TA 31 Spillway East Accident Report

Pursuant to 32MRSA § 15212, the Chief Inspector "may examine or cause to be examined, the cause, circumstances and origin of all tramway accidents in the State". An investigation of a tramway deropement at Sugarloaf Mountain began December 28, 2010. This report outlines the findings of that investigation.

Incident Summary

On December 28, 2010, at approximately 1030 hours, a chairlift located on Sugarloaf Mountain in Carrabassett Valley, Maine, deroped. This deropement occurred at the uphill side of Tower 8 of a chairlift known as Spillway East, or Spillway A. Spillway East has a State of Maine registration number of TA 31. Spillway East was fully loaded at the time of the incident. The winds were gusty and the chairlift had been on "wind hold" earlier in the day. As the deropement occurred, the wire rope that holds the chairlift carriers above the ground immediately plunged toward the ground. This action caused several carriers (chairs) and the occupants (skiers) to strike the snow surface. This accident injured several individuals and 8 individuals sought medical treatment at area hospitals. The deropement did not actuate the brittle bar system so the carriers and wire rope continued to move up the hill until a stop button was actuated utilizing operating controls. Once the lift was stopped, a lift evacuation immediately commenced.

Incident

Sugarloaf Mountain is a ski area located in Carrabassett Valley, Maine operated by Boyne Resorts. On the day of the deropement, the ski area had been dealing with issues resulting from high winds at the area. The lift was not operated from 0830 hours to 0955 hours due to the wind conditions.

At 0955 hours, ski patroller Ben Defroscia and ski lift mechanic Bob Ashe rode the lift for the purpose of evaluating how the lift was reacting to the weather conditions. After riding on the chairlift and assessing the lift's operating condition they made the determination to open the lift to the public.

At 1000 hours the lift was opened and the public was permitted to use Spillway East. At approximately 1015 hours, a ski patroller called in to base operations that the lift was making noise on Tower 8. Two mechanics, Noah Lake (Lake) and Mark Pomeroy (Pomeroy) were dispatched to evaluate the lift. Lake arrived at Tower 8 to assess the situation from the tower and Pomeroy remained at the bottom of Spillway East to control the operation of the lift.

At approximately 1020 hours, Lake climbed Tower 8 to assess the sheave assembly. Once on top, Lake radioed to start the lift so he could evaluate the sheave assembly to investigate what was causing the noise. Pomeroy started the lift and Lake observed that the wire rope was out of the sheave grooves and rubbing on the inside of the outboard sheave flanges. He determined that the sheave assembly on Tower 8 needed to be repositioned to ensure that the wire rope would ride in the grooves of the sheave liners. Lake called for the lift to be stopped so an adjustment could be made. Lake attempted to adjust the sheave assembly position by varying the length of the stiffener.

Lake's initial action was to turn the turnbuckle on the stiffener in the counterclockwise direction. While doing this, Lake noted that the welded joint of the threaded portion closest to the sheave assembly was flexing, and that it was difficult to move the turnbuckle in this direction. Lake placed a "spud wrench" end in the turnbuckle to obtain more leverage. As he was taking this action, Lake determined that the turnbuckle was moving the sheave assembly in the wrong direction to properly adjust position of the sheave assembly. He repositioned the turnbuckle to its original position and then continued clockwise an additional ¼ turn. At this point, Lake radioed Pomeroy to start the lift so he could evaluate whether his actions would cause the wire rope to return to the sheave grooves. As the lift started moving again, Lake realized that he would need to make additional adjustments to get the wire rope back into the sheave grooves and requested that the lift be stopped. At this point, Lake adjusted the turnbuckle, an additional ¼ turn in the clockwise direction. Once this adjustment was completed, the lift was restarted to assess the alignment of the wire rope in the sheave assembly. This adjustment did not correct the wire rope position. The mechanics determined that the lift should be operated on slow to allow passengers to be run off the lift; however, approximately 5 to 10 seconds after restarting the lift to get passengers off, the deropement occurred.

The deropement caused the wire rope and carriers to plunge down towards the ground. Pomeroy pushed a stop button at the loading terminal to shut down the lift. It was reported that the operator at the top terminal also pushed a stop button. We were not able to determine which occurred first.

