section	Lower Splice Coupling Plate
Outside diameter	762 mm (30")	610 mm (24")	--
Thickness	12.7 mm (0.5") (wall thickness)	9.5 mm (0.375") (wall thickness)	35 mm
Length	9,730 mm	7,002 mm	--
Material	API Grade X42	ASTM A53	ASTM A36

8. At the time of the incident, the Lower Excalibur Gondola lift had 23,948.95 hours of operation recorded on the hour meter. This is considered average for an installation of this age (i.e. approximately 14 years old) that operates primarily during the ski season for approximately 9 hours per day.

9. The last recorded line speed that the ropeway or gondolas were travelling at, before tower #4 failed was 3.9 M/S. This is within the design parameters of the maximum permitted speed of 5.0 M/S.

The Incident

10. In the early afternoon of Tuesday December 16, 2008 lift maintenance personnel at Whistler Blackcomb were informed of a noise coming from Tower #4. The reported noise was consistent with the sound caused by the carrier grips contacting sheave assembly components. A lift mechanic was dispatched immediately to investigate and conduct an inspection of Tower #4. After climbing the tower to investigate he discovered that the uphill and downhill sheave assemblies were misaligned causing the haul rope to run to the inside of sheave liner grooves. This caused the carrier rope grips to contact the incoming inside rope guards. He then left the tower to retrieve some tools in order to perform a re-alignment of the sheave assemblies.

11. After retrieving the required tools the lift mechanic climbed Tower #4 and requested a reduction in line speed from dispatch to realign the two-sheave assemblies by adjusting the console bolts. Once the mechanic was satisfied the sheave assemblies were properly aligned he called dispatch to give permission for the gondola to resume normal operating speed. Then he spent several minutes on Tower #4 monitoring the alignment and ensuring no further adjustments were required. Once the lift mechanic was satisfied the sheaves were properly aligned he climbed down and returned to the drive station.

FIGURE 1.

Tower #4 Separation

12. At approximately 14:14, as the lift mechanic approached the gondola drive station, the Excalibur lift stopped. The dispatch office immediately announced a major 10-60 (radio code for announcing lift malfunctions). The lift mechanic checked the low voltage safety circuit panel for the Lower Excalibur Gondola at the drive station and found a derail indication for both tower safety circuit loops on Tower #4. The return station operator was contacted to ask if the operator could see anything abnormal and he reported that three cabins were on the ground from his observations looking uphill from

the return station. The lift mechanic instructed the drive station to keep the lift secure. He left to inspect the lift line and discovered that Tower #4 had completely separated at a point just below the bolted splice coupling plate connecting the upper and lower sections together. The upper section of Tower #4 was located on the ladder side of the lower tower section. The upper tower section was in an upright position and was supported by communication cables attached to the top of the lifting gantry and the haul rope, which was located just under the tower cross-arm.

13. Evacuation of passengers was initiated approximately 25 minutes after the tower failed. During that time lift maintenance staff secured the ropeway to ensure there was no risk of further haul rope movement from the damaged components. A total of 43 passengers were manually evacuated from the gondola by ski patrol staff and local emergency service personnel. No injuries to passengers or emergency services personnel occurred during the evacuation process.

14. Six cabins out of a total of 33 cabins were damaged. Several tower sheave assemblies received impact damage as a result of deropements and the tower failure. The haul rope also received minor damage resulting in abrasions from contact with other components

15. The Lift Maintenance Manager was notified by his staff of the incident and he immediately notified the Provincial Safety Manager in accordance with requirements identified in Directive D-P4 070101 1 Incident Reporting Requirements with Respect to Passenger Ropeways & Passenger Conveyors. The Provincial Safety Manager requested that the incident scene was not to be disturbed until BC Safety Authority Safety Officers were on the scene.

16. Upon notification of the incident, the BC Safety Authority suspended the operating permits for the Excalibur Lower Gondola, registration number 140.021 and the Excalibur Upper Gondola, registration number 140.022.

The Impact on People and Property

17. There were no fatalities arising from this incident. Twelve injuries were reported to the BC Safety Authority at the time of the on site investigation. All passengers with reported injuries were treated and released from the medical clinic on the night of the incident. The injuries are identified in Table 2.

Table 2: Passengers with Reported Injuries

Nature of injury	Status
One individual sustained bumps and bruises	The individual was treated and released from the clinic with a soft collar
One individual was shaken	The individual was examined and released from the clinic
One individual sustained back and neck pain	The individual was examined released from the clinic
One individual sustained a crushed/fractured left middle finger	The individual was treated and released from the clinic
One individual sustained compressed vertebrae and lacerations on top of head	The individual treated and released from the clinic
One individual sustained lower back pain	The individual examined released from the clinic
One individual sustained a fractured vertebra (L4), a concussion, and body bruising	The individual was examined and although sore, was released from the clinic
One individual was shaken	The individual was examined and released from the clinic
One individual sustained lower back pain	The individual was examined and released from the clinic
Unknown	The individual was released from the clinic
Unknown	The individual was released from the clinic
Unknown	The individual was released from the clinic

18. During the investigation a number of passenger ropeway components were found to be damaged as a result of the Tower #4 failure. All of the damaged components were either repaired using an approved procedure from the manufacturer or removed from service prior to resuming operation of the Lower Excalibur Gondola.

Table 3: Damaged Passenger Ropeway Components

Cabin or Equipment	Description of Damage
Cabin 76	Removed from service due to its proximity to the tower failure. The cabin was located between Tower #1 and Tower #2 DH. Manufacturer test procedure to determine future service was required.
Cabin 77	Impacted the bus kiosk on the uphill side of the lift line and was resting on the roof on the east end of the structure
Cabin 78	Removed from service due to its proximity to the tower failure. The cabin was located above Fitzsimmons creek between Tower #3 and Tower #4 DH. Manufacturer test procedure to determine future service was required.
Cabin 79	Impacted a tree which damaged the roof
Cabin 80	Impacted the ground between Tower #4 and Tower #5 Down hill. Cabin #80 received the most severe damage. See Figure 5 on page 11
Cabin 81	Impacted the ground between Tower #5 and Tower #6 Down hill.
Towers	o The ladder, two walkways and two handrails on Tower #4 were bent and twisted o Deropements occurred at Tower #3 downhill (DH) and Tower #5 DH o Sheave assemblies at Tower #3 DH, Tower #4 DH, Tower #4 uphill (UH) and Tower #5 DH were removed from service due to impact damage. See Figures 2-4 on page 11
Haul Rope	o Abrasion damage over 3-5 meter sections at deropement locations was noted but still within tolerances for loss of metallic area. o The most significant damage was located at 576 meters from the haul rope splice where two bent wires were noted – See Figure 6 on page 11
Communications Line	Received localised damage at its connection to the tower #4 lifting frame

FIGURE 2.

View of upper section of Tower #4 supported by haul rope and communication line (crane in place to prepare for removal of upper tower section)

FIGURE 3.

View of damage to Tower #3 DH sheave assembly

FIGURE 4.

View of impact damage to \ Tower #4 DH sheave assembly

Figure 5

View of impact damage to Cabin #80

FIGURE 6.

View of haul rope damage at 576 meters from splice

Part 2 – The Investigation, and the Cause

The Immediate On-site Investigations

19. Following the incident, Whistler Blackcomb Mountain lift maintenance staff conducted inspections of all tower structures at Whistler and Blackcomb Mountains to determine if any other towers on passenger ropeway installations were at risk of failure. Lift maintenance personnel used two inspection methods described in Doppelmayr CTEC Safety Alert Bulletin SA-06-022 issued on December 31, 2006. The two inspection methods were (1) visual inspection and (2) a dead-blow hammer test to detect the presence of water. The hammer test required that the tower be struck with a dead-blow hammer at several ascending points. Test number 2 will later be referred to as a resonance test throughout this document. The result of those inspections indicated no towers were at risk of similar failure.

20. BCSA Safety Officers arrived at the Whistler Blackcomb site at approximately 19:30 on December 16 and initiated the BC Safety Authority's on-site investigations. These site investigations continued on through to December 20. The Safety Officers were provided unlimited access to all components of the Excalibur Lower lift. The Safety Officers conducted inspections of the Tower #4 structure itself as well as other locations along the lift that were affected by the tower failure.

21. The morning following the incident, BC Safety Authority Safety Officers carried out inspections of all towers at Whistler and Blackcomb Mountains of similar design (i.e. all two piece tower structures and towers where the inner cavities were filled with concrete). The inspections were necessary to assess whether other towers presented a similar risk of failure. All these inspections were completed prior to further operation of the other lift lines. The result of those inspections found no towers were at risk of similar failure. One tower was found to be filled with concrete, which was confirmed by drilling into the tube.

22. In addition to the physical inspections of the various towers and lifts, the BC Safety Authority Safety Officers reviewed operational logs and maintenance records. Maintenance records show that the required inspections of towers were performed prior to the incident.

23. On December 18, 2008 the Provincial Safety Manager for Passenger Ropeways issued Safety Order NO: SO-P4 081218 3 for Inspection of Passenger Ropeway Towers for Water Intrusion. This Safety Order was sent to all affected Passenger Ropeway Contractors in British Columbia. The Safety Order required Passenger Ropeway Contractors to undertake inspections of all similarly designed towers to determine the possible presence of water or ice within the inner cavities. The Safety Order required the Contractors to inform the BC Safety Authority of the results of these inspections. Responses were received from all Contractors by December 31, 2008. Their inspections identified that no other towers in British Columbia were at risk of similar failure.

24. On December 19, 2008 inspections of similar towers on the Lower Excalibur Gondola determined that Tower #5 had a similar situation where water had entered the lower section of the tower and froze. This tower also contained concrete and the water level above was up to the tower splice coupling plate. The Tower #5 splice coupling plate weld was subjected to non destructive examination which is described in paragraph 30 of this report.

25. On December 20, 2008 Doppelmayr CTEC issued a safety alert bulletin to all of its customers worldwide. The bulletin required that inspections be conducted to determine if tower structures were at risk of similar failure utilizing the resonance or dead blow hammer test. Continued annual inspection requirements were also noted to look for signs of deformation that could result from ice forming within tower structures. Doppelmayr CTEC also informed its customers that all towers exposed to temperatures where ice may form must be provided with drainage holes in tower tube sections to prevent water accumulating within the inner cavities. On towers of two piece design a drainage hole must be drilled in the upper section where the upper and lower sections are sealed from one another.

The Follow-on Investigations

26. Representatives from Doppelmayr CTEC and Blackcomb Mountain Skiing Enterprises Ltd. participated in the on-site and follow-on investigations.

27. To ensure that no excess stress had been applied to the splice coupling plate connection by volumetric expansion of ice on Tower #5, Intrawest ULC contracted Acuren Engineering Group Inc. (Acuren) to undertake a non-destructive examination utilizing magnetic particle and ultrasonic inspection methods to determine that Tower #5 was safe for continued operation. Separately, Doppelmayr CTEC also directed Whistler Blackcomb Mountain Skiing Enterprises Ltd. to provide drainage holes in the upper and lower sections of Tower #5 to mitigate against future accumulations of water developing within the tower.

28. Subsequent to the on-site investigation, Intrawest ULC contracted Acuren to conduct a metallurgical analysis of the Tower #4 failure. A copy of the Acuren Report entitled Blackcomb Mountain: Metallurgical Evaluation of Excalibur Gondola Lower Tower #4 Failure dated 3 February 2009 was provided to the BC Safety Authority.

29. On January 28, 2009 the BC Safety Authority formed an analysis team to undertake a thorough investigation of the incident, to establish the factors leading up to the incident and its causation, and to produce a Final Incident Investigation Report. The members of the team included:

- the Provincial Safety Manager Passenger Ropeways (Team Lead);
- a Passenger Ropeway Safety Officer;
- the Leader, Engineering and Research;
- a Research Engineer; and

- the Leader, Strategic Projects.

30. The Analysis Team, over the period of February to November 2009, carried out the following tasks and activities:

- Analyzed all documents, records, and witness statements that were obtained during the on-site investigation;
- Reviewed all documents and reports that were provided by Acuren and Doppelmayr CTEC;
- Analyzed the specific factors leading up to the incident through a root-cause analysis practice;
- Commissioned Pol-X West, Inc. as a third-party professional engineering firm with specific expertise and knowledge in passenger ropeway design to provide an independent review of reports obtained from Acuren Doppelmayr CTEC and information collected during the on-site investigations;
- Developed recommendations with a focus in key areas to minimize the risks of another incident like that which occurred on the Excalibur Gondola; and
- Prepared a Final Incident Report.

The BC Safety Authority Analysis Process

31. The purpose of the Authority's analysis was to undertake an objective investigation of the incident, to make findings pertaining to the events, the consequences of the incident and, of course, the cause of the incident. As well the BC Safety Authority makes recommendations, based on those findings, to prevent similar incidents in the future. The analysis of the specific factors leading up to the incident utilized information from the documents, records, and witness statements that were obtained during the on-site investigation as well as reports that were provided by Acuren and Doppelmayr CTEC.

32. The incident reports explained what happened by providing a description of events based on the status of the lift leading up to the tower collapse, records, witnesses statements and physical evidence and a description of the consequences. The analysis used techniques which identify the reasons why the incident occurred. It is a tool to assist in incident investigations by providing methods to scrutinize the information from all the reports to describe not only what happened during the incident as well as to determine how it happened and to understand why it happened.

33. In order to gain a sound understanding of how the incident occurred, process flowcharts for the installation, maintenance and operation of the lift were developed. Using a brain-storming process the flowcharts were reviewed by analysis team members to list all possible causes and these causes were listed as direct and indirect causes. A fishbone cause and effect chart was used to show how all the direct and indirect causes interrelated to trigger the incident.

Based on this work, the root cause(s) of the incident were identified from which recommendations to prevent future incidents were developed.

Statements Obtained During the Investigation

34. During the on-site investigation several witness statements were obtained by the BC Safety Authority in order to establish the factors leading up to this incident. All the statements were provided by Lift Operations and Maintenance staff performing duties on the Excalibur Gondola on the day of the incident.

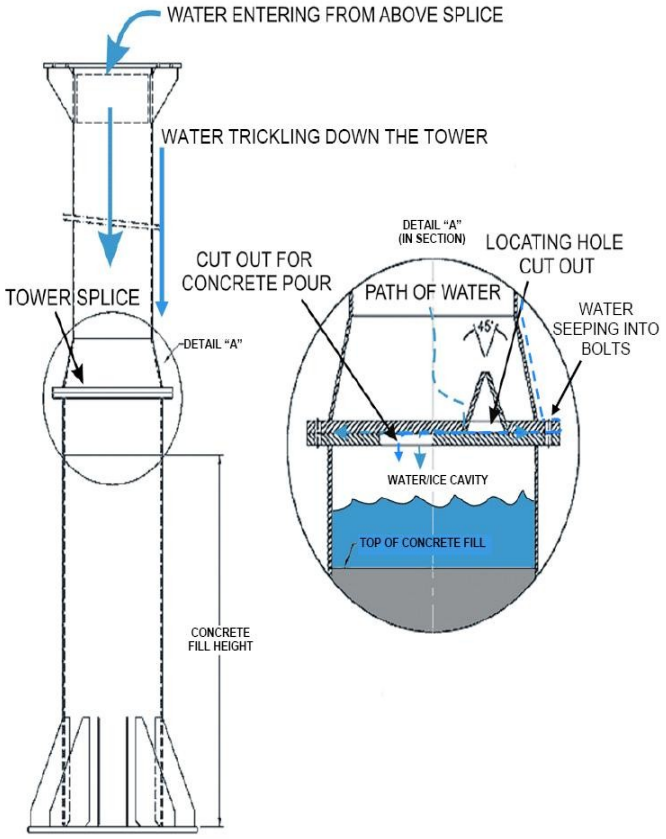
35. A review of the witness statements provided by Blackcomb Skiing Enterprises was undertaken as part of this investigation. Other than the need to re-align the sheaves on Tower #4, the witness statements provided by lift operations staff did not indicate anything unusual with the operation of the Excalibur Gondola immediately prior to the incident.

36. The statement obtained from the lift mechanic that conducted the re-alignment of the sheave assemblies on Tower #4 indicated an unusual situation as both the uphill and downhill sheave assemblies were misaligned. However, this did not indicate to the lift mechanic there was a deformation in the tower structure itself that was causing the misalignment. The lift mechanic also stated that he had to leave the tower to retrieve more tools to complete his task, which meant that he climbed up and down the tower twice and was within inches of the tower splice connection where the failure occurred. Nothing unusual was noted with the tower structure itself on the lift mechanics statement. This was not surprising considering a metallurgical analysis subsequent to the tower failure states that the crack started from the inside of the weld and radiated out.

The Factors Leading up to the Incident and its Causation

37. As noted in paragraph 7, the original design of the Tower #4 structure was for the upper and lower sections to be sealed against the environment and more specifically against the ingress of water. The fact that a column or cylinder of ice some 1.9 meters in length was found in the tower immediately following its failure is evidence that at sometime within the fourteen years the tower was in-situ, water did find a way to enter and collect in the lower section of the tower structure. As depicted in Figure 7 it is believed that the water ingress into lower tower section was facilitated through a rectangular opening located in the splice coupling plate attached to the lower tower section. This opening in the splice coupling plate was provided to allow for the pouring of concrete into the lower section during construction. The filling of towers with concrete is a common practice of Doppelmayr CTEC for towers of this height (i.e. 16.7ms) to help stabilize the tower and prevent excessive movement or sway during operations. It was found that a bolt-hole on the splice coupling plate was flame cut during construction which may have created a path for water to enter between the upper and lower splice ring and into the rectangular hole in the lower plate. The flame cutting of the bolt hole was probably conducted during installation and erection of the tower to assist with aligning the bolt-holes on the splice coupling plates of the upper and lower tower sections.

