## Change Record

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The LSST Working at Altitude Safety Standard

Summary

This in compliance with the standards and norms commonly aimed at preventing Acute Mountain Sickness (AMS), resulting from hypoxia (lack of oxygen) at high altitudes, which may affect people who visit the Observatories on AURA property. These general guidelines are designed to help people understand, adjust, and respond to the unique and sometimes subtle effects on the human body caused by ascending to high altitudes.

This standard is designed to 1) inform people who visit the Observatories on AURA property about the symptoms of AMS, 2) define the training as part of the regular safety induction process that is already a standard practice, 3) define the pre-employment testing for Chilean employees as a means to identify medical conditions that may be affected by altitude and 4) provide advisement for non-Chilean personnel to consult with their personal medical practitioner to determine if there is a personal risk when working at altitude.

AMS occurs when a person cannot get enough oxygen from the air at higher altitudes. It happens most often when people who are not used to high altitudes go quickly from lower altitudes to 8000 ft. (2438 m) or higher. A preventive measure to altitude illness is acclimatization. The human body can adapt to the decrease in oxygen at a specific altitude in one to three days.

Different people will acclimatize at different rates. People should be properly acclimatized before going to a higher altitude. Effective methods of acclimatizing include staying hydrated; avoiding over-exertion; avoiding tobacco, alcohol, and other depressant drugs; eating a high carbohydrate diet, and avoiding gas producing food the day before and the day of going to a higher altitude.

Mild altitude sickness symptoms are common. Experts do not know who will get altitude sickness and who will not. Neither fitness level nor gender plays a role in whether a person gets altitude sickness.

Acronyms and Definitions of Terms

Acclimatization. The process by which the body adapts to the low oxygen levels present at high altitudes.

Acute Mountain Sickness (AMS). The most common type of altitude sickness. AMS doesn’t normally occur below 8,000 feet (2,438 m). Most people who ascend to altitudes of 10,000 feet (3,048 m) or more will have at least some symptoms of mild AMS. These include headache, nausea, weakness and decreased appetite. The onset of mild AMS generally occurs within 12 to 24 hours of reaching a higher altitude and will normally disappear within three days. While there are medications that can treat the symptoms of AMS, they can’t cure it. The only ways to cure AMS are to rest and allow the body to acclimatize (adjust to the change in altitude), or to descending to a lower altitude. Most people afflicted with AMS are ambulatory (able to walk), only in severe cases will they need to be carried or otherwise transported down to a lower altitude.
If symptoms become worse, a person may have progressed to **moderate AMS**. One alarming symptom of moderate AMS is **ataxia**, the loss of coordination. The hallmark of ataxia is the "drunk man's walk," or the inability to walk in a straight line.

If it is suspected that someone has moderate AMS, that person should immediately descend to a lower altitude. Acclimatization and medications won't help at this stage. Even a few hundred feet of descent should quell symptoms, but the lower, the better. In one to three days, the symptoms may disappear entirely.

**Atmospheric Pressure.** Also known as **barometric pressure**, this is a measurement of air's force against a surface. At low elevations, atmospheric pressure is greater, since the molecules of air are compressed from the weight of the air above them. At higher elevations, however, the air molecules are more dispersed, resulting in lower atmospheric pressure.

**High Altitude.** Considered to be between 8,000 and 12,000 feet (2,438 and 3,658 m) above sea level. Very high altitude is any altitude between 12,000 and 18,000 feet (3658 and 5,487 m), and extreme altitude is anything above 18,000 feet (5,500 m).

**High-Altitude Cerebral Edema (HACE).** HACE is a swelling of the brain occurring at high altitude.

**High Altitude Pulmonary Edema (HAPE).** HAPE is caused by excessive fluid in the lungs. For some people, the lack of oxygen at high altitudes can cause blood vessels to constrict. The body responds by forcing blood through unrestricted vessels, which results in high blood pressure and blood vessel leakage. This leaked fluid then builds up in the lungs, interfering with the normal exchange of oxygen. This results in further oxygen loss in the already-depleted bloodstream.