Investigation Summary

Chief Inspector John Burpee and Deputy Inspector Stan Quinn reviewed the scene of the accident on the afternoon of the occurrence. The assessment was conducted from the ground. The haul rope was visually examined for damage. The haul rope was held off the ground by the chairs on the ground. (Photo 1) Five chairs were in contact with the ground. There were drag marks in the snow caused by the carriers. It was estimated that the lift continued to operate (move up the hill) after the deropement for approximately 40 feet before coming to a stop. The sheave assembly was still mounted to the crossarm of Tower 8. (Photo 2) The position of the wire rope appeared to be outboard of the sheave assembly but the wire rope may have moved during the evacuation of the lift. The stiffener was broken, but its attachment to the cross arm and sheave assembly can be seen in Photo 3.

Spillway East is a Borvig chairlift that was installed in 1975. It is a fixed grip double chairlift with 161 carriers. The drive terminal is at the bottom and its primary drive is an electric motor with a gasoline engine for an auxiliary drive. The lift is loaded on the left and turns in a clockwise rotation to move passengers up the hill. The lift has been in operation since installation. The line equipment for the lift is installed on 12 double towers and has a drive and return terminal. The single set of towers serves two lifts, Spillway East and Spillway West. Looking up the slope from the bottom of the lifts, Spillway East was on the left and Spillway West was on the right. Spillway East utilizes Tower 1 through Tower 12. The two lifts share towers up to and including Tower 9. Spillway West is shorter and was installed a few years after Spillway East.

Spillway East has a counterweight block of concrete installed to maintain tension on the lift line during various operating conditions. The bottom drive terminal moves forward and aft on rollers along a rail system installed to accommodate this type of movement.

Interviews were conducted with personnel involved with the operation of the lift on the day of the incident as well as those responsible for maintenance of the lift. Lift operations and maintenance personnel indicated there were no unusual occurrences with the lift prior to the report of the metallic noise at Tower 8 at approximately 1015 hours.

During a records review, we evaluated operational logs, the maintenance manual and records of prior maintenance activities related to the lift.

The maintenance records were inadequate. The area did not have a complete maintenance manual or all the drawings for Spillway East. Some Borvig manuals require the removal and evaluation of sheave assemblies every four years, we are not certain that these documents apply to this lift. The sheave assemblies on this lift were not removed every four years. Some maintenance had been performed and recorded but, in general, maintenance procedures were not specific. Since the maintenance manual was not available there was no way to verify all maintenance items had been completed. Not all maintenance activities were recorded in the maintenance log.

The lift mechanics do not receive training in a structured or formalized manner. The mechanics receive training informally which is provided by ski area personnel but this training was not documented. This training is usually accomplished via a mentoring method. The senior mechanics would have a junior mechanic as a helper while the senior mechanic performed maintenance. Once the senior mechanic determined the junior mechanic was capable of completing the maintenance activities then the junior mechanic completed maintenance tasks alone.

We heard different opinions from mechanics on how to perform tasks, so the training was not consistent. Of particular interest was the method of adjusting the alignment of the sheave assemblies that have stiffeners installed. Some mechanics adjusted the length of the stiffener to move the sheave assemblies so the rope is in alignment with the sheave grooves. After talking to senior maintenance personnel who are no longer employed by the ski area but with significant experience with the intended use of the stiffener, it was determined that the stiffeners were only to be used to hold the sheave assemblies in position once alignment was correct. The intended use of the stiffeners was to reduce any misalignment caused by wind. The stiffeners were not intended to be used as an adjustment device.

Equipment checks evaluated the lift components in an attempt to determine the cause of the deropement and determine the suitability of returning the lift to operation. This review of lift systems revealed some issues that needed to be corrected prior to returning the lift to service. Additionally, criteria were developed by a professional engineer, Boyne personnel and Sugarloaf maintenance staff to determine suitability of sheave assemblies for repair or replacement. Line equipment was evaluated using this criteria and corrective action was taken to ensure proper conditions were met prior to the load test. The stiffener and its use were reviewed by a professional engineer. The entire review and repair efforts were overseen by a professional engineer.

