

SITE INSPECTION REPORT

FOR

A Ski Resort

METER-TREATER, INCORPORATED
1349 South Killian Drive, Lake Park, Florida 33403
Toll Free: (800) 638-3788
www.metertreater.com

TABLE OF CONTENTS

I. GENERAL

The specific subject of this report is the Ski Resort's Chile Express ski lift. The information and subsequent recommendations contained herein result from data obtained during a site inspection of the subject lift.

II. PURPOSE

The purpose of the site evaluation was to survey the operating environment of the Chile Express ski lift providing recommendations for increasing operational reliability. In addition, if possible, provide for a temporary solution enabling lift operations to complete the season.

III. SCOPE

The Scope of this report is to detail findings, uncovered during the site inspection. Areas of concern included:

- **Site History**
- **Utility Power Supply**
- **Data/Signal Communication Links**
- **PLC Interfaces**
- **Harmonics**
- **Lightning and Surge Protection**
- **Shielding**
- **Induced and Coupled Extraneous Signals**
- **Noise Rejection**
- **Grounding**

Note: the data presented in this report is based, in part, upon a walk-through inspection, some simplistic system monitoring, information provided by resort personnel and inputs from the Ski Lift Manufacturer. This report is not to be confused with a detailed Engineering Analysis or Power Quality Audit. It is, however, a reference for future site upgrades and an implementation guide for a Power Quality Program that will facilitate up-time reliability and risk minimization.

IV. HISTORY

A. BACKGROUND

The Chile Express Ski Lift traverses the northwest slope at a bearing of 112º true from the lower shack elevation of 9,480ft to the summit at 10,677ft. Nearly 80% of

the vertical distance traveled is at an incline of approximately 3º. The lift travels a calculated distance of nearly 2.2 miles. Paleozoic and Precambrian rock dominate the area.

A growing community is located adjacent to the Resort Hotel in the valley west of the Mountain. The community shares electrical power with the resort complex via a 20Mva substation located 2 miles from the Chile Express lift. The resort complex has also experienced recent growth with the subsequent increase in demand for electrical power.

The site experiences average snowfall levels during winter with temperatures occasionally dropping significantly below 0º F. Heavy spring and summer showers are common. Cloud to ground and cloud to cloud lightning is extremely common in summer, producing a high lightning flash density.

Radio frequency transmissions are common at or near the Chile Express ski lift. There is a radio broadcast antenna mounted at the summit and guests frequently use cellular telephones and hand held communication radios with varying power and frequency ranges.

Utility power supplied to the summit is in parallel with the Chile Express ski lift. The majority of the power travels above ground at a distance of approximately 50ft from the communication cable traveling along the lift towers.

B. PROBLEM OBSERVATIONS AND NOTATIONS

- Lightning flashes within a radius of 40 miles may cause the Chile Express to shutdown on an input/output (IO) communication error.
- Chronic replacement of Allen-Bradley modules required for continued operation of Chile Express.
- Less frequent IO faults noted when using the backup diesel to power the Chile Express hydraulic system.
- Meters monitoring electrical loading of the Chile Express direct current electric motor are inconsistent. The normal operating current of the motor should be approximately 900 amps. The meters were intermittently indicating an operating current of 1100-1500 amps.

- A power filter for the Chile Express ski lift repeatedly blows one 175Amp fuse. The blown fuse indicator is difficult to see in direct sunlight and tends to go unnoticed.
- Problems with unplanned shutdowns of the Chile Express occur under both no load and full load conditions.
- Problems that affect the Chile Express appear to affect the neighboring Southwest Flyer ski lift symbiotically.
- Power problems that affect the Resort Hotel also affect the Chile Express lift.
- At times, all lifts for the resort have shut down simultaneously.
- The Chile Express has experienced similar random shutdown events for the past few seasons; however, this season the frequency has increased greatly.
- Unanticipated shutdowns have typically occurred between 12:00pm and 3:00pm. Recently the shutdowns have started to manifest at approximately 9:30am.
- The Chile Express diesel governor oscillates the speed of (hunts) the diesel at the summit. Lead apron (hospital type) shielding placed over the diesel governor effectively prevents oscillations.
- The Resort Hotel has experienced brownouts that adversely affected lift operations.
- The site has had damage to other electrical equipment: transformers overheating, electric motor failures, drum controllers, failed battery chargers for the lift's 24vdc electrical system, etc.