FIGURE 7.



Schematic of Tower #4

38. The period of time around the date of this incident saw unusually cold temperatures for the Whistler region. On December 13, 2008 a cold front affected the southwest region of British Columbia with nighttime temperatures reaching approximately -15°C and daytime temperatures on the order of -8°C. The average temperature for this region, throughout the entire winter season, is -3.2º C, (as reported by Environment Canada). The temperature recorded by Environment Canada at 14:00 on the day of this incident was -8.7 º C. See Figure 10 on page 20.

39. These unusually cold temperatures contributed to the freezing of the water inside the tower structure as depicted in figure 8. The forces generated from the volumetric expansion of water due to freezing within the lower tower section are key factors contributing to the Tower #4 splice coupling failure. This phenomenon is also commonly referred to as 'ice jacking'. See Figure 8.

40. Following the failure and prior to sending the failed section of Tower #4 to Acuren, the lower section of Tower #4 was taken to the Whistler Blackcomb Mountain maintenance shop where it was heated with propane torches to break free the ice column inside. The ice column that was removed measured 1.9 meters in length and is shown in Figure 9. The ice column was found to be still in liquid form near its center as sections of it were removed from the tower tube. This indicates the freezing process was not complete and that the column of ice was in a continued state of expansion. Below this ice column the rest of the lower section of the tower structure was filled with concrete to a height of 7.8 meters, which met the minimum level of 4 meters as per Doppelmayr's design specifications. See Figure 9.

FIGURE 8.

Top of Ice Column found in Tower #4 Lower Section Tube

FIGURE 9.

Partially Frozen Ice Column Inside Tower #4 Lower Section Tube

41. The lower section splice coupling plate was later sent to Acuren who conducted a metallurgical analysis of the failed splice connection of Tower #4. All of the materials used in the manufacture of Tower #4 were confirmed to be consistent with the specified design. Acuren found that the features of the December 16 crack were consistent with those of a brittle fracture in plain carbon steels. Acuren also identified the existence of dark pre-cracks in the splice joint weld that were likely caused by either cold cracking subsequent to welding or by stresses generated from a previous freezing cycle. Acuren also found that the weld, which connected the splice coupling plate to the lower tube section of Tower #4 was not a full penetration weld for upwards of 70% of the circumference of the tower tube. Acuren calculated that the load imparted to the tower structure as result of the ice expansion, causing the tower splice joint failure, was 238 tons.

42. As a follow-up to the original Acuren recommendations, Intrawest ULC requested that Acuren Group conduct further analysis of the fracture toughness of the steels used in two piece towers susceptible to a similar failure as Tower #4. This analysis was to determine fitness for service of Tower #4 and the other two piece towers utilizing the same design. Acuren used design stresses supplied by Doppelmayr which take into account static and dynamic loading including wind loading. Among all towers on the lower Excalibur lift, Tower #7 is identified to be the most stressed tower shown in the Doppelmayr design documentation and this stress value was used in the analysis for the “Two piece” design tower such as Tower #4 and Tower #6. Acuren concluded that these two piece towers were fit-for-service once they met weld sizes and penetration conditions as verified by ultrasonic testing.

43. The BC Safety Authority considered Acuren’s “Fitness for Service Report” to be valid for Tower #4 and Tower #6 since the weld sizes and penetration on splice coupling plate weld connections for those towers met the fitness for service conditions as confirmed by ultrasonic testing conducted by Acuren.

44. The BC Safety Authority sought a review of the analysis work completed by Acuren from an independent engineer with expertise in the design and manufacture of passenger ropeways. Pol-X West Engineering in Carson City, Nevada was contracted to conduct a review of Acuren findings and provide comments. Pol-X West has been involved with many passenger ropeway projects in British Columbia. The principal of this company is also a member of the Z98 National Code Technical Committee for Passenger Ropeways and a registered professional engineer with Association of Professional Engineers and Geoscientists of British Columbia.

45. Pol-X West’s conclusions also found that water accumulation within the tower structure was the primary cause of this incident and that passenger ropeway towers are not required by the Z98 code to be designed to resist the forces generated by the expansion of ice within those structures. Pol-X West also concluded that the materials used in the construction of the tower were acceptable and have been utilized in the construction of passenger ropeways all over the world.

Figure 10.

Hourly Data Report for December 16, 2008

Time	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
00:00										
01:00										
02:00										
03:00										
04:00										
05:00										
06:00										
07:00	-14.9	-17.7	79		0	25.0	94.50			Clear
08:00	-14.8	-18.1	76		0	25.0	94.44			Clear
09:00	-14.6	-17.3	80		0	25.0	94.38			Clear
10:00	-13.0	-15.9	79	5	6E	25.0	94.36			Mostly Cloudy
11:00	-11.3	-14.4	78		0	25.0	94.26			Mostly Cloudy
12:00	-10.6	-15.8	66	36	4E	25.0	94.18			Mostly Cloudy
13:00	-9.7	-14.6	67		0	25.0	94.06			Mostly Cloudy
14:00	-8.7	-13.3	69		0	25.0	93.99			Mostly Cloudy
15:00	-8.0	-13.6	64		0	25.0	93.93			Cloudy
16:00	-6.7	-11.0	71	18	17E	25.0	93.77		-13E	Cloudy
17:00	-6.8	-9.7	80	18	22E	25.0	93.75		-14E	Cloudy
18:00										

Weather Data for Whistler on December 16th, 2008 *(Source: Environment Canada Website)*

Figure 11.

View of ice protruding approximately 10 mm above failure point from within lower section of Tower #

Figure 12.

View of Tower #4 lower section splice coupling plate with rectangular opening

Figure 13.

View of ice column removed from lower section of Tower #4

The Design Standard

46. The Z98-M91 standard was the adopted national code for use in the Province of British Columbia at the time the Excalibur Gondola was constructed. The code clauses that were applicable to the design of Tower #4 at the time of installation were as follows:

- 3.4 General Design Requirements.
- 3.5 Materials, Manufacturing, and Quality Control.
- 3.6 Fatigue Design.
- 3.7 Corrosion Protection.
- 3.9 Welding Connections.
- 3.10 Buildings and Structures.
- 3.18 Towers and Equipment.

47. Section 1, item 1.7 of the CSA Z98-M1, S1 lists Reference Publications. Listed below are publications that would relate to the design and fabrication of Tower # 4 lower section.

- CAN/CSA-G40.20-M87, General Requirements for Rolled or Welded Structural Quality Steel.
- CAN/CSA-G40.21-M87, Structural Quality Steels.
- CAN/CSA-S16.1-M89, Limit States Design of Steel Structures.
- W47.1-1983, Certification of Companies for Fusion Welding of Steel Structures.
- W59-1989, Welded Steel Construction (Metal Arc Welding).
- W178-M1973, Qualification Code for Welding Inspection Organizations. W178S1-1988, Supplement 1 to W178-1973.
- W178.2-1982, Certification of Welding Inspectors. W178.2S1-1988, Supplement 1 to W178.2-1982.

48. Clause 3.7.2 of the Code specifically identifies the need for a “positive means of drainage” where necessary. The design philosophy utilized by Doppelmayr was to seal the tower structures from the external environment to prevent water and oxygen ingress to minimize the potential for corrosion and therefore drainage was not considered to be necessary. It appeared that the mating of the two splice coupling plate surfaces was relied upon to provide an effective seal as no other sealing means such as gasket material or flexible caulking was observed between the surfaces. Whether by inadequate initial design or deterioration in service, the seal of the splice joint connection failed to prevent water from entering the tower nor did in service inspections and tests detect the accumulation of water. The design requirement for a sealed tower was not achieved and it would have been more appropriate to incorporate a positive means of drainage into the tower design.

49. There are no clauses in the standard requiring the designer to ensure the tower will resist the forces generated from a possible buildup of ice within the tower structure. Three editions of the Z98 Standard have been released since the M-91 edition. The clauses applicable to the design of passenger ropeway towers have not been amended or changed since the Excalibur Gondola was installed in 1994.

The Design Submission

50. At the time application was made by Blackcomb Skiing Enterprises Ltd. to install the Excalibur Gondola the design standard in use was CAN/CSA Z98-M91. Aerial Tramway Inspectors, now referred to as Passenger Ropeway Safety Officers, reviewed the documentation for required content and verified that the required review was conducted by a professional engineer licensed in the province of British Columbia. The Province of British Columbia accepted design documentation from Doppelmayr using the following process:

- All submitted drawings and technical documentation were submitted under seal by a professional engineer licensed in British Columbia.
- The above engineer supplied two statements under their engineering seal: (1) A certificate of construction indicating that the installation conformed to all specifications identified in the “As-Built” design documentation. (2) A certificate of design specifying that the design met all the requirements of CAN/CSA Z98-M91.
- Aerial Tramway Inspectors verified that the above submission met all documentation requirements identified in CAN/CSA Z98-M91. This included use of Appendix A in this Standard, which is a checklist of technical documentation on new and modified installations.

51. Doppelmayr submitted all documentation described in Paragraph 50 as required in 1994. Doppelmayr utilized the services of an independent engineering firm to provide the required engineering certification on all documents.

52. The review conducted by the Province of British Columbia at the time of installation did not include verification of design calculations. Statements provided by the professional engineer under seal were relied upon to confirm the design.

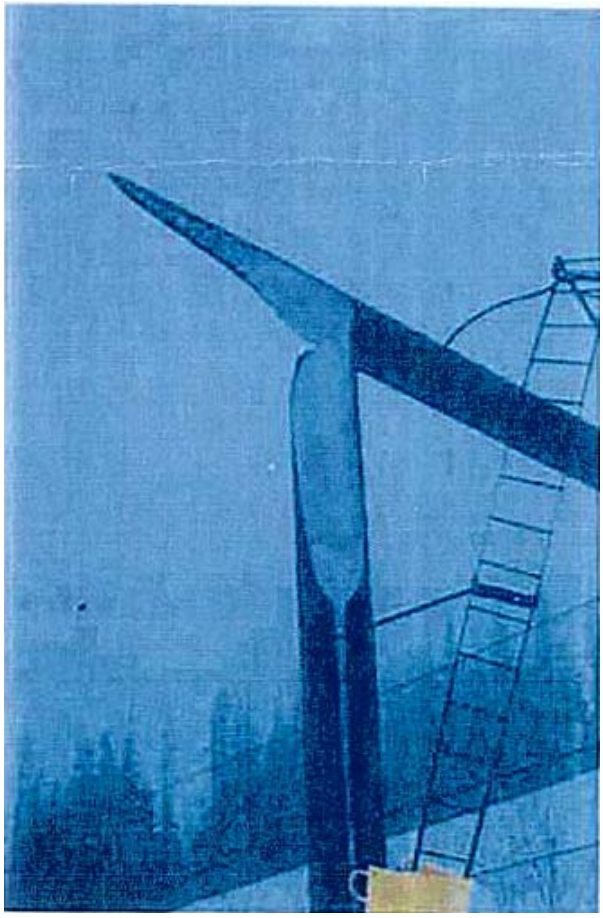
Doppelmayr Bulletin History Related to Water Ingress in Structures

53. In July of 1997 Doppelmayr issued bulletin SB.97-003 to all of its customers regarding the ingress of water in all structures. This bulletin reminded customers to check their structures for water ingress. This bulletin was not issued as a result of a tower failure.

54. In October of 2002 Doppelmayr CTEC issued a bulletin warning customers of water ingress in chairlift carriers. The bulletin warned that a customer had detected a significant reduction in wall thickness of square tubing with which the carrier was constructed. The tubing was compromised when it was struck with a hammer. The bulletin warned its customers that the presence of water within structures may lead to corrosion and cracking due to the expansion of ice.

55. In December of 2006 Safety Alert bulletin SA-06-022 was issued to Doppelmayr customers. The document identified that it affected not just Doppelmayr installations but all installations that Doppelmayr took responsibility for as a manufacturer through company mergers and acquisitions. The safety alert identified an installation in Idaho that failed due to the formation of ice within the tower structure on a Von-Roll chairlift. The tower affected was of a two piece design but did not have the same construction details as Tower #4 on the Excalibur Gondola. The tower was 46 feet tall and the ice which formed within it was up to the 30 foot level. The tower split vertically from the base and then hinged at approximately 18.5 feet and fell towards the uphill side of the lift. The temperature at the time this incident occurred was approximately -18º C. This Safety Alert bulletin described for the first time the test referred to as a resonance test. Doppelmayr required that inspections of affected towers be completed within 30 days of the issuance of the bulletin if routine inspections had not been performed already on the installation. The bulletin also stated that holes to evacuate water could only be installed if the presence of water was detected. The bulletin did not address the fact that some towers may be filled with concrete. The tower failure identified in this bulletin is shown in Figure 14.

Figure 14.



Idaho Tower Failure

56. Safety Alert Bulletin SA-06-022 was received by the BC Safety Authority on January 11, 2007 and it was distributed to Safety Officers as noted on the copy inserted into file where these documents are stored. There is no documented action from the BC Safety Authority regarding this bulletin. However the BC Safety Authority's Safety Officers did receive the bulletin and recall addressing it with passenger ropeway contractors during routine inspections.

57. Blackcomb Skiing Enterprises also received bulletin SA-06-022 in January of 2007. Since routine inspections had been conducted by lift maintenance staff the next inspections were not conducted until March of 2007. A work order obtained during the investigation instructed personnel to tap the tower base with a hammer to detect water that may have accumulated. The work order did not include any of the details from the bulletin SA-06-022. If the circumstances surrounding the incident that occurred in Idaho in 2006 had been provided on the work order it may have heightened the diligence of the persons performing the required inspections to determine the ingress of water.

58. Following the Tower #4 Excalibur Gondola failure Doppelmayr issued Safety Alert Bulletin SA-08-021 Wolfurt KD08003E to all of its customers worldwide. This safety alert described the failure of Tower #4 and required that visual and resonance inspections be conducted. Additionally Doppelmayr now required that drainage be installed in all of its tower structures instead of only when the presence of water is detected.

59. In the BC Safety Authority's view the resonance test described in Doppelmayr safety bulletins is not a definitive means to determine the ingress of water in structures. The effectiveness of the test is subject to the knowledge and experience of the person performing it. Even when performed by trained and experienced persons its effectiveness is in question. This conclusion is drawn from the data recorded during the installation of drain holes of all towers identified in the Doppelmayr Safety Alert Bulletin SA-08-021 Wolfurt KD08003E. When drilled several towers were found to contain accumulations of water that were not detected when using the resonance test inspection method. It does not appear that any of the water found was to a level that would produce a risk of ice forming and exerting an unwanted stress on tower tube cap plates or splice coupling plate connections.

Findings and Conclusions

60. The Provincial Safety Manager is of the view the forces created from the expansion of the ice were the primary contributors to the stresses that initiated the December 16, 2008 crack causing the tower to fail. Other factors such as low temperature toughness, the pre-existing crack and stresses from independent loadings such as those that occur when a gondola passes through a tower's sheaves may have contributed to the failure stresses.

Arising from investigations the Provincial Safety Manager has identified the following as contributory factors in the cause of the failure on December 16, 2008:

61. Tower #4 consisted of two sections an upper and lower section. The two sections were connected together by a bolted splice coupling plate that was welded to the steel tubes. The lower section of the tower was filled with concrete up to a level of 7.8 meters above the base. The original design of Tower #4 was for both of the sections to be sealed against the ingress of water. No provisions were provided in the original design to drain water from the inner sections should water find a way to enter the tower structure.

62. The splice coupling plate on the lower section of Tower #4 was found to have a rectangular hole to facilitate the injection of concrete in to the lower tower tube. The splice coupling plate on the upper section was found to have a rectangular hole installed to receive two plates welded together to form a locator piece on the lower splice coupling plate for proper alignment of the two tower sections during construction. A bolt hole on the upper splice coupling plate was found to be flame cut which is a common practice used when installers are unable to align bolt holes between upper and lower plates during construction. These findings were the only possible paths for water ingress discovered during the investigation.

63. When Tower #4 was removed from its site following the failure a cylinder of ice was found in the lower section of the tower above the 7.8 meters of concrete. This ice column filled the entire central portion of the lower tube cavity and was some 1.9 meters in length. The column of ice was not completely frozen at its center indicating that the ice was still forming and the column was a continued state of expansion.

64. From the period of December 13, 2008 through to the date of the incident (December 16, 2008) the Whistler area was under the influence of a cold front that dropped nighttime temperatures to as low as -15°C and daytime temperatures to -8°C in contrast to an average temperature of -3.2°C.

65. The fact that ice was found within the tower cavity indicates that over the fourteen years since the Excalibur lift was installed, water had entered the

tower inner cavity and collected in the lower section of the tower above the concrete.

66. As water had entered the tower cavity the inspections conducted by Whistler Blackcomb to detect the ingress of water proved to be ineffective.

67. The water within the tube cavity froze when the temperatures fell to below 0°C. As this water froze the ice expanded imparting a longitudinal force onto the splice coupling plate as well as an axial force directly onto the weld of the splice coupling plate.

68. Immediately preceding the failure the sheaves on top of Tower #4 were realigned. Following realignment the lift was returned to normal operating conditions and speed. The Provincial Safety Manager is of the opinion that the realignment of the sheaves in and of itself was not a contributing factor to the incident.

