

Lightning Protection to High Value Facilities: A Peruvian Gold Mine Case Study

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1.0 Summary: Lightning incidents to heavy industry bring serious consequences to people safety and to productivity. Lightning strikes upon high value assets are not well recorded – statistics are elusive. This paper presents a case study of lightning threats to a \$340 million gold mining operation in Peru. Efforts to mitigate the consequences of lightning are described in two broad categories: detection and protection. The presentation is illustrated with many examples of lightning vulnerabilities and solutions.

2.0 Background. Barrick Gold Corp. (BGC, see www.barrick.com) operates a large gold mine on the western flank of the Peruvian Andes at an elevation of 4830 m. The mine employs 500 + people and is an open pit crush heap leach operation. In its first full year of operation the BGC mine produced 550,000 ounces of gold at a cash cost of \$110/ounce (\$228,250,000 assuming gold price @ \$525/ounce).

Lightning arrives over the mountains from the eastern Amazon basin with little advanced notice. On 28 Nov 2004 five employees were injured while working outdoors. This raised labor questions and management concerns for possible future lightning events. NLSI was retained to produce a site assessment to improve safety and increase productivity.

3.0 Caveat. Because of its arbitrary, capricious, random stochastic and unpredictable nature, absolute protection from lightning's effects is impossible. A Matrix of Lightning Protection Sub-Systems is shown below and can be applied to specific sites to reduce the risk.

MATRIX OF LIGHTNING PROTECTION SUB-SYSTEMS

	DIRECT STRIKE	INDIRECT STRIKE	EXTERIOR LOCATION	INTERIOR LOCATION	PEOPLE SAFETY	STRUCTURE SAFETY
AIR TERMINALS	YES	NO	YES	NO	NO	YES
DOWN-CONDUCTORS	YES	NO	YES	YES	NO	YES
BONDING	YES	YES	YES	YES	YES	YES
GROUNDING	YES	YES	YES	YES	YES	YES
SHIELDING	YES	YES	YES	YES	YES	YES
SURGE PROTECTION	YES	YES	YES	YES	YES	YES
DETECTION	YES	YES	YES	YES	YES	YES
POLICIES & PROCEDURES	YES	YES	N/A	N/A	YES	YES

4.0 Lightning Detection.

- 4.1 Past procedures employed small hand-held detectors. False positives and arbitrary distance determination of these equipments caused faulty safety estimates and excessive downtime. In one case, a handheld detector went into alarm during nearby electric (arc) welding. In another example, it was shown the detectors were sensitive to nearby RBG computer monitors and microwave ovens. Confidence in existing detection equipment was low.
- 4.2 Detection equipment upgrades were studied. BGC sent a team of four technical engineers to the USA to assess more reliable equipment. Visits to three vendors included product demonstrations and discussions with engineering and technical persons. Improved equipment accuracy and user confidence resulted in BGC replacing existing detectors. Factory technicians assisted in the installation of new detectors at the BGC mine site.
- 4.3 A refined lightning safety shutdown program was instituted. Both Policy and Procedural Plans were adopted. In brief, at the initial stage these are:
 - 4.3.1 Yellow Alert when lightning enters 60-32 Km zone.
 - 4.3.2 Orange Alert when lightning enters zone between 32-16 Km. Deactivate this Alert if 15 minutes has passed without lightning entering the 16 Km zone.
 - 4.3.3 Red Alert when lightning enters a 16-0 Km zone.
 - 4.3.4 Red Alert if Electric Field within 4 Km zone exceeds 2000 V/m.

The above defaults may be changed to more restrictive thresholds as empirical studies merit.

5.0 Lightning Protection.

- 5.1 BGC lightning protection for structures such as refueling depots, crushers, ANFO storage, refining laboratory, administration buildings, maintenance

buildings, truck shop, etc. were inadequate. Active mining operations such as blasting, drilling, loading and hauling sometimes used inefficient lightning safety criteria. Each site and each activity was studied from the BGC mantra of “Every Worker Goes Home Safe Every Day.” Appropriate modifications were suggested, studied and implemented.

5.1.1 By example, personal safety for outdoor workers was addressed by using large metal shipping containers (quasi-Faraday Cages) as safe refuges. They are skid-mounted and moved to needed locations as required.

5.1.2 By example, close-in lightning called for suspending mine face Reed Drilling and loading/hauling. It was determined that operators inside operating equipment robust cabins were safe from direct lightning effects. This work could continue when lightning threatened.

5.2 Air terminal designs of the Early Streamer Emission (ESE - Thor Aerodynamico Ionizante Pararayos) type were widespread. Vendors to BGC asserted the ESEs provided safe zones for personnel and that ESEs assured a large protective radius. Neither of the preceding statements are correct. It is not the place of this paper to re-introduce discussions about ESEs, already well-described elsewhere. It should be sufficient here to state that these designs are not approved by most code-making authorities nor by mainstream science (Uman & Rakov, 2002). Corrective measures here also were suggested, studied and implemented.

6.0 Conclusion. NLSI recommendations have been implemented. NLSI may re-visit the BGC mine in 2006 to inspect modifications. This case study can serve as a template for open pit mining operations elsewhere.

7.0 Appendix.

7.1 NLSI Deliverables for BGC Lagunas Norte.

7.2 BGC Press Release.

8.0 References

8.1 Accidente Rayo en Plataforma Chancado Primario, BGC Lagunas Norte, Nov. 2004.

8.2 Politica de Alertas Por Tormentas Electricas, BGC Lagunas Norte, Jan. 2006.

8.3 Uman M. and Rakov V., “A Critical Review of NonConventional Approaches to Lightning Protection”, American Meteorological Society, Nov. 2002.

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