The above were either directly observed during the site inspection or were previously documented by resort maintenance personnel.

C. FINDINGS AND COMMENTARIES

1. The communication cable between the upper and lower lift shacks of the Chile Express is too long. The manufacturer's maximum recommended distance is 10,000 feet; however, the actual distance traveled is approximately 11,500ft. The communication line is set up as a loop so that the return path is required in the total length calculation. Signals sent from the top shack to the bottom shack and back again would provide a cumulative distance traveled of 23,000ft.

2. Figure 1 shows significant signal distortion on communication wires between upper and lower control shacks.

Figure #1

In figure #1 the signal appears degraded and shows a significant amount of noise. Disconnecting the old style carbon surge protectors, located at both ends of the communication wires, reduced the amount of signal noise dramatically. Some harmonic distortion and random noise was still evident; however the

Figure #2

amount (shown in figure 2) was significantly less than with the carbon suppressors online.

3. Utility representatives examined the nearby substation for abnormalities. The only noted anomaly was an overexcited power transformer. This condition was deemed minimal and no corrective action was recommended.

4. Utility power was secured to the lines running parallel to the Chile Express ski lift towers. Some improvement in communication line noise was observed.
5. Utility representatives attempted to quantify the amount of harmonic distortion produced by the Chile Express. The levels were determined to be 9% harmonic distortion for the Chile Express without power filtration and 4% harmonic distortion with power filtration. Electrical systems may become unstable with harmonic distortion levels greater than 10%.
6. The power filter for the Chile Express is not operating satisfactory, possibly the result of a failed capacitor. An imbalance of capacitance could cause an amplification of harmonic distortions and/or excessive circulating currents within the filter network. The result of such an imbalance could be responsible for blowing the 175amp fuse on the filter device. The securing of one phase of the filter could also further amplify power line distortions.
7. Communication line distortion was monitored after the power filter for the Chile Express was taken offline. No appreciable change in signal noise level was noted.
8. It was not possible to take actual ground resistance measurements due to the extreme hardness of the frozen rocky landscape and limited time. All parties acknowledged that the ground resistance is relatively poor due to the type of rock and soil present. The altitude and distance from the water table heighten the inadequacy of grounds. There is a ground rod and ring installed at the lower lift shack. A ground rod with an attached 1AWG wire running to the snowmaking water piping near the upper shack was present (figure 3).

Figure #3: Ground attached to water pipe.

The temporarily twisted 1AWG wire on the water pipe appeared to slightly reduce the amount of noise on the communication circuit.

9. To reduce the impedance of the communication line between the upper and lower shacks, the wiring was doubled by twisting an unused wire in the cable bundle in parallel with the original communication wires. This resulted in higher noise on the communication line.

10. Noise at 80Hz noted on the communication line when running the diesel. Noise levels approaching 1.4KHz may cause the Chile Express ski lift communication system to become unstable. Frequencies as high as 5KHz at 10v peak-to-peak were noted.

11. The measured peak signal line voltage at the lower shack was 0.3volts with occasional spikes to nearly 1volt. The communication system became unstable with voltage spikes >1volt.

12. Use of filter transformers on the communication line in the lower shack, as an attempt to reduce noise levels, resulted in excessive signal degradation and was unusable.

13. Use of filter resistor banks, of various resistivities, placed between the communication lines and ground attempted to shunt noise to earth. This had no effect on the level of noise.