69. Acuren's examinations of the crack features found that the crack surfaces exhibited features wholly representative of a brittle fracture event with some minor ductile tearing.

70. Charpy tests undertaken by Acuren identified that at temperatures of -15C the steel from which the lower splice coupling plate was manufactured absorbed approximately 65% less energy than when tested at ambient temperatures (approximately 20C) indicating that the steel was more susceptible to brittle fracture at the lower temperature.

71. Acuren's examinations also identified a pre-existing crack within the weld where the crack of December 16 originated, as well as the fact that the weld was not a full penetration weld for 70% of the circumference. The Provincial Safety Manager is of the opinion that the lower splice coupling plate on Tower #4 was not designed for the forces developed by the expanding ice and therefore was unable to resist the forces generated from the continued expansion of ice. The Z98 standard in use at the time of the construction of the Excalibur Gondola and the current Z98 standard does not require manufacturers or designers to design a tower structure to resist this type of internal force

72. The weld detail identified on the drawing submitted in the original technical documentation for this installation identifies that the weld required was a partial penetration butt/fillet weld of 12.5 mm in size. The last 2mm of the weld were not to be penetrated. This is confirmed by statements by the manufacturer's Chief Welding Engineer in Wolfurt Austria who also states that in his opinion the weld met the details identified on the design drawing. The Provincial Safety Manager has confirmed that the welding symbol on the drawing meets the symbol for a weld of this type identified in CAN/CSA W59-03 Appendix A.

73. With the facts currently in its possession the Provincial Safety Manager cannot conclude whether the forces arising from the continuing freezing of the water into ice itself would have initiated the start of the crack or that some other third independent force or factor such as the stresses imparted to the tower structure that occur when a gondola cabin passes through a tower's sheaves may have initiated the crack. An inspection of the ice column in Tower #4 indicates that it was only partially frozen and may have still been in a state of expansion.

Part 3 – The Provincial Safety Manager's recommendations

Recommendations to Prevent Future Incidents and their Status

Observation 1 - Installation of Drain Holes: When designing tower structures the Z98 standard requires that the possibility of corrosion be considered and addressed including, if warranted, drainage to prevent water accumulations. Doppelmayr's design appears to have been reliant on sealing tower tube structures from any external source of oxygen or moisture to prevent internal corrosion. Based on this design philosophy to seal the towers, the installation of drain holes was not considered necessary by Doppelmayr. In 2006 Doppelmayr made their customers aware of an incident that found maintaining an adequate seal over the service life of a tower proved not to be effective. Doppelmayr attempted to correct this by requiring drain holes only when water intrusion is detected.

Recommendation 1:
All operators of passenger ropeway installations must assure towers are fitted with drain holes or have equivalent strategies in place to prevent the accumulation of water as required in the CAN/CSA Z98 standard.

Status: *The Provincial Safety Manager issued Safety Order SO-P4 0910021 to all operators of passenger ropeways identified in Doppelmayr Safety Alert Bulletin 08-021 Wolfurt KD08003E. The safety order required confirmation from all affected operators to confirm compliance with the Doppelmayr bulletin by November 15, 2009. All responses to Safety Order SO-P4 0910021 to confirm that the required work is complete have been received by the BC Safety Authority. The Provincial Safety Manager has issued a second safety order to all operators of passenger ropeways not affected by the Doppelmayr safety alert bulletin requiring confirmation that drainage provisions are in place in tower structures. The Safety Order requires that operators who identify towers without drainage in place that the manufacturer or a professional engineer be consulted to determine a method to be put in place to prevent the accumulation of water. The safety order requires this prior to the 2010/2011 operating season. Inspections of towers following this incident found that the resonance test alone failed to detect when water had accumulated in the tower cavities.*

Observation 2 – Clear and Effective Safety Bulletins: The 'resonance' inspection method used to detect water intrusion is too subjective in determining the presence of water. Further research by the Provincial Safety Manager found that this inspection method is ineffective in some instances based on results of tower drilling conducted by passenger ropeway contractors following this incident. This included towers where no concrete stabilization efforts were utilized. The test is based on the judgment of the person conducting it which is impacted by their level of knowledge of the as built details of the tower and their experience in the use of the test. The Doppelmayr bulletin issued in 2006, SA-06-022 Tower Failure due to Water Intrusion did not warn of the possibility that concrete may be found in towers of similar design and that the level of concrete must be known in order to differentiate

Recommendation 2:
Manufacturers must ensure the required inspection procedures, as described in their safety bulletins, are clear and effective in communicating all requirements for inspections.

whether the lack of resonance is due to water or other factors such as the presence of concrete.

Status: *Doppelmayr issued Safety Alert Bulletin SA-08-021 requiring the installation of drain holes in all tube tower sections on passenger ropeway installations world-wide. The installation of drain holes will require annual inspections to ensure that drainage has not become blocked and the inspections must be conducted in the fall season. This way any blockages that may have occurred in the spring and summer will be detected and corrected prior to the occurrence of freezing temperatures. A recommendation has been put forward to the Z98 Technical Committee Chairman to implement a standardized safety bulletin format to be used by all passenger ropeway manufacturers. A standardized format would introduce a consistent approach by all manufacturers and the reader would always know where to find crucial information related to the safety issue and what actions are required to be taken.*

Observation 3 – Contractors Internal Communication Process: The Provincial Safety Manager found that details from the SA-06-022 Safety Alert Bulletin issued by Doppelmayr were not included in the work orders issued to field staff at Whistler-Blackcomb. The required 'resonance test' was identified on the work order but no other information was provided. A system is in place at Whistler-Blackcomb to notify the persons responsible for implementing safety alert bulletins that a bulletin has been issued and those persons are required to sign off that the bulletin has been read and understood. If the person conducting the inspection was alerted to the circumstances of the issue better results may have been achieved and the lack of knowledge regarding the level of concrete within the tower could have been questioned.

Recommendation 3:
Passenger ropeway contractors must ensure the effectiveness of their internal communication processes to ensure that manufacturer safety bulletins are followed correctly by responsible staff and the results recorded.

Status*: Immediately following the incident, Whistler-Blackcomb maintenance staff implemented a system to attach safety bulletins to work orders generated as a result of the issuance of safety bulletins. The Provincial Safety Manager already requires that passenger ropeway contractors identify similar systems in their safety management plans and will use the knowledge gained from this investigation during audits of these plans to improve their effectiveness. A communication will be issued to all passenger ropeway contractors identifying the recommendations in this report at the time of the report publication.*

Observation 4 – As-Built Conditions Identified: The drawings submitted by Doppelmayr at the time of the installation did not identify the 'as-built' conditions with regard to the level of concrete inside the lower tube of tower 4. Not knowing the level of concrete made it difficult to determine if there was water above the concrete fill and therefore was detrimental to the effectiveness of tower inspections to determine

Recommendation 4:
Manufacturers must ensure that 'as built conditions' are identified with respect to concrete levels in tower structures and all other construction details in existing and future passenger ropeway installations.

possible water ingress. As per Appendix A of Z98-M91, the national standard at the time of construction, clause 3.36.2 required that the manufacturer must supply all technical information prior to the inspections and tests required by the standard. This requirement does not clarify that all As-built conditions must be identified; however it is critical that all construction details be provided to assist operators in their required tests and inspections.

Status: *The Provincial Safety Manager is now taking steps to verify with the manufacturers if concrete stabilization efforts were utilized in other installations already in place in British Columbia as well as when it is used in future tower designs. Doppelmayr customers were required to locate the concrete level in towers to determine the proper location to install drain holes as required by Doppelmayr Safety Alert Bulletin SA-08-021. The Provincial Safety Manager will be taking action to ensure that all operators of passenger ropeways have knowledge of existing tower installations where concrete has been included in the structure and to what level to assist in determining where drainage should be installed. All future documentation submissions will be required to identify concrete levels within tower structures on tower drawings where necessary. A recommendation will be put forward to the Z98 Technical Committee to clarify that all final drawings submitted by the manufacturer must identify as-built conditions in order to assist with required inspections and tests.*

Observation 5 - Technical Committee Review: In the interest of complete transparency the Provincial Safety Manager must bring this topic forward for discussion at the next CAN/CSA Z98 technical committee meeting. As a member in good standing of this committee it is incumbent upon the Provincial Safety Manager to ensure that a discussion takes place at a national level to determine if code revisions are necessary as a result of this incident and the subsequent investigation.

Recommendation 5:

The Provincial Safety Manager will submit the findings of this report to the CAN/CSA Z98 Technical Committee for review and discussion of possible code changes.

Status: *The Provincial Safety Manager has submitted a formal request to the Z98 Technical Committee Chairman to include this topic on the agenda of the next committee meeting in June, 2010.*

Observation 6 – The BC Safety Authority's Safety Bulletin Process: The BC Safety Authority does not have records of communication with passenger ropeway contractors regarding bulletin SA-06-022 issued by Doppelmayr in 2006. Standard practice of safety officers would be to discuss any recently issued bulletins with passenger ropeway contractors as they receive them. However this policy is not documented. As part of the BC Safety Authority's oversight efforts a policy should be developed to follow up on safety bulletins to ensure they are implemented by the passenger ropeway contractor, who is responsible to ensure that manufacturer's requirements identified in safety bulletins are followed.

Recommendation 6:

The BC Safety Authority shall improve their internal communication processes to ensure Safety Officers are aware of and have understood the safety bulletins issued by manufacturers to enable a more effective auditing and inspection process.

Status: *A system to confirm that safety officers have received and understood bulletins has been implemented using electronic mail. This system is being assessed to determine if further enhancements are required. A similar system is in place to notify contractors and confirm their receipt for more serious safety bulletins. The regular follow up on all received bulletins through periodic on site inspection will continue. An automatic email notification system is now part of the BC Safety Authority website.*

Appendix A: Timeline of Key Events

December 31, 2006

- Doppelmayr issued Safety Alert Bulletin SA-06-022 entitled Tower Failure Due To Water Intrusion.

March 6, 2007

- Whistler-Blackcomb Mountain conducted mid-season tower inspections to comply with Doppelmayr Safety Alert Bulletin SA-06-022.

October 8, 2008

- The BC Safety Authority conducted a periodic inspection of the lower Excalibur Gondola and no non-compliances were noted in relation to structural problems with Tower 4. A noncompliance was noted in relation to the Tower #4 sheave assembly; however, this was not considered to be a factor in the incident.

December 16, 2008

- At 12:45 lift maintenance personnel were informed of a noise coming from Tower #4.
- At 13:00 a lift mechanic visually inspected Tower #4 and discovered misaligned sheave assemblies.
- At 13:15 the lift mechanic climbed Tower #4 and aligned the sheave assemblies.
- At 14:06 the lift mechanic completed alignment adjustments to Tower #4 and proceeded to the drive station.
- At 14:14, the lift mechanic who completed alignments to Tower #4 returned to the drive station. Upon his arrival the gondola stopped and dispatch announced a status of 10-60 for the Excalibur Gondola.
- At 14:30, The Provincial Safety Manager was notified of the incident by the Whistler-Blackcomb Lift Maintenance Manager.
- At 14:40, damaged lift components were secured by lift maintenance staff and a manual evacuation of passengers on the gondola was initiated.
- At approximately 16:55, the manual evacuation of passengers was completed.
- At approximately 19:30, one BC Safety Authority Safety Officer arrived on scene and immediately initiated the investigation. A second Safety Officer arrived at approximately 20:30. Prior to their arrival, the scene was secured by Whistler-Blackcomb security. Several Whistler-Blackcomb lift maintenance staff were at the Tower #4 location. Prior to the arrival of the BC Safety Authority at the scene, Whistler-Blackcomb lift maintenance staff had conducted inspections of all tower structures at Whistler and Blackcomb Mountains to determine if any other towers on passenger ropeway installations were at risk of failure.

December 17, 2008

- The BC Safety Authority conducted inspections of all towers of similar design at Whistler-Blackcomb to ensure that they were not at risk of a similar failure.

December 18, 2008

- The Provincial Safety Manager for Passenger Ropeways issued Safety Order NO: SO-P4 081218 3 for Inspection of Passenger Ropeway Towers for Water Intrusion to all affected Passenger Ropeway Contractors in British Columbia.

December 19, 2008

- The Excalibur Gondola Tower #5 inspection revealed ice from concrete level in lower section to cap plate at splice connection.
- Certificate of Inspection File #3941850 was issued by the BC Safety Authority. A request for repair procedure on Tower #5 was noted.

December 20, 2008

- Doppelmayr CTEC issued Safety Alert Bulletin SA-08-021 Wolfurt KD08003E – Tower Failure due to Water Intrusion to all its customers worldwide.
- Lower section of Tower #4 was repaired by Canadian Welding Bureau (CWB) certified welding shop using repair procedure provided by Doppelmayr.
- Ice was removed from Tower #5. Acuren conducted a non-destructive test procedure to confirm 'fitness for service' of Tower 5. Results indicated no damage to Tower #5.

December 23, 2008

- The BC Safety Authority conducted an inspection of Lower Excalibur with all required repairs completed. Results of inspection were recorded and the operating permit was reactivated on certificate of inspection file #3954581.

December 24, 2008

- Lower Excalibur gondola re-opened to the public.

January 28, 2009

- The BC Safety Authority formed an analysis team to ensure the thorough investigation of the incident, to establish the factors leading up to the incident and its causation, and to produce the Final Incident Investigation Report.

References

Appendix 1: Safety Alert Bulletin SA-06-022 – Tower Failure due to Water Intrusion, Doppelmayr CTEC, December 31, 2006

Appendix 2: Certificate of Inspection File No. 3941845, BC Safety Authority, December 17, 2008

Appendix 3: Safety Order SO-P4 081218 3 – Inspection of Passenger Ropeway Towers for Water Intrusion, BC Safety Authority, December 18, 2008

Appendix 4: Certificate of Inspection File No. 3941850, BC Safety Authority, December 19, 2008

Appendix 5: Blackcomb Excalibur Gondola Repair Procedures, Doppelmayr CTEC, December 20, 2008

Appendix 6: Safety Alert Bulletin SA-08-021 Wolfurt KD08003E – Tower Failure due to Water Intrusion, Doppelmayr CTEC, December 20, 2008

Appendix 7: Certificate of Inspection File No. 3954581, BC Safety Authority, December 23, 2008

Appendix 8: Lower Excalibur Tower No. 5 Non Destructive Testing of Flange Welds, Acuren Group Inc., December 23, 2008

Appendix 9: Doppelmayr Repair Procedure Review, CWMM Consulting Engineers Ltd., December 23, 2008

Appendix 10: Blackcomb Excalibur Gondola Tower No. 4 Cause of Failure, Doppelmayr CTEC, December 25, 2008

Appendix 11: Doppelmayr Drawing No. 19219 D 051500 rev. b

Appendix 12: Doppelmayr Drawing No. 20002605H006822 rev. b

Appendix 13: Doppelmayr Drawing No. 19230 D 051500 rev. b.

Glossary of Terms and Definitions

Acuren refers to Acuren Engineering Group Inc. which is an engineering company that conducted metallurgical analysis of the tower failure.

Catastrophic failure means a sudden, unexpected failure that occurred without prior indication of degradation causing the complete breakdown and collapse of a structure.

Charpy Test means an impact test to determine the ductility of a metal.

Communications Line means a multi-paired low voltage electrical cable utilized to carry the safety circuit signal between passenger ropeway towers.

Ice jacking is a broad term used to describe the phenomenon that occurs when water invades a confined space in a structural support, or geologic formation, and upon freezing causes structural fracture as the ice expands.

Fitness for service means an assessment performed to determine adequacy for future use typically performed by a professional engineer utilizing sound engineering practice.

Toughness is a term used to describe a materials ability to resist tearing or cracking where materials with low toughness are more susceptible to brittle fracture (rapid tearing or cracking).

Magnetic Rope Test means a non-destructive test for ferromagnetic wire ropes using electromagnetic or permanent magnetic equipment employing magnetic flux and/or magnetic flux leakage principles and capable of detecting discontinuities and/or changes in metallic cross-sectional area. (Definition from CAN/CSA Z98-07).

M/S means meters per second.

Resonance test As described in Doppelmayr Safety Alert Bulletins, means a test which requires that a tower structure be struck with a “dead blow” or soft hammer at several ascending points along an enclosed tower tube to determine if water intrusion has occurred within the structure.

Sheave means a pulley or wheel grooved for a rope and/or grip.

Sheave Assembly means a frame containing a series of sheaves used to guide and support a haul rope between the drive and return stations.

Tower means a structure supporting a sheave or series of sheaves that resists the downward (positive) or upward (negative) force of a hauling rope. (Definition from CAN/CSA Z98-07).

Z98 is the national technical standard for passenger ropeways in Canada.

Author *Auteur*	Release date *Date émission*	Doc. no. *No. de doc.*	Doppelmayr CTEC
SLC/GSM	**12-31-2006**	**SA-06-022**	

SAFETY ALERT BULLETIN / *BULLETIN DE SÉCURITÉ*

Lift manufacturer / *Fabricant :*	**THIOKOL, STADELI, HALL, VON ROLL, CTEC, GARAVENTA CTEC, DOPPELMAYR, DOPPELMAYR CTEC**	**Fab. Group / *Groupe de fabrication :***	**025 – TOWERS**
Lift type / *Type de remontée :*	**CHAIRLIFT**		
Supercedes / *Remplace :*	**N/A**	**Effective date / *Date en vigueur :***	**December 31, 2006**

Title / Titre : **Tower failure due to water intrusion**

1. Generalities / *Généralités*

1.1 Abstract of issue (summary) / *Résumé*
Accumulated water within tower tubes can have catastrophic effects upon structural integrity.