Because of some similar symptoms (such as fluid in the lungs and difficulty breathing), HAPE is sometimes misdiagnosed as pneumonia. This can be a fatal mistake. A person afflicted with HAPE may fall into a coma and die within a few hours. HAPE usually manifests at night, and many climbers have been found comatose in the morning by their companions. HAPE symptoms include trouble breathing when at rest, persistent cough, weakness, and feeling of tightness in the chest. If two or more symptoms are present, it's best to immediately descend and get medical attention. Other signs of HAPE include fever, gurgling sound while breathing, or extreme discomfort when lying flat.

**Hypoxia.** A condition in which the body or a region of the body is deprived of adequate oxygen supply at the tissue level. Hypoxia may be classified as either generalized, affecting the whole body, or local, affecting a region of the body.

**Reference Documents**

NOAO Working at Altitude Awareness Policy

Daniel K. Inouye Solar (DKIST) Telescope, Maui, HI

Altitude Safety Lowell Observatory, Flagstaff, AZ – visitor safety

Mt. Graham International Observatory (MGIO), Safford, AZ – visitor safety
Gemini Visitor Safety Guidelines

Keck Observatory High Altitude Information

“High Altitude Safety Protocol” by Mountain Medical Services

Humans at Altitude: physiology and pathophysiology

https://academic.oup.com/bjaed/article/13/1/17/281180

How to Identify High Altitude Sickness/REI


Chilean Supreme Decree 594, Regulation concerning basic sanitary and environmental conditions in workplaces, Art 110 B, Art. 110 B.1 – B.10
Working at Altitude Safety Standard

1 Introduction

Acute Mountain Sickness (AMS) is the most common unhealthy response to altitude, it’s a collection of signs that the body is becoming ill and has not adapted successfully to a higher altitude.

The concentration of oxygen at sea level is about 21% and the atmospheric pressure averages 760 mm Hg. As altitude increases, the oxygen concentration remains the same but the number of oxygen molecules per breath is reduced. At 12,000 feet (3,658 meters) the barometric pressure is only 483 mm Hg, so there are roughly 40% fewer oxygen molecules per breath. In order to properly oxygenate the body, a person’s breathing rate (even while at rest) has to increase. This extra ventilation increases the oxygen content in the blood, but not to sea level concentrations. Since the amount of oxygen required for activity is the same, the body must adjust to having less oxygen. In addition, for reasons not entirely understood, high altitude and lower air pressure causes fluid to leak from the capillaries which can cause fluid build-up in both the lungs and the brain. Continuing to higher altitudes without proper acclimatization can lead to potentially serious, even life-threatening illnesses.

Altitude sickness is primarily caused by a lack of oxygen - hypoxia. The major cause of altitude illnesses is going too high too fast. A preventive measure to altitude illness is acclimatization. The body can adapt to the decrease in oxygen at a specific altitude in 1-3 days. At 9186 ft. (2800m), the standard barometric pressure is 550 mm Hg. This means that there is 72% of the oxygen molecules per breath available at sea level. LSST top of dome is 8812 ft. (2686 m).

It is also possible, although rare below 3000 meters (9840 feet), to develop one or more of the more severe mountain sicknesses: pulmonary or cerebral edema, both of which can be fatal. Altitude may also aggravate pre-existing disease, particularly cardio-vascular and respiratory diseases. People with these conditions should seek professional medical advice before planning any trips to higher elevations.

2 Signs and Symptoms of Acute Mountain Sickness (AMS)

For safety purposes, individuals should assume that any symptoms of illness at altitude result from AMS. Individuals commonly fail to descend because they mistake their symptoms for another illness, assume they are too fit to have AMS, or feel that admitting AMS symptoms is a sign of weakness. Assume AMS first: it occurs in healthy, strong people. And even if a person is sick with something else, descending to a lower altitude will make it easier for the body to heal. (See Appendix 1 for More Detailed Information on Signs and Symptoms of High Altitude Sickness)

If a person has recently ascended, and has a headache and any other symptom of illness, assume AMS. The other signs of AMS vary for different people, but include:

- Fatigue
- Dizziness
- Loss of appetite
• Irritability
• Insomnia (if sleeping at altitude)
• Nausea or vomiting
• Reduced intellectual capacity
• Confusion
• Difficulty walking
• Rattling breath
• Feeling extremely ill

The last three signs in particular are signs that a person is becoming quite ill, do not wait for the onset of these symptoms before acknowledging AMS.