14. Inspection of communication lines on towers revealed no moisture present.

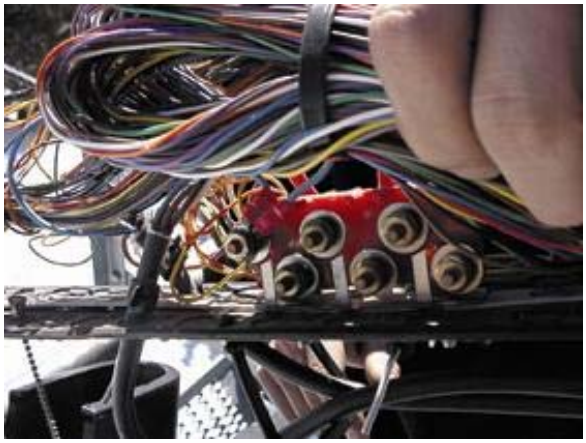


Figure #4

15. The lift controls on the Chile Express and the lift controls on the Southwest Flyer appear sensitive and susceptible to power fluctuations and abnormalities. The Chile Express ski lift is more sensitive to power disturbances than the Southwestern Flyer ski lift.

16. Low voltage control circuits in the upper shack of the Chile Express have inadequate shielding from the main power circuits. This arrangement creates the potential of inducing noise onto the control circuits from the power circuits.

V. PROBABLE CAUSES:

A. LIFT COMMUNICATION CABLE

It appears that most shutdowns of the Chile Express are associated with communication difficulties between the control circuits of the upper and lower shacks. In addition, the Chile Express is susceptible to various power related anomalies that tend to take it and other lift systems, such as the Southwest Flyer, offline. The power anomalies associated with the resort complex only compound the communication shutdown problems of the Chile Express. Establishing a more stable communication link between the upper and lower control circuits of the Chile Express will solve many of the random shutdown problems.

The impedance of the wire significantly degrades the communication signal. Stray signals received by the wire due to electromagnet radiation and induced voltages further reduce lift reliability. Due to the extremely weakened communication signal, cellular phones and hand held radios used by guests can cause a breakdown in lift communication data and result in an IO fault. The communication wire runs in a straight line nearly perpendicular to magnet north for over two miles. This orientation makes the data line susceptible to induced noise from solar events.

Figure #5: Chile Express Lift

B. ELECTRICAL CONNECTIONS

With age, the electrical connections in both upper and lower shacks will degrade. Degradation of electrical connections can be a major contributor to seemingly random electrical anomalies. Regular inspection and recommended preventative maintenance should be an essential part of routine resort activities.

C. AC POWER

With new building developments and the expansion of the service infrastructure in and around the resort, the local electrical power grid may require updating to better serve the needs of the growing community.

D. GROUNDING

Poor grounds are a major concern. Reduction of signal noise at the upper shack of the Chile Express by temporarily attaching the water pipe indicates that the upper shack ground system is insufficient. A detailed grounding survey is required to determine the type and placement of a grounding system that would be adequate. Lightning events and time tend to reduce the effectiveness of grounding systems. Regular inspections of facility grounding are a necessity. Failure to perform inspections and preventative maintenance usually results in poor performance and downtime.

VI. PROBLEMS IDENTIFIED

The extreme length of the communication line between upper and lower shacks of the Chile Express appears to be the cause of non-power related shutdowns of the Chile Express. The poor RF shielding at the upper shack contributes to overall noise problem on the communication line.

Power quality shortcomings contribute to reduced lift reliability. Anomalies in the local power grid tend to affect the entire complex. Various lifts at the Resort have different fault tolerance levels and will tend to shutdown in accordance with the severity of an unwanted electrical event and the sensitivity of the equipment. Harmonic distortion is prevalent in the power system near lift equipment. Installed power quality filters require evaluation for proper application and acceptable operation. At night, utility voltage will drift high due to a lack of loading on the system. Any power filtration or surge protection system should be tolerant of voltage drift.

Induced power from the utility lines parallel to the Chile Express is a minor contributor to noise problems on the Chile Express communication circuits.