1.2 Reason for release (summary) / *But*
Recently, accumulated water within a tower tube froze and resulted in a complete failure of the tower tube. The failure occurred on a closed, unloaded lift at night after daily operations were complete.

2. Scope / *Objet*

2.1 Generalities / *Généralités*
The affected tower design had an open center splice ring connecting a larger diameter lower tube to a smaller diameter upper tube. The design of the splice ring had connecting bolts passing through the upper ring and threading into the lower ring. The threaded holes for the connecting bolts in the lower ring were inside the lower tube diameter. Typical assembly instructions for this type splice connections call for the use of mastic or caulking to inhibit water intrusion.

2.2 Affected model, type, parts / *Modèle, type, pièces affectées*
While the noted failure involved a 1992 Von Roll two-piece tower on a fixed grip double chair, any tower design that has a sealed base could be similarly affected if there is a pathway for water intrusion.

3. Action to be taken and completion date / *Actions à entreprendre et délais de réalisation*

(Inspection, modification, replacement, NDT, part, manual revision, procedural change)
(Inspection, modification, remplacement, END, révision du manuel, changement de procédure)

Routine annual maintenance activities must include a close visual inspection of all tower components including the tower base. Signs of fatigue due to freeze / thaw cycles or cyclic loading may present themselves as indications (cracks) during the early stages, therefore, all welds,

Author *Auteur*	Release date *Date émission*	Doc. no. *No. de doc.*	Doppelmayr CTEC
SLC/GSM	**12-31-2006**	**SA-06-022**	

SAFETY ALERT BULLETIN / *BULLETIN DE SÉCURITÉ*

Lift manufacturer / *Fabricant :*	**THIOKOL, STADELI, HALL, VON ROLL, CTEC, GARAVENTA CTEC, DOPPELMAYR, DOPPELMAYR CTEC**	**Fab. Group / *Groupe de fabrication :***	**025 – TOWERS**
Lift type / *Type de remontée :*	**CHAIRLIFT**		
Supercedes / *Remplace :*	**N/A**	**Effective date / *Date en vigueur :***	**December 31, 2006**

gussets and tower tubes should be subject to close visual inspection annually. Any suspected indication noted visually should be confirmed by magnetic particle examination. The presence of any confirmed indication must be reported to Doppelmayr CTEC Engineering Department for review and recommended repair procedures.

Signs of weeping may indicate the presence of additional water within a tower. When struck with a dead-blow hammer in several ascending points from the base, a change in the resonating tone of the tower may indicate the presence of water (a tower with water tends to exhibit a solid "dead" sound compared to a more normal bell-like tone). Some tone differences may be noted due to proximity to base gussets and will not necessarily indicate the presence of water. Care should be taken to eliminate or minimize any obvious source of water intrusion.

Unless water is suspected to be collecting inside the tower, it is neither necessary nor recommended to provide a drain hole. Sealed towers have historically exhibited very little internal corrosion.

- If water is suspected to be present, a small hole (⅜" ~ ½") may be drilled near the tower base at the side of the tower (90° to the haul rope) to provide a pathway for water to escape. This is a recommended action only where the presence of water is suspected. Holes should not be installed purely as a preventative measure or in lieu of annual inspection. Periodic cleaning of drain holes may be required to maintain their functionality.

Required action

<u>If tower base inspections have not routinely been included and documented in annual maintenance activities</u>, a visual inspection of each tower base for signs of fatigue must be completed within the next 30 days. Any suspected indication noted visually should be confirmed by magnetic particle examination. The presence of any confirmed indication must be reported to Doppelmayr CTEC Engineering Department for review and recommended repair procedures.

Any confirmed indication greater than 1 inch (25 mm) in length shall be cause for immediate and continued closure of the lift to public transportation until repairs are authorized by Doppelmayr CTEC and implemented.

Author *Auteur*	Release date *Date émission*	Doc. no. *No. de doc.*	Doppelmayr CTEC
SLC/GSM	**12-31-2006**	**SA-06-022**	

SAFETY ALERT BULLETIN / *BULLETIN DE SÉCURITÉ*

Lift manufacturer / *Fabricant :*	**THIOKOL, STADELI, HALL, VON ROLL, CTEC, GARAVENTA CTEC, DOPPELMAYR, DOPPELMAYR CTEC**	**Fab. Group / *Groupe de fabrication :***	**025 – TOWERS**
Lift type / *Type de remontée :*	**CHAIRLIFT**		
Supercedes / *Remplace :*	**N/A**	**Effective date / *Date en vigueur :***	**December 31, 2006**

4. Detail of issue / *Details*

Text, drawings, schematics
Textes, dessins, schémas

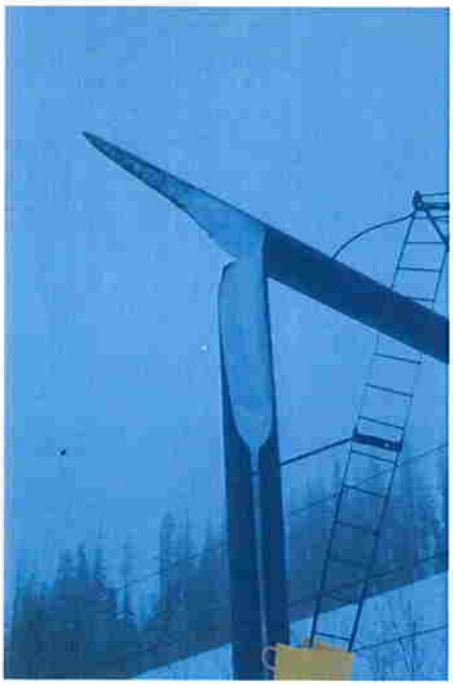
Tower: 6S/4S; 46' tall; 30' of 20" tube spliced to 16' of 16" tube. Ice filled to 30' position.

Weather conditions at failure:
Night; ~-5° F.; Wind ~ 57 mph.

Tower split vertically from base then hinged at approx. 18-1/2' and fell toward heavy side (uphill) line in the direction of prevailing wind.

Haul rope was trapped on both HS & LS assemblies.

Horizontal tower base crack 10-1/2" long, 14" up from base.



88 6th Street, Suite 400
New Westminster, BC V3L 5B3

Toll Free: 1-866-566-SAFE
Fax: (604) 660 - 6215
www.safetyauthority.ca

Appendix 2
CERTIFICATE OF INSPECTION

Activity Date: 2008/12/17
File Number:

For INCIDENT INSPECTION Inspection

Registration Number: 140.021 Status: Active Site: Blackcomb Skiing Enterprises Limi Area:2 - Whistler/Blackcom

Customer: BLACKCOMB SKIING ENTERPRISES LTD
4545 BLACKCOMB WAY
WHISTLER BC V0N 1B0

Unit Name: EXCALIBER LOWER
Carrier Capacity: 8
Last Inspection Date: 2008/10/08

Manufacturer: DOPPELMAYR
Total Operating Hrs: 23946
Actual Speed:

Unit Type: DETACH GONDOLA
Hrs. Since Last Inspection: 168
Actual Aux Speed:

MAIN DRIVE	SB	EB	BOTH	NORM./REGEN.
Dist. (M)				
Time (S)				
Decel (M/S^2)				

AUX. DRIVE	SB	EB	BOTH	NORM./REGEN.
Dist. (M)				
Time (S)				
Decel (M/S^2)				

Advise the British Columbia Safety Authority in writing when non-compliances are completed or any changes on the Contractor status

		Non-Compliances (non-compliance may result in shut down and/or charges under the Safety Standards Act and Regulations)	**CSA/EDSR/SSGR/ SSA**	**Required Completion Date**	**Date Issued**
3	306	CARRIERS - CARRIER REPAIR OR REPLACE - Repair winch for raising lowering upper deck on work carrier. Winch clutch is slipping.		**2008/11/15**	**2008/10/08**
1	603	MISC - DOCUMENTATION, PROVIDE - Submit copy of daily checklists for maintnenace and operations dated December 16, 2008.		2008/12/19	2008/12/17
2	603	MISC - DOCUMENTATION, PROVIDE - Provide statements from lift operators that were on duty at drive and return stations at the time the incident occurred on December 16, 2008.		2008/12/19	2008/12/17
3	603	MISC - DOCUMENTATION, PROVIDE - Provide statement from lift maintenance mechanic who was on tower 4 making alignment adjustments just prior to this incident.		2008/12/19	2008/12/17
4	603	MISC - DOCUMENTATION, PROVIDE - Submit report from ski patrol which identifies the following: 1. Total number of people evacuated. 2. Number of people in each cabin when evacuated. 3. Number of injured in each cabin and type of injuries. 4. Names of injured if available.		2008/12/19	2008/12/17
5	603	MISC - DOCUMENTATION, PROVIDE - Submit incident report for tower 4 failure that occurred on December 16, 2008.		2008/12/18	2008/12/17
6	603	MISC - DOCUMENTATION, PROVIDE - Submit repair procedure for tower #4 and include any NDT requirements. Procedure to submitted under seal of a professional engineer licensed in BC. Professional engineer must verify in writing that replaced critical components and repair meet CAN/CSA Z98-07 clauses 4.6.2 and 4.9.2.		2008/12/19	2008/12/17

Client Signature:	Safety Officer's Name: David L. Looney Fax (250) 334-1106	Safety Officer ID#: 35

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Appendix 2
CERTIFICATE OF INSPECTION

Activity Date: 2008/12/17
File Number:

For INCIDENT INSPECTION Inspection

Registration Number: 140.021 Status: Active Site: Blackcomb Skiing Enterprises Limi Area:2 - Whistler/Blackcom

Advise the British Columbia Safety Authority in writing when non-compliances are completed or any changes on the Contractor status

		Non-Compliances (non-compliance may result in shut down and/or charges under the Safety Standards Act and Regulations)	**CSA/EDSR/SSGR/ SSA**	**Required Completion Date**	**Date Issued**
7	421	LINE EQUIPMENT - TOWER, REPAIR OR REPLACE - Provide method to prevent water from entering or a method to drain water from the lower tube section of tower #4 and any other split half towers on this installation that is acceptable to a professional engineer licensed in BC.		2008/12/19	2008/12/17
8	603	MISC - DOCUMENTATION, PROVIDE - Obtain inspection procedure for all components of the this installation (e.g. carriers, sheave assemblies, towers, haul rope, communication lines, foundations, tension system components and all station equipment) to ensure these components are acceptable for operation for public. Procedure is to be submitted to BCSA under seal of a professional engineer licensed in BC.		2008/12/19	2008/12/17
9	603	MISC - DOCUMENTATION, PROVIDE - Submit report from a professional engineer licensed in BC that identifies the results of the required inspections (as per non-compliance #8) and any components that have been removed from service. A statement must be included in the report that verifies the installation meets the requirements of CAN/CSA Z98.		2008/12/19	2008/12/17
10	603	MISC - DOCUMENTATION, PROVIDE - Submit report under seal of a professional engineer licensed in BC that identifies the cause of the critical component failure as per CAN/CSA Z98-07 clause 12.8.3.3.		2008/12/19	2008/12/17
11	608	MISC - NO NUMBER EXISTS - Once all repairs are complete installation must be inspected by the BCSA prior to operation for public.		2008/12/18	2008/12/17
12	130	ROPES, CHAINS, FITTINGS - TEST N.D. ROPES & PROVIDE REPORT - NDT haul rope and submit report to BCSA.		2008/12/19	2008/12/17

Notes:

Incident investigation December 16,17,18, 19 - 2008, this Certificate of Inspection was issued as part of an incident investigation by Dave Looney and Jason Gill, for complete details of incident see Posse Job # 3941200.

☐ Could not inspect

Billable Hrs:	Overtime Hrs:	Holiday Hrs:	Accomodation:
Meals:	Ferry/Air:	Misc:	Km Cost

Client Signature:	Safety Officer's Name: David L. Looney Fax (250) 334-1106 Safety Officer ID#: 35

SAFETY ORDER

No: SO-P4 081218 3

INSPECTION OF PASSENGER ROPEWAY TOWERS FOR WATER INTRUSION

Date of Issue: December 18, 2008

This safety order is being issued pursuant to section 31 of the Safety Standards Act. A person affected by this safety order may appeal this order, in writing, to the Safety Standards Appeal Board in accordance with Section 51 of the Safety Standards Act. It is an offence under section 72 not to comply with a safety order.

Part 1: Details of Regulated Work or Regulated Product

This safety order is being issued in relation to a regulated product – specifically **towers of hollow steel construction that support circulating above surface passenger ropeways with either fixed or detachable grips.**

An incident involving the failure of a steel support tower on a detachable 8 passenger gondola has been reported to the British Columbia Safety Authority. The incident occurred Dec 16, 2008. It has been determined that water had accumulated in the lower tower tube of a two section 15 m support tower. The lower tower tube, which is partially filled with concrete, is flanged and connected to a companion flange on the upper tube with 24 bolts. Water entered the void in the lower tube above the concrete. During an extended period of cold weather, the water in the void froze and expanded. It appears that the weld connecting the flange to the lower tube failed as a result of the upward pressure from the ice. The upper 7m tower tube, the cross arm and two combination sheave assemblies fell off the lower 9m tube. The result was a sudden detensioning of the haul rope with several 8 passenger gondola cabins coming into contact with structures on the ground. 53 passengers were riding the ropeway at the time of the incident.

Part 2: Requirement(s) of this safety order

All operators of circulating above surface passenger ropeways with either fixed or detachable grips are hereby ordered to inspect affected tower components, including tower bases, tower tubes, tower cross arms and tower splices on the installations for signs indicating the presence of water or ice inside these tower components. One example of a method that may be used to check for this condition is to use a "sounding test" by striking the side of the component with a ball peen hammer (a tower component with water or ice inside tends to exhibit a solid "dead" sound compared to a normal bell like tone). If you are unsure how to conduct these inspections please contact the manufacturer or a professional engineer licensed in BC for instructions. ***All affected towers must be inspected within four days of receipt of this order.***

If any towers or related tower components are found to have water or ice in them, or the operator is unsure of what is inside of the component (e.g., concrete) the operator is hereby ordered to contact the manufacturer to determine what actions shall be taken to address the situation. If an operator finds any tower or tower related components which have been damaged by ice jacking, the operator is hereby ordered to remove those affected passenger ropeways from operation and notify the BC Safety Authority immediately. The manufacturer shall be contacted to provide repair procedures. Once repairs have been completed permission to return the passenger ropeway to service shall be requested from the BC Safety Authority.

Complete the attached response form and fax to the British Columbia Safety Authority New Westminster office (fax number 604-660-6661 c/o Greg Paddon) upon completion/verification that the above noted requirements have been complied with. Completed forms shall be received by the Provincial Safety Manager no later than December 31, 2008.

88 – 6TH STREET, SUITE 400, NEW WESTMINSTER, BRITISH COLUMBIA, CANADA V3L 5B3
Toll Free: 1-866-566-SAFE (7233) Fax: 604 660-6215 Web Site: www.safetyauthority.ca E-mail: info@safetyauthority.ca

Part 3: Details of Issue (if applicable)

This safety order is being issued to all passenger ropeway operators who operate circulating above surface passenger ropeways with either fixed or detachable grips.

Part 4: Details of Ordering Safety Manager or Safety Officer – Please read following page

I certify that I am authorized to issue this safety order in accordance with section 15 (d) of the Safety Standards Act or that I have been delegated this power under section 15 (g) of the Safety Standards Act.

Greg Paddon
Provincial Safety Manager - Passenger Ropeways & Amusement Devices **Date: December 18, 2008**

Safety Standards Act:

Safety Orders

31 (1) To prevent, avoid or reduce risk of personal injury or damage to property, a provincial safety manager may, in writing, issue a safety order.

(2) A safety order may be issued to any person in relation to any of the following:
- (a) regulated work or regulated products generally;
- (b) a specific class of regulated product or regulated work;
- (c) a specific regulated product or regulated work.

(3) For certainty, a safety order issued under this section may apply to
- (a) regulated work that meets the requirements under this Act,
- (b) regulated work that previously met the requirements under this Act or a former Act but does not meet the current requirements under this Act,
- (c) regulated products that meet the requirements under this Act, or
- (d) regulated products that previously met the requirements under this Act or a former Act but do not meet the current requirements under this Act, including a regulated product that bears a certification mark.

(4) A safety order may specify any requirement that is intended to prevent, avoid or reduce the risk of personal injury or damage to property and may include any of the following orders:
- (a) that an existing regulated work or regulated product must be made safe in compliance with the safety order;
- (b) that a regulated product must be
  - (i) disconnected from a power source,
  - (ii) uninstalled, or
  - (iii) modified before continued use;
- (c) that a regulated product must be operated, installed, manufactured or disposed of only as specified or that a regulated product must not be moved;
- (d) that current or future regulated work or a regulated product must conform to the terms or conditions of the order;
- (e) that a person take or refrain from taking any action that a safety manager considers necessary to prevent, avoid or reduce a risk of personal injury to persons or damage to property;
- (f) that the manufacturer make reasonable efforts to recall the regulated product.

(5) The provincial safety manager must give written notice of the safety order to the following persons:
- (a) the manufacturer of the regulated product;
- (b) an owner of the regulated product if the identity of the owner is known to the provincial safety manager;
- (c) the person in charge of the regulated work.

(6) The notice must state the reasons for the decision and that the person has the right to appeal the decision to the appeal board.

(7) Despite section 54, a safety order may not be stayed during an appeal.