The counterweight system permits the drive carriage to move forward and aft so as to maintain proper line tension and adjust for load changes. The drive carriage moves on wheels and steel rails to maintain tension on the lift line. The steel rails, which appear to be part of the original installation, had channels worn into them where the carriage wheels move. These channels were as wide as the carriage wheels and had enough depth to permit the buildup of ice or snow. These channels in the rails were repaired by covering them with plate steel welded to the rail support to provide for a smooth surface for the carriage wheels to move on.

The drive carriage moves on four carriage wheel assemblies. These assemblies are located in the four corners of the carriage and permit movement. Each carriage wheel assembly has a pin and bearing set attached to the wheel. When the carriage wheel assemblies were taken apart, we noted that the loaded surfaces of the pins were worn on three of the four wheel assemblies. The pin and roller bearing sets on these wheel assemblies were replaced. The fourth wheel assembly located on the back left side of the carriage was not replaced. This wheel assembly has a sleeve bearing instead of a roller bearing. This sleeve bearing was made of a bronze type material. It is not known why the bearings were different in this fourth carriage wheel assembly. The condition of the three carriage wheel assemblies prior to being repaired would not have allowed them to move as freely as intended thereby hindering carriage movement.

The counterweight sheave system was evaluated to ensure adequate movement of the sheaves to permit proper range of movement of the counterweight. No adverse conditions were noted.

We noticed the bullwheel was wearing a notch in one of the support beams in the carriage structure. The bullwheel upper flange was not true, so as it rotated, the bullwheel was coming into contact with the structural support. The bullwheel brake was adjusted to ensure that the bullwheel brake did not apply too much upward force on the bullwheel upper flange; this adjustment prevented the bullwheel upper flange from coming into contact with the support structure during actuation. The support structure was repaired by welding additional plate steel to it. Once completed, this repair allowed for continued use.

The installed sheave assemblies and line equipment for the lift were re-evaluated to criteria established after the accident to ensure the existing components were suitable for continued operation. A specific maintenance record was developed to document the noted conditions as the sheave assemblies and components were evaluated. These maintenance records are at the area. Corrective actions were taken to address noted deficiencies. Some sheave assemblies were replaced with new sheave assemblies. Many sheave assemblies were removed from the towers and repaired in the shop. Once a sheave assembly was down off the towers, area personnel used the opportunity to change out many of the components, regardless of condition. The pins were replaced as needed and any looseness or play was corrected by the installation of new pins and/or welding to correct for any oblong or egged out holes noted on the sheave walking beams. These repairs included, but were not limited to, the repair of sheave walking beams, and the replacement of sheave walking beam pins, sheave liners, sheave flanges and bolts. All pivot points and bolts were verified for tightness and movement prior to returning each sheave assembly to the towers.

A line survey was conducted by Sawyer Engineering to verify the alignment of Tower 8. The tower was not significantly out of alignment; however, as a result of the survey, the mounting bracket for the sheave assembly located on Tower 8 was moved out (to the outside) approximately 3 inches total. The survey was done while there was no load on the lift line and while there was no load on Spillway West.

The tower bolts were checked for tightness on Towers 6, 7 and 8.

We noted no issues with the electric drive, auxiliary engine or gear box.

The sheave assembly installed on Tower 8 was removed from the tower and taken down to the maintenance garage to be evaluated in detail to assist in determining the cause of the deropement.

The evaluation of the sheave assembly revealed the following:

(Diagrams 1 and 2 have been marked to assist in following the descriptions below.)

The sheave assembly was free to move as intended. The main beam was able to rotate up and down in the plane of the wire rope as permitted by the main beam pin. The articulating joint permits the sheave assembly below this joint to rotate side to side in relation to the plane of the wire rope. The main hanger joint permits the entire sheave assembly to rotate forward and aft with the direction of the wire rope. The sheave assembly had two 4-sheave assemblies. Each of the 4-sheave assemblies was able to move up and down, as intended, on its pin. The incoming 4-sheave assembly had loose bolts and allowed side to side movement relative to the plane of the rope. The outgoing 4-sheave assembly was tightly attached by its bolts and did not permit side to side movement relative to the plane of the rope. The sheave assembly had four 2-sheave pairing beams. Each of the four 2-sheave pairing beams was free to move in an "up and down" movement, as intended, on its pin. No looseness was observed in the bearings or pivot pins. Each of the eight sheaves rotated freely. The sheave liners seemed in acceptable condition although some minor degradation of the liners was noted. Many of the sheaves had relatively new bolting material which secures the liner in between the sheave flanges. (Photo 10)

Diagram 1 is a typical 8-sheave assembly. As noted above, the incoming 4-sheave assembly was loose. Photo 4 is of the attachment point on the main beam for the incoming assembly which shows how the main beam connects to the 4-sheave assembly. Proper alignment of the sheave assembly could not have been maintained if the incoming sheave assembly was loose while installed on the tower.