Poor grounds are evident at the upper shack of the Chile Express. An adequate ground grid would increase the efficiency of surge suppression systems and reduce ambient noise levels on communication and data lines.

VII. RECOMMENDATIONS

A. TEMPORARY SOLUTIONS

Communication Lines: Replace carbon suppressor blocks on the Chile Express (figure 6) with more up-to-date surge suppression technology.

Rational: The use of gas tubes, silicon diodes or a combination of these two devices provides a tighter control of transient energies without the RF noise interference associated with carbon suppressors.

Figure #6: Carbon Block Suppressors

Backup Generators: Operation of the diesel may be desired over operating on utility power until the lift system can be secured and long-term solutions can be implemented.

Rational: There appears to be too many operating flaws with the present system configuration on the Chile Express for it to sustain reasonable run times without a shutdown incident.

B. LONG TERM SOLUTIONS

1. Communication Control Cable…

Replace the low voltage cable between the upper and lower shacks with a more reliable system. The Ski Lift Manufacturer recommended the installation of a separate control system for the lower section of the Chile Express that would communicate with the upper control system by a more reliable communication circuit.

Rational: This should greatly enhance the operational reliability of the control system.

2. Harmonic Filters…

Repair or replace the power filtration on the Chile Express to minimize the effects of harmonic distortions.

Rational: The effects of harmonics on other operating systems can and will reduce operational performance. The filters are there for this reason and require proper maintenance per manufacturer's specifications.

3. **Grounding and Bonding …**
   a. Upgrading the electrical grounding of the Chile Express must be a major priority as soon as weather conditions permit. A detailed grounding survey is required and placement of additional ground rods maybe necessary.
   b. Ensure that all grounding points are tied (bonded) together to prevent damaging circulating currents from forming.
   c. Connect communication line shields at one end only to avoid circulating currents.

   Rational: The lift is a series of complex networks, all electrical equipment (AC, DC, and communication) share a common denominator in the ground system. Potential differences in grounds will cause unwanted currents to flow, resulting in problems that produce unfavorable operating scenarios. The ungrounded end of the communication cable shield should be marked as to prevent inadvertent attachment of both ends of the shield to ground. Grounding the communication cable shield only at one end will prevent circulating currents from inducing noise into the communication signal.

4. **Site/Equipment Monitoring…**
   Install power-monitoring equipment in suspected trouble areas to evaluate power quality. Use voltage and phase monitoring devices on vital equipment to warn operators or deenergize the effected equipment in the case of utility power abnormalities. Voltage and phase monitors should be user adjustable and provide for a trip time delay to prevent unwanted alarm conditions during normal distribution transient events.

   Rational: Site/equipment monitoring serves two very useful purposes. First, it identifies problems and provides data that will help to facilitate negotiations with the local Electric Company for the needed upgrades to the local power grid.

Second, it is another power quality tool to prevent unwanted and unnecessary equipment damage and downtime.

5. **Communication Protection…**

   Replace carbon block suppressors on all Chile Express communication and monitoring circuits. Carbon type suppressors have unpredictable failure modes and frequently place a significant amount of unwanted noise on data communication lines.

   Rational: Following a transient event, carbon block suppressors pit and with each additional transient event the pitting gets worse. The pitting not only produces noise it also raises the clamping threshold of the device to the point where it may become no longer effective as a suppressor. A silicone-gas-tube hybrid technology is the preferred choice over carbon based technology for survivability and noise reduction. (Model SLT-HEB and SLT/SO)

6. **AC Power Protection**

   Place hardwired AC Surge Protective Devices on all power feeds to the lift. This will further reduce the threat of downtime caused by transient activities induced on the power lines from lightning and utility sources.

   Rational: It is extremely important to keep dangerous, high-energy, transients from gaining entrance into the equipment. Once ingress has been achieved, transients will propagate throughout the entire internal wiring system. (Model RCHW and MST)

7. **EMI/RFI Shielding…**

   a. Install adequate EMI shielding around all low voltage control circuits. Shield the 24vdc system in the upper shack of the Chile Express between the high and low voltage cabinets. Where ever possible, place shielding between low voltage relays and other sensitive electronic devices to minimize interference from the magnetic field created by relay coils.

   b. Install appropriate EMI shielding around the diesel governor to prevent diesel hunting.