References:

Safety Standards Act

For more information on the British Columbia Safety Authority, please visit our website at:
www.safetyauthority.ca

88 – 6TH STREET, SUITE 400, NEW WESTMINSTER, BRITISH COLUMBIA, CANADA V3L 5B3
Toll Free: 1-866-566-SAFE (7233) Fax: 604 660-6215 Web Site: www.safetyauthority.ca E-mail: info@safetyauthority.ca

SAFETY ORDER RESPONSE FORM

The information on this form is collected to administer the provisions of the *Safety Standards Act*. If you have questions about the collection, use or disclosure of this information, contact the Records, Information and Privacy Analyst for the BC Safety Authority at telephone (604) 660-6286.

The company and/or designated representative in receipt of a safety order must fill out and submit this form to the British Columbia Safety Authority within the timeframe stipulated on the safety order.

Safety Order No: _____

Operating Company: _____

The following have been completed as required in the above safety order:
(use additional pages as necessary and attach)

_____

_____

_____

_____

Person signifying completion of safety order requirement/s: _____
(Please print name)

Position Title: _____

Signature: _____

Completion Date: Month / Day / Year _____

Return this form to:

Attention: Greg Paddon
Provincial Safety Manager, Passenger Ropeways & Amusement Devices
British Columbia Safety Authority
Suite 400, 88 – 6th Street
New Westminster, BC V3L 5B3
Tel: 604-660-5964 Fax: 604-660-6661

88 – 6TH STREET, SUITE 400, NEW WESTMINSTER, BRITISH COLUMBIA, CANADA V3L 5B3
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Appendix 4
CERTIFICATE OF INSPECTION

88 6th Street, Suite 400
New Westminster, BC V3L 5B3

Toll Free: 1-866-566-SAFE
Fax: (604) 660 - 6215
www.safetyauthority.ca

Activity Date: 2008/12/19
File Number:

For INCIDENT INSPECTION Inspection

Registration Number: 140.021 Status: Active Site: Blackcomb Skiing Enterprises Limi Area:2 - Whistler/Blackcom

Customer: BLACKCOMB SKIING ENTERPRISES LTD
4545 BLACKCOMB WAY
WHISTLER BC V0N 1B0

Unit Name: EXCALIBER LOWER
Carrier Capacity: 8
Last Inspection Date: 2008/10/08

Manufacturer: DOPPELMAYR
Total Operating Hrs: 23946
Actual Speed: 5.08 M/S

Unit Type: DETACH GONDOLA
Hrs. Since Last Inspection: 168
Actual Aux Speed:2.7 M/S

MAIN DRIVE	SB	EB	BOTH	NORM./REGEN.
Dist. (M)				
Time (S)				
Decel (M/S^2)				

AUX. DRIVE	SB	EB	BOTH	NORM./REGEN.
Dist. (M)				
Time (S)				
Decel (M/S^2)				

Advise the British Columbia Safety Authority in writing when non-compliances are completed or any changes on the Contractor status

		Non-Compliances (non-compliance may result in shut down and/or charges under the Safety Standards Act and Regulations)	**CSA/EDSR/SSGR/ SSA**	**Required Completion Date**	**Date Issued**
3	306	CARRIERS - CARRIER REPAIR OR REPLACE - Repair winch for raising lowering upper deck on work carrier. Winch clutch is slipping.		**2008/11/15**	**2008/10/08**
1	421	LINE EQUIPMENT - TOWER, REPAIR OR REPLACE - Ensure lower section of of tower # 5 is inspected using a procedure established by a BC P.Eng, provide BCSA with a copy of this test procedure. Provide BCSA with a report detailing the results of this inspection and any recommendations, this report and test procedure must be endorsed by a BC P.Eng.		2008/12/20	2008/12/19
2	421	LINE EQUIPMENT - TOWER, REPAIR OR REPLACE - Warm lower section of tower # 5 to remove ice from tube and establish level of concrete in tube.		2008/12/20	2008/12/19

Notes:

Follow up to report issued on Thursday December 18, 2008.

☐ Could not inspect

Billable Hrs:	Overtime Hrs:	Holiday Hrs:	Accomodation:
Meals:	Ferry/Air:	Misc:	Km Cost

Client Signature:	Safety Officer's Name: Safety Officer ID#: 35 David L. Looney Fax (250) 334-1106

December 20, 2008

Wayne Wiltse
Manager Lift Maintenance
Whistler & Blackcomb Mountains Resorts Ltd
4545 Blackcomb Way
Whistler, BC V0N 1B4

wwiltse@intrawest.com

Doppelmayr CTEC ltd
567 Adams Road
Kelowna, BC Canada
V1X 7R9
Phone: (250) 765-3000
Fax: (250) 765-5877

warren.sparks@doppelmayrctec.com

RE: **Blackcomb Excalibur Gondola Repair Procedures**

Dear Wayne:

Blackcomb Lower Excalibur Gondola Repair Procedures

Pursuant to the collapse of tower 4 and resulting damage, the following repairs shall be implemented prior to public transportation.

1.1 Tower 4 upper section repairs:

- Mag particle test all welds, report any defects to Doppelmayr, otherwise this section can be reused as is.
- Replace ladder with new.
- Install ½" drain hole just above the base plate weld, on the ladder side (so the functionality of the drain hole can be checked annually)
- Use new nuts, bolts and washers according to the drawing. Do not use split lock washers at the splice ring, use flat washers (in an effort to prevent water ingress at the bolt holes)

1.2 Tower 4 lower section repairs:

- Remove ice inside the tower section and locate top of concrete tube fill
- Install ½" drain hole just above the concrete fill, on the ladder side (so the functionality of the drain hole can be checked annually)
- Cut 50 mm off the top (this zone is considered damaged by deformation).
- Mag particle test the top 100 mm of pipe to verify zero indications. Visually inspect for deformation, cracking, distortion, corrosion.
- If necessary, cut more off the top until damaged pipe is removed. If the tube is shortened by more than 100mm, inform Doppelmayr so the resulting revised sheave loads can be checked (or tube length adjustment procedures prescribed as necessary).
- Report final tube length to Doppelmayr.
- Fabricate a new cap plate of Grade 50W according to Drawing 19219D051500b, 1994-04-20, "Tower Shaft Extension 30" x ½" 12 bolt" (without any holes in it, except the bolt holes) and prepare the pipe end according to this drawing.

- Install the new cap plate using procedure “General Repair Instruction For Welded Structures”, IN-05-092-E, 2007-08-08 according to Drawing 19219D051500b, 1994-04-20, “Tower Shaft Extension 30” x ½” 12 bolt”.
- Mag particle test cap plate weld and longitudinal pipe seam weld, report any defects to Doppelmayr.
- Replace ladder with new.
- Use new nuts, bolts and washers according to the drawing. Do not use split lock washers at the splice ring, use flat washers (in an effort to prevent water ingress at the bolt holes)
- Torque 1” SAE Grade 5 splice bolts to 500 ft-lb.

1.3 Tower 5 repairs

- Install 3/8”- ½” drain hole in the lower tower section just above the concrete tube fill on the ladder side of the tower.
- Install 3/8”- ½” drain hole in the upper tower section approx. 50 mm above the base plate weld on the ladder side of the tower.
- Heat to melt ice and drain water from both sections.
- Perform UT inspection of all tower splice welds and pipe in proximity to splice welds by qualified inspector (as a precaution since cracked paint was observed just above the splice weld in the upper section).
- Provide test report endorsed by BC PEng.
- Report any defects to Doppelmayr.

1.4 Tower Cross-arms and Sheaves

- replace sheave assemblies T3DH, T4DH, T4UH and T5DH (total of 4 assemblies). Sheave mounting consoles and associated axles can be re-used provided they are inspected by mag particle method. Report any defects to Doppelmayr. Replace sheave mounting console bolts with new, although a few old bolts can be temporarily re-used for a few days if necessary.
- On T4 replace the 2 bent platforms and bent hand railings (this can be done later as time permits)
- On T4 replace the bent platform support beams (this can be done later as time permits).
- On T4 mag particle test all welds (with particular attention to the mounting tabs and ropelifting frame connection). Visually inspect for deformation, cracking, distortion and corrosion.
- Report any defects to Doppelmayr.

1.5 Carriers

- Remove damaged cabins 76, 77, 78, 79, 80, 81 from service until repairs authorized by CWA have been implemented.
- Dismantle and inspect all grips associated with damaged cabins according to inspection instructions normally used for annual 20% sample.
- Inspect hangers associated with damaged cabins according to inspection instructions normally used for annual 20% sample.

- Visually inspect 100% of grips for signs of damage, stress, impact, deformation.
- Visually inspect 100% of cabins for signs of damage, stress, impact, deformation.
- Check the door mechanisms for proper function.

1.6 Haul Rope

- Visually inspect rope damage vicinity T3, T4, T5 by qualified inspector
- Perform MRT inspection of entire haul rope by qualified inspector
- Provide inspection report to Doppelmayr endorsed by BC PEng.
- Report to Doppelmayr any defects outside Z98-07 tolerances.

1.7 Comm Line

- Repair comm. line as necessary
- Repair fiber optic line as necessary

Yours truly,

DOPPELMAYR CTEC LTD

Warren Sparks, P.Eng.
Executive Vice-President

cc: Greg Paddon, BCSA
Jason Gill, BCSA
Dave Looney, BCSA
Danny Cox
Matheus Zudrell, Doppelmayr
Jim Anderson, Doppelmayr
Paul Ehlert, Doppelmayr
Patrice Munier, Doppelmayr
Rene Boisselle, Doppelmayr
Stefan Huter, Doppelmayr
Michael Klimmer, Doppelmayr
Christoph Hinterreger, Doppelmayr
Markus Beck, Doppelmayr

Author *Auteur*	Release date *Date émission*	Doc. no. *No. de doc.*	Doppelmayr CTEC
WOL	**12/20/2008**	**SA-08-021 Wolfurt KD08003E**	

SAFETY ALERT BULLETIN

Lift manufacturer / *Fabricant :*	**Hall, VonRoll, Thiokol, CTEC, Garaventa CTEC, Doppelmayr, Doppelmayr CTEC**	**Fab. Group / *Groupe de fabrication :***	**FAB GROUP** **25 – Tower Equipment**
Lift type / *Type de remontée :*	**All lifts**		
Supercedes / *Remplace :*	**N/A**	**Effective date / *Date en vigueur :***	**December 20, 2008**

Title: **Tower Failure Due to Water Intrusion**

1. Generalities

1.1 Abstract of issue (summary)

In direct response to a recent incident, the Doppelmayr main office in Wolfurt, Austria has released the attached Safety Alert Bulletin KD08003E.

1.2 Reason for release (summary)

See attached Doppelmayr Wolfurt Safety Alert Bulletin KD08003E.

2. Scope

See attached Doppelmayr Wolfurt Safety Alert Bulletin KD08003E.

3. Action to be taken and completion date

(Inspection, modification, replacement, NDT, part, manual revision, procedural change)

All actions prescribed by attached Doppelmayr Wolfurt Safety Alert Bulletin KD08003E must be completed and documented by all customers.

4. Detail of issue

Text, drawings, schematics

See attached Doppelmayr Wolfurt Safety Alert Bulletin KD08003E.

DOPPELMAYR SEILBAHNEN GmbH, WOLFURT

BULLETIN	Ersteller/ Author	Datum/ Date	Dok.- Nr./ Doc.-ID	Seite/ Page
	CH/HS/LAK	20.12.2008	KD08003E	1 / 5

Ersatz für/ Supersedes:	Ersetzt durch/ Replaced by:	Type:	Baugruppe/ Assembly group:
--	--		Towers
Abgeleitet von / Based on:	SA-06-022 Safety Alert Bulletin		
Classification Code:	x OS	O	IS	I

Tower failure due to water intrusion

1. General

1.1 Abstract of issue (summary)

Accumulated water within tower tubes and other hollow sections that have a sealed base or clogged drainage (including but not limited to terminal structures, crossarms, carriers, etc.) can have catastrophic effects upon structural integrity.

1.2 Reasons for release

Recently, accumulated water within a tower tube froze and resulted in a complete failure of the tower splice plate weld. The failure occurred during operation on an 8MGD installation built in 1994 in Canada. The affected tower design was a two-section tower of which the lower section had an opening for concrete fill in the top plate. The lower section was filled approximately 70% with concrete. The remaining space within the tower tube filled up with water which froze and expanded causing the upper section of the tower to separate and fall.

Inspections subsequent to the event, have reported that water or ice has been discovered in towers and other structural members. In some instances, damage to structure members has been noted.

2. Scope

2.1 Affected model, type, parts

While the noted failure involved a 1994 Doppelmayr two-piece tower on a detachable gondola, any tower design or other hollow structures that have a sealed base or clogged drainage could be similarly affected if there is a pathway for water intrusion or an opening for air to enter and cause condensation.

This bulletin specifies describes tower inspections but also applies to terminal masts and other hollow structures with a sealed base. If the presence of water/ice is found or suspected within other hollow structures, consult with the nearest Doppelmayr office for review and recommended procedures.

BULLETIN	Ersteller/ Author	Datum/ Date	Dok.- Nr./ Doc.-ID	Seite/ Page
	CH/HS/LAK	20.12.2008	KD08003E	2 / 5

Ersatz für/ Supersedes:	Ersetzt durch/ Replaced by:	Type:	Baugruppe/ Assembly group:
--	--		Towers
Abgeleitet von / Based on:	SA-06-022 Safety Alert Bulletin		
Classification Code:	x OS	O	IS I

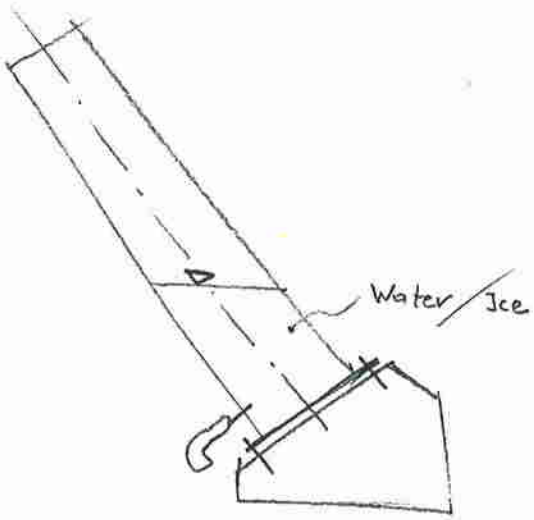
3. Action to be taken / Completion date

3.1 Required Actions: inspections ASAP but at the latest within the next 30 days
ASAP / no later than within the next 30 days, a resonance check and visual inspection of each tower tube or other hollow structure with a sealed base must be completed.

3.1.1 Resonance check: Each tower tube or other hollow structure with a sealed base must be checked for the presence of internal water/ice. When struck with a hammer in several ascending points from the base, a change in the resonating tone of the tower may indicate the presence of water/ice (a tower with water/ice or concrete tends to exhibit a solid "dead" sound compared to a more normal bell-like tone). Some tone differences may be noted due to proximity to base gussets or the presence of internal concrete (see additional information within Section 3.1.2) and will not necessarily indicate the presence of water.

If with a resonance check, water/ice is suspected to be present within the tower but further than 4" (100 mm) from the top plate, a small hole 3/8" - 1/2" (10 - 12 mm) must be drilled near the tower base at the downhill side of the tower along the centerline of the lift 2" to 4" (50 – 100 mm) from the tower base to provide a pathway for water to escape. See illustration below.

If with a resonance check, water/ice is found or suspected inside the tower within 4" (100 mm) of the top plate (see Section 3.1.2) **this shall be cause for immediate and continued closure of the lift to public transportation** and must be reported to the nearest Doppelmayr representation office for review and recommended repair procedures.



DOPPELMAYR SEILBAHNEN GmbH, WOLFURT

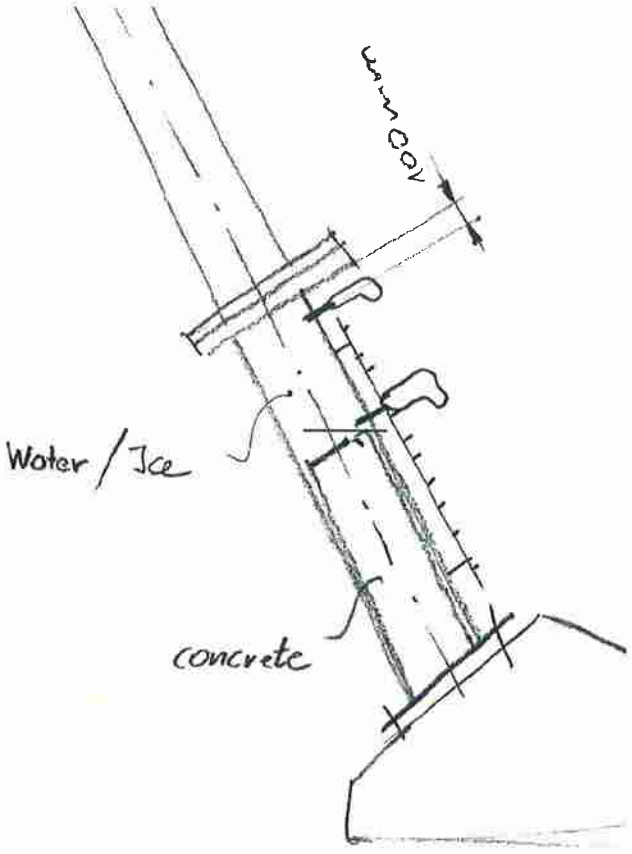
BULLETIN	Ersteller/ Author	Datum/ Date	Dok.- Nr./ Doc.-ID	Seite/ Page
	CH/HS/LAK	20.12.2008	KD08003E	3 / 5

Ersatz für/ Supersedes:	Ersetzt durch/ Replaced by:	Type:	Baugruppe/ Assembly group:
--	--		Towers
Abgeleitet von / Based on:	SA-06-022 Safety Alert Bulletin		
Classification Code:	x OS	O	IS I

3.1.2 Concrete-filled shafts / shaft sections

For tower shaft sections partially filled with concrete through the top plate, check the tower section with the hammer method as described previously. If water/ice is suspected, drill a small hole 3/8" - 1/2" (10 - 12 mm) approx. 2 inches (50 mm) below the top plate on the uphill side of the tower (behind the ladder). Tower shafts with a cover for concrete fill on the outside of the shaft already have a drain hole and the cover can be removed for inspection purposes. **If ice is found in this section, this shall be cause for immediate and continued closure of the lift to public transportation** and must be reported to the nearest Doppelmayr representation office for review and recommended repair procedures.