The 4-sheave assembly is connected to the main walking beam by two bolts through a bracket. The bracket on the incoming 4-sheave assembly beam has two different types of bolt holes. The bolt hole on the incoming side of the bracket is round and the bolt hole on the outgoing side is elongated. This elongated hole allows for side to side adjustment to assist with aligning the sheave assembly with the wire rope. Shims were installed between the main walking beam and the 4-sheave assembly bracket. At this attachment point, the metal of the main walking beam was bowed up approximately 1/8 inch. (Photo 4) The bolt installed in the elongated hole of the incoming sheave assembly bracket had been replaced and the bolt was different than the others that were installed. This bolt had a washer installed between the bolt head and the bracket. When the bolt and washers were removed, this washer was found to be deformed (dished and beveled).

Although the stiffener's effect on the sheave assembly was not taken into account during the evaluation of the sheave assembly described above, it is important to the review of the accident. The stiffener in this case is a mechanical device that acts as a brace and is rigidly affixed to the hanging arm of the sheave assembly and the bottom of the tower cross arm. This device was made out of what appears to be a turnbuckle, threaded rod, steel brackets, and plate steel welded together to form a single component whose length could be adjusted by turning the turnbuckle portion of the stiffener. On this particular stiffener, as installed, if the turnbuckle is moved clockwise, the length of the stiffener to shortened. Movement in the opposite direction causes the length of the stiffener to increase. The stiffener was broken in two pieces; it failed at the welded joint where a threaded portion attached to a bracket that was clamped on the arm of the sheave assembly. A report regarding the broken stiffener is provided in appendix A.

Photo 8 shows the main beam attachment point to the outgoing 4-sheave assembly and the bowed main walking beam.

The sheave assembly has many outside sheave flanges that have little or no metal extending above the surface of the liner. (Photo 7)

Sheave number 5 had a different style flange from the other sheaves.

Sheave number 6 was shiny on the inside face of the outside flange indicating that the wire rope was recently rubbing along it.

The sheave flanges were modified to reduce the height of the outside flange. Some of the flanges were impacted by grips at some point in the operation of the lift but no bright metal was noted to indicate recent grip contact. (Photo 7)

The sheave assembly was slammed into the mounting bracket (Photo 9) and cross arm of the tower during the deropement.

The cable catcher on the outgoing 4-sheave assembly was impacted by the rope as it slipped off the sheaves. (Photo 5)

The cable catcher on the incoming 4-sheave assembly was not impacted by the wire rope as it slipped off the sheaves. The brittle bar was intact on the incoming sheave assembly. (Photo 6)

Summary

Although we were not able to determine the exact cause of the December 28, 2010 deropement, interactions involving mechanical components, the environment and human factors all are believed to have contributed. Some of the primary factors that could have contributed to the deropement are listed below. This list is not comprehensive. Additional factors occurring at the time of the accident remain unknown, such as actual wind speed, actual load on the line, load and effect of the other lift on the tower.

Environmental:

Wind conditions caused the carriers to swing on the line

Systemic:

Lack of formal training program

Procedures for evaluating the conditions which authorize the lift to operate are subjective.

Lift maintenance training program did not provide for consistent results

- The maintenance program as practiced did not adequately address the issues with the lift

Components:

The carriage was not able to move freely due to the deformation of the rails and worn pin and roller bearings in the wheel assemblies.

The counterweight was in contact with the wall in the counterweight pit.

Tower 8 sheave assembly:

- did not maintain proper alignment.
- any self adjustment of assembly was restricted by the stiffener.
- all components were not tight.
- sheaves in some cases did not have outside flanges that extended high enough above the liner.

Stiffener was used to adjust the alignment of the sheave assembly.