Rational: Shielding is an essential part of a total systems approach to an effective operating system. There is little doubt that RFI/EMI interference is a significant contributor to the problems influencing the Chile Express ski lift operations.

8. **Special Equipment Note…**

   Place bleeder diodes on low voltage DC relay coil power leads. This is to prevent high transient voltages from returning to the relay control circuit.

   Rational: Transients created by the collapsing magnetic field of the relay coils can damage electronic components.

9. **Preventative Maintenance…**

   Develop a preventative maintenance program for the upkeep of all lifts and their electrical systems. The program should stress the importance of maintaining clean and tight electrical connections for both power distribution and data communications equipment. In addition, make regular inspections of the on site power distribution systems. Look for any damage or irregularities in electrical connections, circuit breakers, fuse holders, or busswork. A poor connection or a contact misalignment can significantly affect the performance of electrical loads.

   Rational: Preventative maintenance is the most cost effective way of getting maximum uptime service out of the systems that make up the Angle Fire Resort.

Figure #7: Chile Express Distribution System on Mountain Summit.

VIII. SUMMARY:

Shutdowns and failures of the Chile Express operating system are due to several cumulative problems. Foremost is the length of the communication link between the upper and lower shacks of the Chile Express. The extreme length of communication wire causes significant signal degradation. In addition, the length of the communication line promotes the introduction of noise. The negative effects of noise on the communication lines are enhanced because of the weakening of the data signal with lead length.

Monitor electrical power supplying the facility. Poor power regulation or persistent distribution faults will significantly degrade the performance and reliability of electrical loads. The lift systems are sensitive to power anomalies and will be quick to shutdown. Clean, reliable power from the utility is imperative. Continued cooperation between the Resort and the supplying utility should benefit the entire community with cleaner, more reliable electrical power. Recent events indicate a power quality problem and require correction by the utility. The use of power monitoring equipment can help the utility localize power quality problems.

Grounding at the top of the Chile Express and Southwest Flyer ski lifts needs improvement. The currently installed grounding scheme at the summit appears to have degraded over time and is probably inadequate. Poor grounding produces unsafe equipment operation and contributes to ambient electrical noise. Lightning and surge protection systems rely on a good grounding system to provide protection to connected loads.

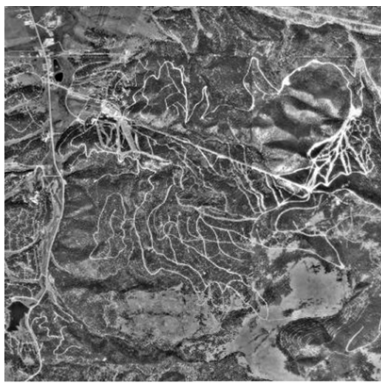
A preventative maintenance plan for electrical equipment is highly recommended. The plan should include regular inspections of all power and data connections.

Additional EMI shielding is required for low voltage control circuits. Shielding will minimize the induced noise from radio and cellular telephone transmission, high voltage power, and solar activity.

Create and maintain a detailed set of prints or drawings identifying all site and equipment configurations and include any recommendations adopted from this report. In the future, add all new equipment installations to the drawings and address all Power Quality concerns at the time of installation. It is important to remember that any physical changes to the site could reduce the Power Quality/Loss Prevention Program to a condition that it is no longer capable of safely protecting the operating environment.

IX. CLOSING

The geographical location of this site and the prevailing climatic conditions of the area make it financially prudent to apply the recommendations provided in this report. Implementation of recommendations as stated above will result in increased lift reliability and operating performance.



For more information about protecting Ski Resort Equipment visit:

http://www.metertreater.com/Ski_Industry.html