A small drain hole 3/8" - 1/2" (10 - 12 mm) is required to eliminate the water above the concrete level. See illustration below.



	BULLETIN	Ersteller/ Author	Datum/ Date	Dok.- Nr./ Doc.-ID	Seite/ Page
		CH/HS/LAK	20.12.2008	KD08003E	4 / 5

Ersatz für/ Supersedes:	Ersetzt durch/ Replaced by:	Type:	Baugruppe/ Assembly group:
–	–		Towers
Abgeleitet von / Based on:	SA-06-022 Safety Alert Bulletin		
Classification Code:	x OS	O	IS	I

Required Actions: 30 day inspections (continued)

3.1.3 Visual inspection: Each tower tube or other hollow structure with a sealed base must be checked for signs of fatigue or deformation caused by ice. Any suspected indication noted visually must be confirmed by magnetic particle examination. The presence of any confirmed indication must be reported to the nearest Doppelmayr representation office for review and recommended repair procedures. Any confirmed indication greater than 1 inch (25 mm) **shall be cause for immediate and continued closure of the lift to public transportation** until repairs are authorized by Doppelmayr and implemented.

3.2 Required Actions: Annual Inspections

Routine annual maintenance must include a close visual inspection of all tower components including the tower bases and splice connection plates. Signs of fatigue due to freeze / thaw cycles of cyclic loading may present themselves as indications (cracks) during the early stages, therefore, all welds, gussets and tower tubes should be subjected to close visual inspection annually. Any suspected indication noted visually must be confirmed by magnetic particle examination. The presence of any confirmed indication must be reported to the nearest Doppelmayr representation office for review and recommended repair procedures.

A small hole 3/8" - 1/2" (10 - 12 mm) must be drilled near the tower base at the downhill side of each tower along the centerline of the lift 2" to 4" (50 – 100 mm) from the tower base to provide a pathway for water to escape. This hole must be inspected annually and kept clear of debris. Where there are upper tower sections that are not open to the base section, a hole must also be drilled along the centerline of the lift 2" to 4" (50 – 100 mm) above the tower section base plate. This hole may be drilled on the ladder side of the tower.

DOPPELMAYR SEILBAHNEN GmbH, WOLFURT

	BULLETIN	Ersteller/ Author	Datum/ Date	Dok.- Nr./ Doc.-ID	Seite/ Page
		CH/HS/LAK	20.12.2008	KD08003E	5 / 5

Ersatz für/ Supersedes:	Ersetzt durch/ Replaced by:	Type:	Baugruppe/ Assembly group:
--	--		Towers
Abgeleitet von / Based on:	SA-06-022 Safety Alert Bulletin		
Classification Code:	x OS	O	IS I

4. Detail of issue

Text, drawings, schematics

Tower with 2 x 6T/2FR assemblies; 16,7m tall; 9,7m of 30" tube spliced to 7m of 24" tube.

Lower tower section filled approx. 5m with concrete, the remainder with ice.

Temperature approx. -12°C/10°F.

Bottom tower section top flange plate was pushed off the shaft by ice and caused top tower section to separate and fall.

The comm. line and the haul ropes supported the tower head so the upper section came to rest in a more or less vertical position on the ground.

Appendix 7
CERTIFICATE OF INSPECTION

88 6th Street, Suite 400
New Westminster, BC V3L 5B3

Phone: (604) 660 - 6200
Toll Free: 1-866-566-SAFE
Fax: (604) 660 - 6215
www.safetyauthority.ca

Activity Date: 2008/12/23
File Number:

For ANNUAL REINSPECTION Inspection

Registration Number: 140.021 Status: Active Site: Blackcomb Skiing Enterprises Limi Area:2 - Whistler/Blackcom

Customer: BLACKCOMB SKIING ENTERPRISES LTD
4545 BLACKCOMB WAY
WHISTLER BC V0N 1B0

Unit Name: EXCALIBER LOWER
Carrier Capacity: 8
Last Inspection Date: 2008/10/08

Manufacturer: DOPPELMAYR
Total Operating Hrs: 23952
Actual Speed: 5.02 M/S

Unit Type: DETACH GONDOLA
Hrs. Since Last Inspection: 174
Actual Aux Speed:

MAIN DRIVE	SB	EB	BOTH	NORM./REGEN.
Dist. (M)	17.1		11.5	23.7
Time (S)	6.2		4.1	8.7
Decel (M/S^2)	0.81		1.22	0.58

AUX. DRIVE	SB	EB	BOTH	NORM./REGEN.
Dist. (M)				
Time (S)				
Decel (M/S^2)				

Advise the British Columbia Safety Authority in writing when non-compliances are completed or any changes on the Contractor status

		Non-Compliances (non-compliance may result in shut down and/or charges under the Safety Standards Act and Regulations)	**CSA/EDSR/SSGR/ SSA**	**Required Completion Date**	**Date Issued**
1	421	LINE EQUIPMENT - TOWER, REPAIR OR REPLACE - Replace missing handrail on downhill side tower walkway on outgoing end of sheave assembly.		2009/01/31	2008/12/23
2	154	ROPES, CHAINS, FITTINGS - VISUALY INSPECT ROPES - Conduct monthly visual inspections of anomaly located at 576 meters (identified on page 3 of Dopplemayr CTEC rope NDT report) where 2 bent wires are located as a result of incident on December 16, 2009.		2008/12/23	2008/12/23
3	603	MISC - DOCUMENTATION, PROVIDE - Ensure all original documents with professional engineering seals identified on the certificate of inspection issued on December 17, 2008 are submitted to the BCSA office no later than December 31, 2008.		2008/12/31	2008/12/23

Notes:

Inspection conducted with Dan Williams (L/M Supervisor), Jeff Ihaksi (L/M) & Bill Stiles (L/M Supervisor). Inspection conducted as per requirement identified on non-compliance #11 issued on December 17, 2008 certificate of inspection for incident that took place on December 16, 2008 where tower 4 failed just below the splice coupling. This inspection included visual inspection of all affected towers (towers 3-5) and all deropement switches were checked for proper function at these locations. Ground fault detection was verified on both loops (1 & 2) at tower #4. Alignments are also acceptable at these locations. Drive and return stations were checked visual at various speeds. The tension system was checked for free carriage movement and a low pressure tension fault was verified at 126 Bar (126 Bar required) and normal tension pressure was correct a t 140 Bar. Haul rope speed verified with BCSA hand tachometer. As result of this inspection and a review of submitted documentation the operating permit for the Excalibur Lower Gondola, Reg. No. 140.021, is considered to be reactivated and permission to open for public operation is granted. Documentation required as per non-compliance #10 issued on December 17, 2008 certificate of inspection, statement for critical component failure clause, will be submitted under seal of a professional engineer licensed in BC once complete. A bulletin issued by Doppelmayr CTEC on December 22, 2008 identifies the cause of the critical component failure and required inspections for all similar installations.

Client Signature:	Safety Officer's Name: Jason Gill (604) 660-5979	Safety Officer ID#: 31

88 6th Street, Suite 400
New Westminster, BC V3L 5B3

Phone: (604) 660 - 6200
Toll Free: 1-866-566-SAFE
Fax: (604) 660 - 6215
www.safetyauthority.ca

Appendix 7
CERTIFICATE OF INSPECTION

Activity Date: 2008/12/23
File Number:

Registration Number: 140.021 Status: Active Site: Blackcomb Skiing Enterprises Limi Area:2 - Whistler/Blackcom

☐ Could not inspect

Billable Hrs:	Overtime Hrs:	Holiday Hrs:	Accomodation:
Meals:	Ferry/Air:	Misc:	Km Cost

Client Signature:	Safety Officer's Name: Safety Officer ID#: 31 Jason Gill (604) 660-5979

Acuren Group Inc.
12271 Horseshoe Way
Richmond, BC, Canada V7A 4V4

Phone: (604) 275-3800
Fax: (604) 274-7235

Materials Engineering & Testing
a Rockwood Company

ISO 9001:2000

December 23, 2008 File Number: A08605-04669

FARRIS VAUGHN WILLS & MURPHY
25TH FLOOR
700 GEORGIA ST WEST
VANCOUVER, BC V7Y 1B3

Attention: Mr. Robert Kennedy

Dear Sir:

Re: Lower Excalibur Tower No. 5 Non Destructive Testing of Flange Welds

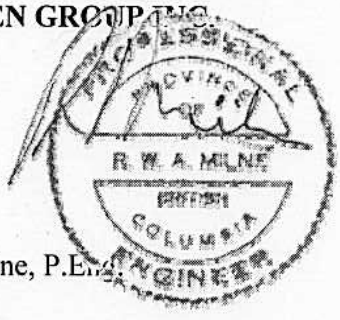
The attached nondestructive test report shows that the Lower Excalibur No. 5 tower flange to shaft welds are fillet welds that have variable penetration into the base plate material. The 6mm leg requirement was met at all locations.

The fillet welds are penetrated deeper than required at all locations and will provide the full strength of a 6mm fillet weld. No cracks or significant welding defects were found. The welds examined meet the requirements of Dopplemeyer Drawing "Tower Shaft Connection - 941.S.0014+15" - 1 R Gondola Blackcomb".

Please call at your convenience if you have any questions.

Yours truly,

ACUREN GROUP INC.



Bob Milne, P.Eng.

BM/mac

ACUREN

Acuren Group Inc.
12271 Horseshoe Way
Richmond, BC, Canada V7A 4V4
Phone: (604) 275-3800
Fax: (604) 274-7235

Materials Engineering and Testing
a Rockwood Company

ISO 9001:2000

NONDESTRUCTIVE EXAMINATION REPORT

TO: FARRIS VAUGHN WILLS & MURPHY
25TH FLOOR, 700 GEORGIA ST WEST
VANCOUVER, BC
V7Y 1B3

DATE: December 20, 2008 TIME: ---
ACUREN JOB #: 6054669
P.O.: ---
WORK LOCATION: On Site (Blackcomb Mountain)

ATTENTION: **ROBERT KENNEDY**
PROJECT: Blackcomb Lower Excalibur

ACCEPTANCE STANDARD: Client's information REV./DATE:
PROCEDURE #: --- REV./DATE: ---
ITEM(S) TESTED: Tower #5 TECHNIQUE #: --- REV./DATE: ---

PART #: Tower #5 MATERIAL: Carbon steel THICKNESS: 12.7 mm

SCOPE: To complete ultrasonic shear wave inspection on the lower tower shaft extension to flange weld. To carry out magnetic particle inspection on the tower shaft to flange weld.

TYPE(S) OF INSPECTION: Magnetic Particle; Ultrasonic

RESULTS: (Metric)

Magnetic Particle Inspection:

No discontinuities were found.

Ultrasonic Inspection:

A 50 mm wide 360° ultrasonic lamination scan was carried out on the lower tower shaft extension to flange where ultrasonic shear wave inspection was going to take place, and on the tower shaft to flange weld. Ultrasonic shear wave inspection was completed on the lower tower shaft extension to flange weld.

The lower tower shaft extension weld was not a full penetration weld. Reflectors were noted at various depths for the entire length of the scan. See the attached table for the location and reflector depths.

0 mm is the center of the pipe on the uphill side (center bolt).

Locations are laid out counter clockwise when looking uphill from the 0 mark. See attached diagram for details.

Depths are from the inside surface of the pipe.

CLIENT REPRESENTATIVE: (Signature on original)
TECHNICIAN: (Signature on original)
PRINT NAME: R. Hausenblas
1st Technician
CGSB/SNT Level II MT II
CGSB Registration No. 10307
2nd Technician

	TOTAL HOURS	S.T.	O.T.	SHIFT
1ST TECHNICIAN:	11		11	Day ☒
2ND TECHNICIAN:				PM ☐

KILOMETRES: 290 OTHER CHARGES: YES ☒ NO ☐

TABLE 1 - INCOMPLETE PENETRATION LOCATIONS AND DEPTHS

Location (mm)	Depth (mm)
15 - 75	6
90 - 130	4
140 - 300	4
330 - 450	7
540 - 660	5
670 - 890	6 - 8
940 - 960	3
1045 - 1100	6
1135 - 1145	3
1275 - 1570	6 - 8
1610 - 1670	5
1700 - 1790	7 - 9
1810 - 1830	6
1880 - 1900	5

FIGURE 1 - ORIENTATION DIAGRAM

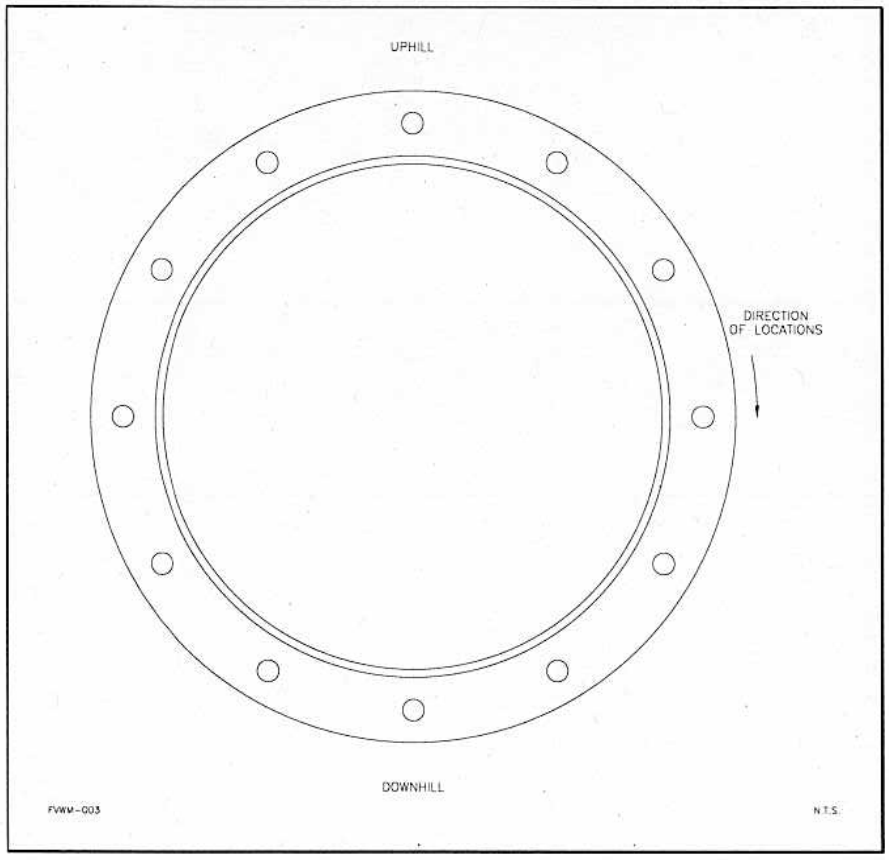


Photo 1:

General view of Excalibur tower #5.

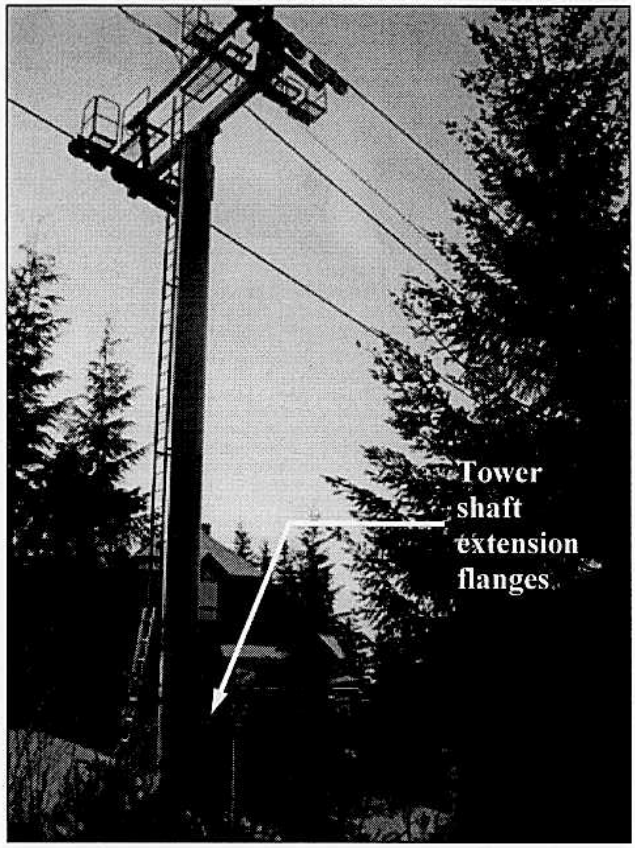
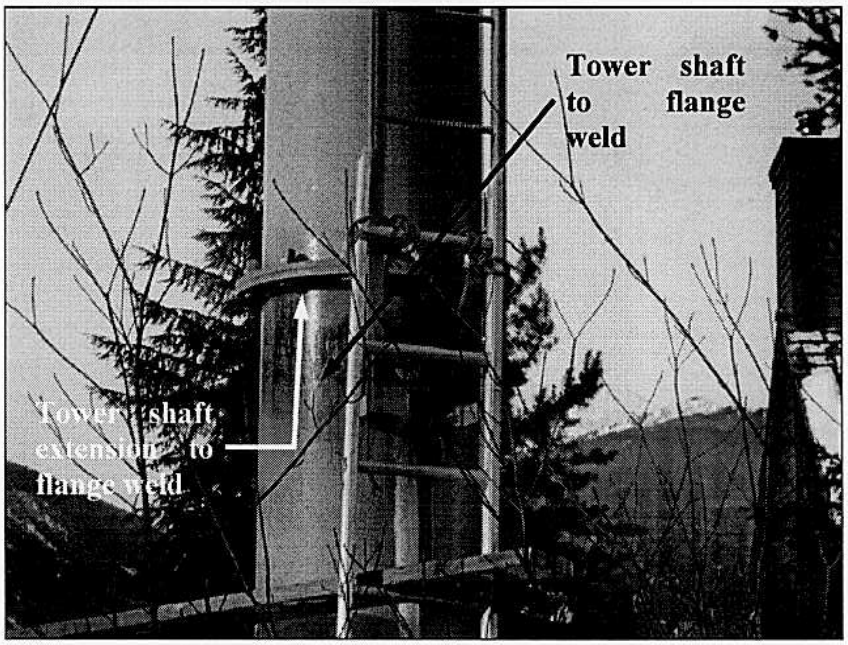


Photo 2:

Close up down hill view of the tower shaft extension and tower shaft to flange weld.



ACUREN

FARRIS, VAUGHN, WILLIS & MURPHY
Lower Excalibur Tower # 5 - Nondestructive Testing of Flange Welds

TEST DETAILS: MAGNETIC PARTICLE

TYPE: Dry Visible			METHOD: Yoke		
PARTICLE BRAND:	Magnaflux	PRODUCT NO.: 8A	CURRENT: AC	MT INSTRUMENT:	Parker B-300
PARTICLE COLOUR:	Red		MT INSTRUMENT S/N:	15952	CAL DUE: Nov 09
SUSPENSION:	---		BLACKLIGHT S/N:	---	MAKE: ---
CONTRAST PAINT:	---	PRODUCT NO.: ---	LIGHTING EQUIPMENT:	---	
MAG TIME (SECONDS):	3	DEMAG REQUIRED?: No	LIGHT METER S/N:	---	CAL DUE: ---
			LIGHT INTENSITY:	---	

THE TECHNIQUE HAS BEEN DEMONSTRATED OVER A PAINTED SURFACE: Not Applicable
SURFACE CONDITION: Clean bare metal SURFACE TEMPERATURE: <57°C/135°F

TEST DETAILS: ULTRASONIC

TYPE: Flaw Detection			METHOD: Contact		
INSTRUMENT:	Panametrics	MODEL: Epoch IV	S/N: 61458006		CAL DUE: Nov 09
CAL. BLOCK:	Step block	S/N: APR 0670116	CABLE-TYPE:	Coaxial	LENGTH: 1 m
CAL. BLOCK:	IIW	S/N: 03-7384	COUPLANT:	UTX with windshield washer fluid	
CAL. BLOCK:	---	S/N: ---	SPECIAL EQUIP.:	---	

TRANSDUCER MANUFACTURER & TECHNIQUE DETAILS:

	TEST ANGLE	PROBE TYPE	FREQUENCY (MHz)	SERIAL NUMBER	PROBE Ø	TRANSFER VALUE	TEST FROM	REFERENCE REFLECTOR	REFERENCE dB	REFERENCE % FSH	SCAN SENSITIVITY	RANGE (MM)
1	0°	Dual	5.0	647884	12.7	---	Front	Backwall		100	+6	50
2	70°	Single	2.25	95804	6.4	---	Front	SDH	46	80	+6	150

SURFACE CONDITION: Painted SURFACE TEMPERATURE: <0°C/32°F

CWMM Consulting Engineers Ltd.
1412 West 7th Ave., Vancouver, B.C.,
Canada V6H 1C1
Tel: (604) 731-6584
Fax: (604) 738-5110
Email: engineer@cwmm.com

December 23, 2008

Job No. 11264

Doppelmayr CTEC Ltd.
567 Adams Road
Kelowna, B.C.
V1X 7R9

via email: warren.sparks@doppelmayrctec.com

Attention: Warren Sparks, P.Eng.

Dear Mr. Sparks:

Re: Blackcomb Excalibur Gondola Tower 4 - Proposed Repair Procedures

This letter confirms that CWMM Consulting Engineers Ltd. has reviewed the proposed repair procedures for Tower 4 of the Excalibur Gondola as provided in your letter dated December 20, 2008. We agree that the repairs and additional testing proposed for Tower 4 are adequate, and that when properly implemented, the tower will be safe to reuse in service. Our review includes the repair procedures for Tower 4 only, and is based on our observations of the damaged tower at our site inspection on December 17th. We note that the procedures include all of our verbal recommendations provided to you at our meeting on December 17th.

Additional comments:

- We have confirmed that the steel used for the new cap plate conforms to CSA G40.21 Grade 50W and that Charpy V-Notch impact testing performed by Acuren Group Inc. confirmed that the material has adequate notch toughness at -35C.
- We assume that all mag particle testing has been completed and that no defects were identified and no additional remedial work was required.

I trust this letter is adequate for your needs at this time. Please contact me if you require any additional information or clarification.

Sincerely,

CWMM Consulting Engineers Ltd.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
GEORGE J. STRAZICICH

George Strazicich, P.Eng., Struct.Eng.
Associate

December 25, 2008

Wayne Wiltse
Manager Lift Maintenance
Whistler & Blackcomb Mountains Resorts Ltd
4545 Blackcomb Way
Whistler, BC V0N 1B4

wwiltse@intrawest.com

Doppelmayr CTEC ltd
567 Adams Road
Kelowna, BC Canada
V1X 7R9
Phone: (250) 765-3000
Fax: (250) 765-5877

warren.sparks@doppelmayrctec.com

Dear Wayne:

RE: **Blackcomb Excalibur Gondola Tower 4 Cause of Failure**

BCSA's Certificate of Inspection requests an opinion about the cause of failure.

1.1 Background

Incident involves the Blackcomb Lower Excalibur 8MGD, 941.S.0014, year 1994. On Dec 16, 2008 at approx 2:15 pm the spliced tower number 4 broke into 2 pieces at the splice connection. The lower section is 30" OD x 1/2" WT x L= 9730 mm, API Grade X42, the upper section is 24" OD x 3/8" WT x L = 7002 mm, ASTM 53. The tower was manufactured by M3 Steel in Kamloops, BC according to Wolfurt drawing 19219D051500b 1994-04-20.

In early 2007 Doppelmayr issued safety bulletin SA-06-022 dated 2006-12-31 in connection with a similar tower failure in Idaho. This bulletin warns all customers of Doppelmayr related companies and all inspection authorities about the risk of tower and structure failures caused by water ingress and prescribes annual inspections to check for water ingress and prescribes remedial action if water is suspected.

In October 2002 Doppelmayr issued safety bulletin SB-02-008 reminding customers to inspect for water leaks.

In July 1997 Doppelmayr issued safety bulletin SB-97-003 reminding customers to inspect for water leaks.

As a result of the Excalibur incident, Doppelmayr issued safety bulletin SA-08-021 which requires installation of drain holes and annual inspections. Various provincial and state authorities also issued safety bulletins.

1.2 Evidence

At time of incident the hour meter reading was 23,948.95 hours.

The Excalibur is not equipped with an event recorder, but a WB computer system recorded the last stop data at 3.9 m/s, 4.4 s, 9.3 m, rate of 0.88 m/s^2 which is consistent with a service stop. The outcome of a tower fault is a service stop. The lift attendant did not record the type of fault that stopped the lift, but it was most likely a tower derail fault. The rollback

detection pads moved a few millimeters (but were not faulted), which is consistent with a service stop. The carriage was at 1.4m in the morning. After the incident, the carriage stopped at 2.1 m (i.e. moved 0.7m forward). The tension pressure gauge read 113 bar after the incident (normal is 140). The carriage travel limit switch was positioned at 1.6m and was found in the faulted position.

On Dec 16 at approx.12:45 pm, Steve Henderson reported a noise on T4 to Lance Bailey (WB mechanic). Lance responded at about 1:15 pm and observed sheave misalignment on T4. He improved the alignment on the sheaves and just as he returned to the shop he heard the news of a deropement on Excalibur. This tends to indicate the tower started to lean immediately prior to its catastrophic failure.

No sign of water or ice was present in T4 upper section. The upper tower shaft section was completely undamaged, except for the ladder which was destroyed.

The lower section of T4 was full of concrete and ice. The ice projected approximately 10 mm above the tube after the cap plate was torn off.

The weldment ruptured abruptly due to an apparent brittle failure of the cap plate material. The weldment was more or less intact on the tower shaft. There was no sign of fatigue or corrosion or distortion. The weldment showed no signs of porosity, slag inclusions, or undercut. A few short sections of weld showed a few millimeters of incomplete penetration toward inside of the tube.

It appeared that water or ice was forced through a small leak in the weld, which created a frozen icicle on the tower shaft.

There was no obvious path for water to enter the lower section. There is a hole in the base plate of the upper section for an alignment tab to insert from the lower section. The lower section has a hole in the cap plate to facilitate the concrete tube fill. The 2 holes do not align, but perhaps water can seep through the base plate of the upper section into the hole in the lower section.

The splice bolts were arranged with the heads down. Split lock washers were used, and perhaps water could enter the bolt holes via the lock washer gaps. However, T5 was also full of ice to the splice, and this splice used flat washers for the splice bolts.

Tower tubes are known to generate vacuum pressure when they are heated by the sun and then cooled overnight.

Inspection of other lifts revealed some water in other towers: Excelerator had 7 towers, Solar Coaster 3 towers, Upper Excalibur 2 towers. Wizard T14A is full of concrete to the cap plate. Glacier Express T17 bottom section (of 3 section tower) is full of concrete to the cap plate.

After the incident, customers at other ski resorts reported ice in some towers.

Lower Excalibur 8MGD T5 was filled with ice to the level of the ring splice. This tower is partially filled with concrete, and the ice depth was approximately 20 cm.

Repairs were implemented and the Lower Excalibur was cleared for public transportation by BCSA on December 23, 2008 at approx. 3:00 pm.

The new cap plate for T4 lower section was fabricated without a hole and without the alignment tabs (in an effort to prevent water ingress).

1.3 Apparent Cause of Failure

The lower section of T4 was partly filled with concrete (7.8 m), and somehow the rest filled with water (1.9 m) through leakage at the spliced connection. The ice expanded and forced the cap plate off the top of the lower section by tearing the full penetration weld, thereby causing the upper section bolted to the failed lower cap plate to fall to the ground. The comm line and the haul ropes supported the tower head so the upper section came to rest in a more or less vertical position, resting on the ground.

The volume of water/ice is estimated at 800 litres = Avg 59 litres/year = Avg 160 ml/day. Of course, water would not leak in during periods of freezing, but it is interesting to consider the order of magnitude of the leakage.

No obvious leaks were observed. It is probable that water entered the hole in the cap plate of the lower tower section. This water probably entered through the bolt holes. Same for T5.

1.4 Conclusion

We know from the history of water found in other towers, that it is futile to try to keep water out of all the towers. The annual leakage inspections do not appear effective to safeguard against tower failure. Therefore it is probably wise to install permanent drain holes in all tower sections as a preventative measure, despite the potential risk of corrosion thereby created. The drain holes will need to be cleared and checked annually. Research seems to indicate the risk of corrosion caused by drain holes is negligible. Future tower designs should avoid holes in cap plates and should provide drain and/or covered inspection holes.

Yours truly,

DOPPELMAYR CTEC LTD

Warren Sparks, P.Eng.
Executive Vice-President

cc: Greg Paddon, BCSA
Jason Gill, BCSA
Dave Looney, BCSA
Danny Cox
Matheus Zudrell, Doppelmayr
Jim Anderson, Doppelmayr
Paul Ehlert, Doppelmayr

Patrice Munier, Doppelmayr
Rene Boisselle, Doppelmayr
Stefan Huter, Doppelmayr
Michael Klimmer, Doppelmayr
Christoph Hinterreger, Doppelmayr
Markus Beck, Doppelmayr

Lower Excalibur T4, underside of lower section cap plate, shiny weld surface shows brittle plate failure (i.e. plate tore away from the weld)

Lower Excalibur T4, Ice protruding above failed connection

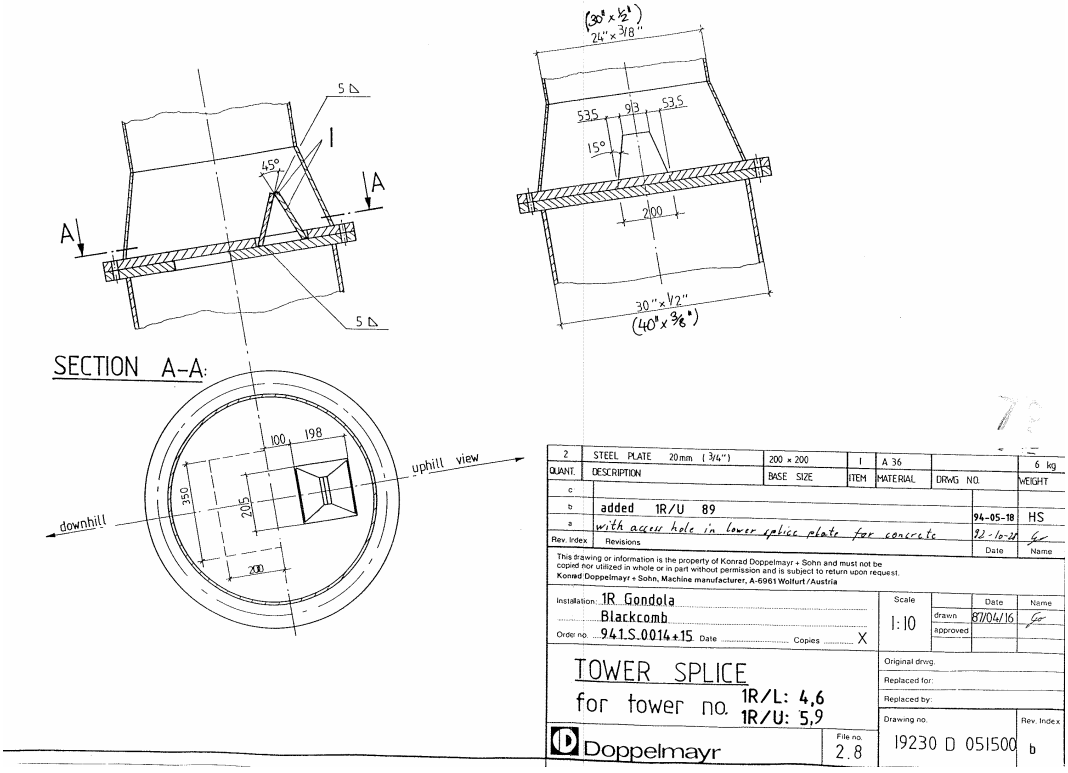
Lower Excalibur T4, top side of lower section cap plate

Lower Excalibur T4, lower side of upper section base plate

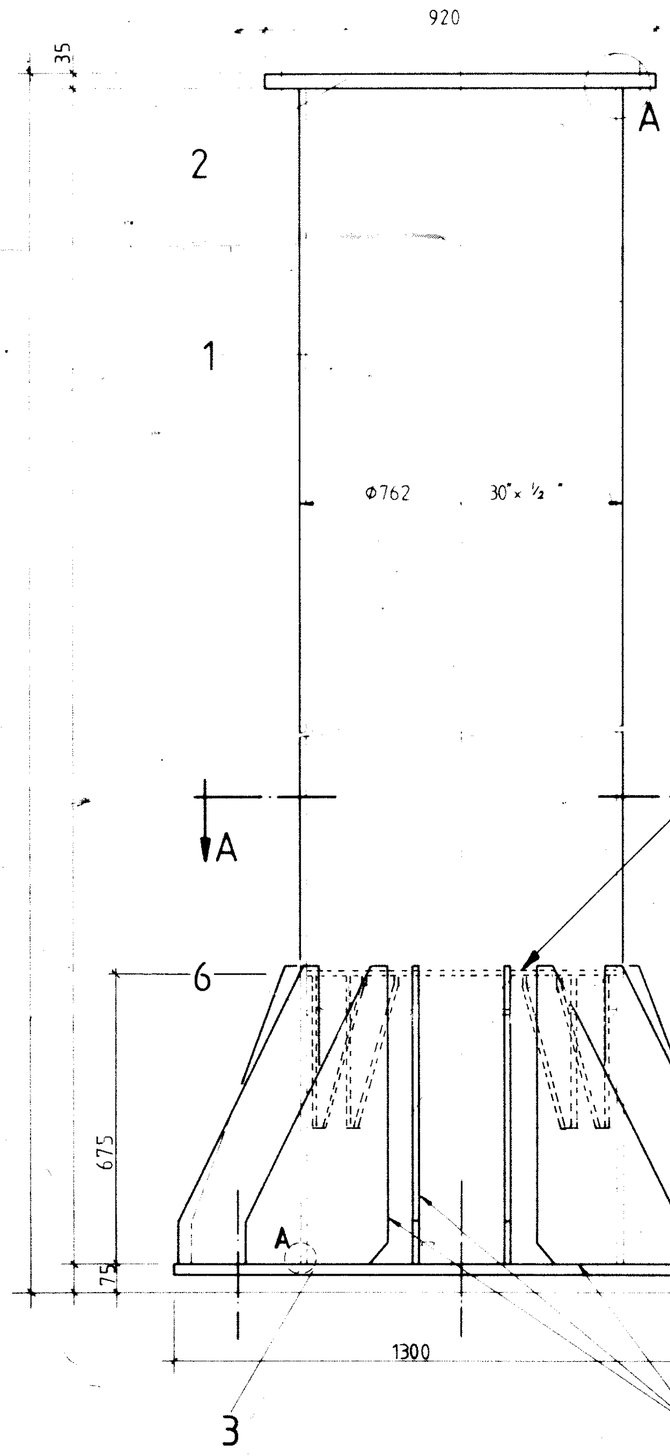
Lower Excalibur T4, incomplete penetration at lower section cap plate

Lower Excalibur T5, pilot holes to determine concrete/ice interface

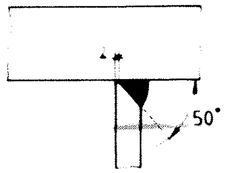
Lower Excalibur T5, rusted lower flange from water leakage

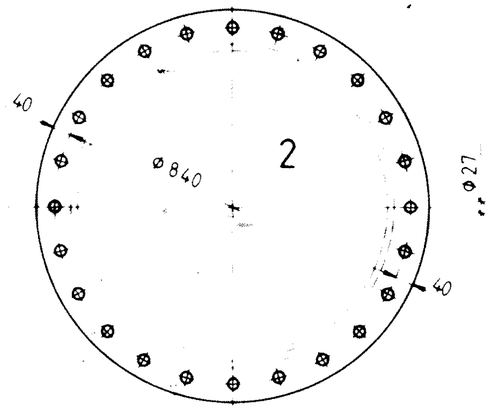


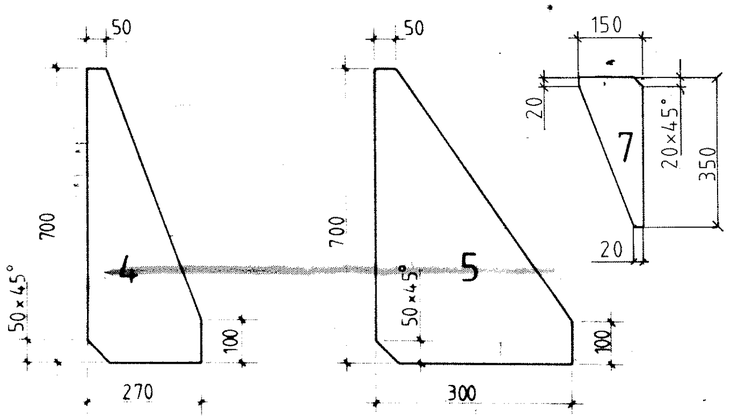
Lower Excalibur T4, splice details

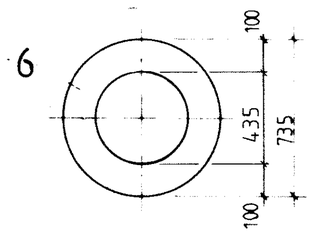


DETAIL A

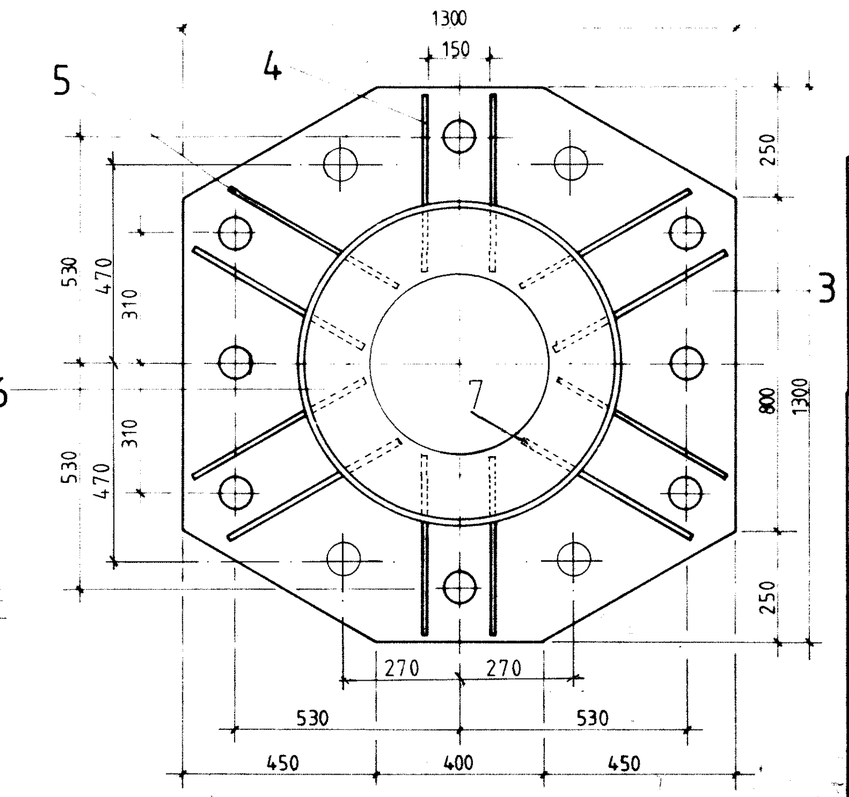








SECTION A-A



TOWER	TUBE length(mm)
FOR 1R/LOWER:	
4	9730
6	9830
FOR 1R/UPPER:	
5	8830

Unless otherwise indicated on the drawing the minimum thickness of fillet welds (a) in relation to the maximum and minimum plate thickness is

s_{max}	12	15	20	25	30	Beveled when s is smaller than s_{min}
s_{min}	4	5	6	6,5	7,5	
amin	3	3,5	4	4,5	5	

Note preheat when s_{max} is larger than 25 mm!

preheat!

24	HEX BOLT 1" x 5		10		GRADE 8.8		
24	WASHER "		9				
48	HEX NUT "		8				
12	SHEET METAL 10 mm	150x350	7	A36			
1	SHEET METAL 10 mm	Φ 735	6	A 36			15,96
8	" 15 mm	700 x 300	5	A 36			201,60
4	" 15 mm	700 x 270	4	A 36			90,72
1	STEEL PLATE 35 mm	1300 x 1300	3	A 36			473,2
1	" 35 mm	Φ 920	2	A 36			186,10
1	ROUND TUBE 30" x ½"	L = mm	1	APIGRX42			
QUANTITY	DESCRIPTION	BASE SIZE	ITEM	MATERIAL	DRAWING NO.		WEIGHT

Rev. index	Revisions	Date	Name
c			
b	1R/L T6 Length changed	20.04.94	S
a			

Installation: 1R Gondola
Blackcomb
Order no: 941.S.0014+15 Date: Copies: X

Scale: 1:10

		Date	Name
drawn		86 05.06	
approved		89-04-23	

TOWER SHAFT EXTENSION
30" x ½" 12 BOLT.

Original drwg:
Replaced for:
Replaced by:

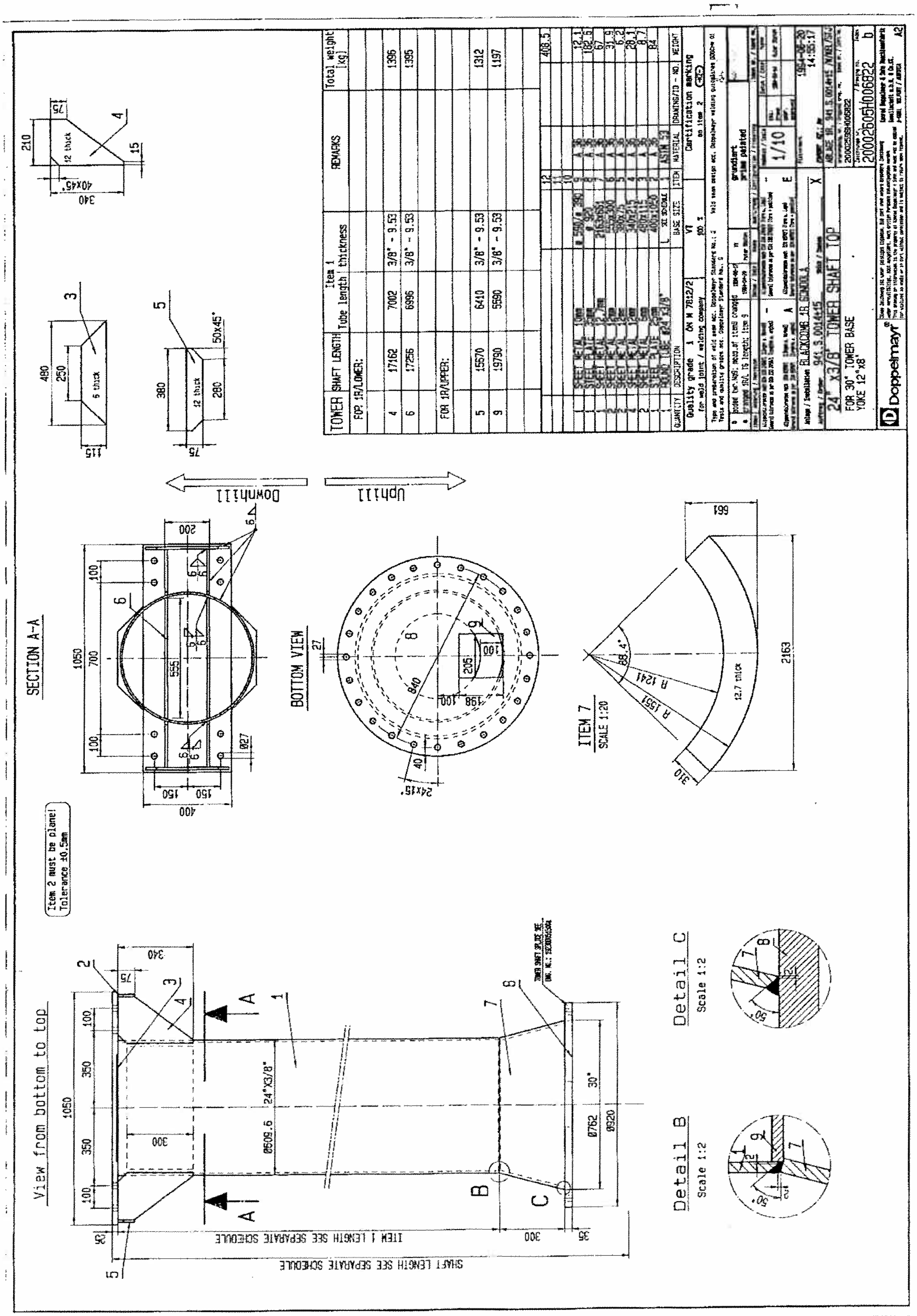
Doppelmayr

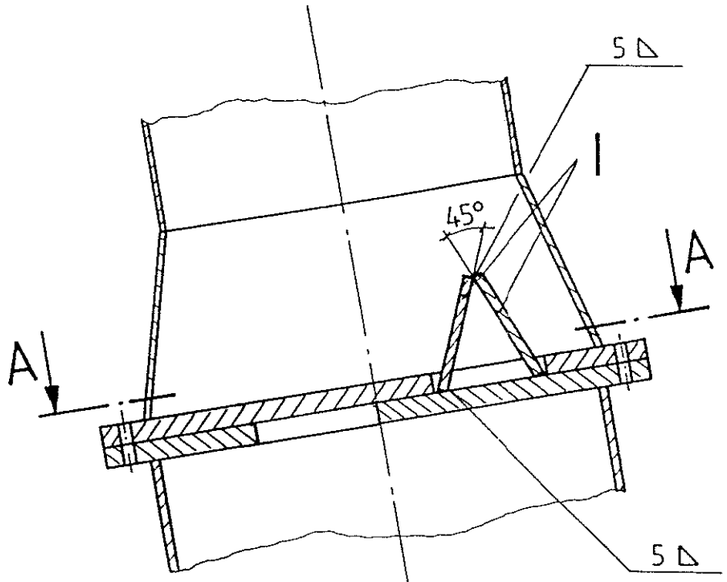
File no: 2.8

Drawing no: 19219 D 051500

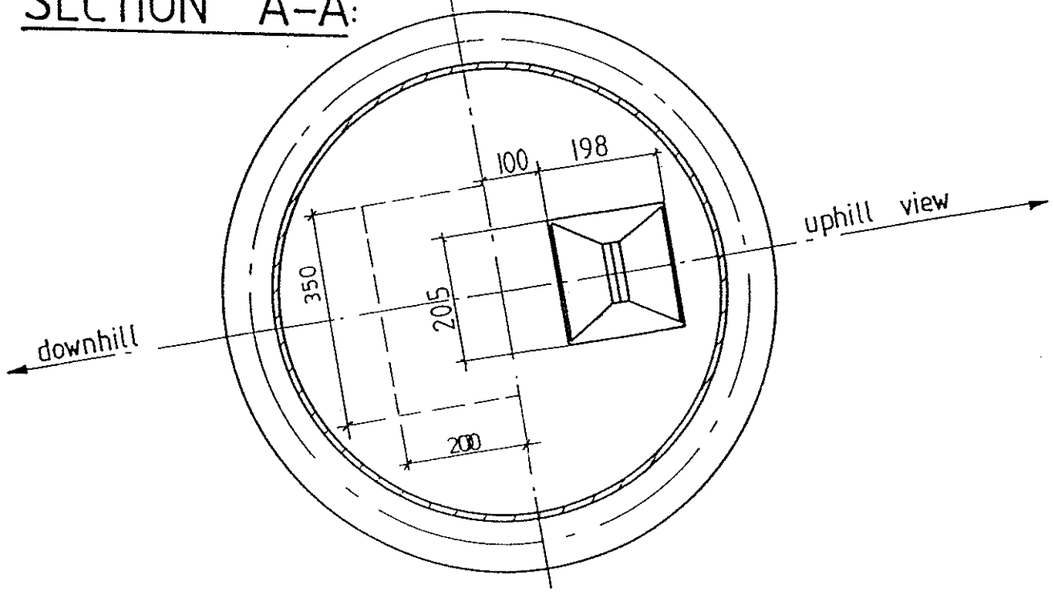
Rev. index: b

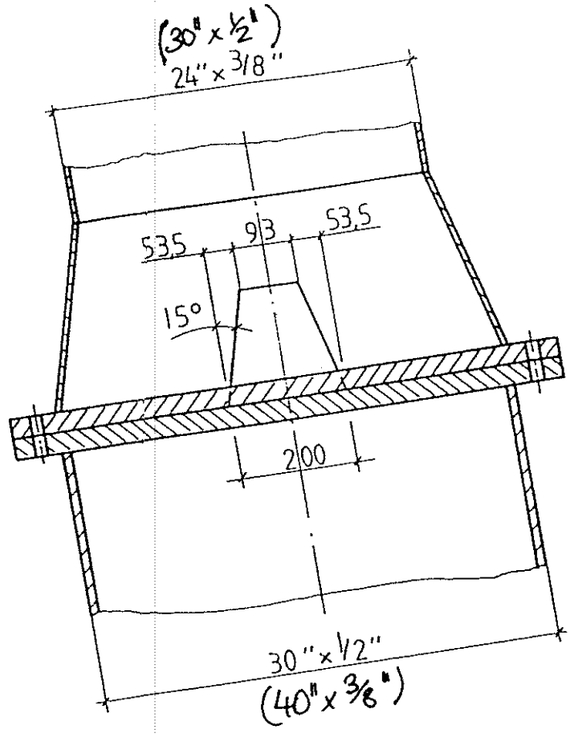
Appendix 12


View from bottom to top
SECTION A-A
BOTTOM VIEW
ITEM 7
Detail B
Scale 1:2
Detail C
Scale 1:2
Downhill
Uphill
Item 2 must be plane!
Tolerance ±0.5mm
SHAFT LENGTH SEE SEPARATE SCHEDULE
ITEM 1 LENGTH SEE SEPARATE SCHEDULE
24" x3/8" TOWER SHAFT TOP
FOR 30" TOWER BASE
YOKE 12"x8"
Doppelmayr



SECTION A-A:





2	STEEL PLATE 20mm (3/4")	200 x 200	1	A 36		6 kg
QUANT.	DESCRIPTION	BASE SIZE	ITEM	MATERIAL	DRWG NO.	WEIGHT
c						
b	added 1R/U 89				94-05-18	HS
a	with access hole in lower splice plate for concrete				92-10-28	Go
Rev. Index	Revisions				Date	Name

Installation: 1R Gondola
Blackcomb
Order no. 941.S.0014+15 Date ..... Copies X

Scale 1:10

	Date	Name
drawn	87/04/16	Go
approved		

TOWER SPLICE

for tower no. 1R/L: 4,6
1R/U: 5,9

Original drwg.
Replaced for:
Replaced by:

Doppelmayr

File no. 2.8

Drawing no. 19230 D 051500

Rev. Index b