Observe others for signs of AMS. If someone has AMS, monitor the symptoms to ensure they do not worsen. Very sick people can become confused and not realize how unwell they are. Loss of appetite is a particularly indicative sign; anyone who has been walking or climbing at altitude should be hungry for a good meal in the evening.

If a person has symptoms of AMS, they should not ascend further and should descend to a lower altitude.

3 Responsibilities and Authority

Functional roles and general responsibilities in the prevention of, and response to, AMS are listed below. The roles may be performed by one or more individuals and an individual may play more than one role, depending on the structure of the organizations involved and delegation of responsibilities.

3.1 Personnel

Employees, visitors, observers, and contractors are all responsible for making themselves aware of the symptoms of AMS in this standard, and for knowing their own limitations while working at altitude.

It is important to remember that just because someone is young and healthy, or hasn’t experienced AMS in the past, doesn’t mean they are immune to it in the future. Physical fitness is not necessarily a good indicator, and neither are strength or good health when related to AMS. A person may react badly to altitude despite being fit, young and healthy. In fact, the fit, young and healthy have a hidden risk: their general physical capacity may lead them to believe that they should handle altitude without complications, which is not always true.

Having a medical condition may be a risk factor, particularly a cardiac or respiratory problem. Healthy hearts and lungs have a hard enough time getting oxygen to body tissues at high altitudes. If a person has physical conditions that make exertion difficult considerations should be made when working at altitude.

3.2 Management

Management ensures that the proper medical services are available, personnel are trained or provides on-the-job training related to this standard, determines and ensures appropriate medical evaluation for personnel working at altitude as required by law or policy, and verifies contractors, subcontractors,
visitors, students, and other people who may be exposed to hazards comply with the requirements in this safety standard.

### 3.3 Safety Personnel

Coordinates the requirements of this safety standard and keeps documents and related training current. Facilitates and supports a work environment where “Altitude Awareness” is part of the culture. This may take the form of formal and informal training, coaching, observation, and other activities to promote awareness of the overt and subtle effects that altitude can have on people and the work they do. Safety personnel should also incorporate altitude illness treatment into the emergency medical response system, including ensuring the availability of medical oxygen.

### 3.4 General Guidance

These guidelines are based on research and experience from working in telescope operations that are located at high altitude.

**DRINK WATER:** Drink approximately one extra liter of clear fluids per day. Drinking larger volumes of water does not protect against AMS, and can give the same symptoms (headaches, nausea, vomiting and more) as severe AMS from electrolyte imbalance. The human body may purge water to help with short-term adjustments to altitude. Drinking water will compensate for losses from dry air. Drink three to four cups of plain water if experiencing a pounding headache and relief should manifest in a few minutes.

**MINIMIZE THE CONSUMPTION OF CAFFEINE:** It is a diuretic and can prevent adequate hydration.

**ACCLIMATIZE TO ALTITUDE GRADUALLY:** Acclimatization is the process of helping the body adapt to lower atmospheric pressure by ascending slowly to higher altitudes.

**CONTROL BREATHING:** Take slow, even breaths.

**MOVE SLOWLY:** Consider moving at a slower pace at the summit. Use the chairs that are available. Don’t stand for long periods of time. The effects of exercise are more intense at altitude; walking up to elevated telescope locations may be more strenuous than anticipated. Take extra time when walking to these locations.

**DESCEND FOR RELIEF:** For all stages of altitude sickness, the main treatment is to go down to a lower altitude as quickly and safely as possible. For mild altitude sickness, over-the-counter medicines may relieve headaches. Other symptoms will go away quickly at a lower altitude.

**STAY RESTED:** Avoid exhausting tasks or short sleep the day before going to the summit. Adequate rest provides more cardio-respiratory reserves for adjustment to altitude.

**AVOID ALCOHOL:** Stay away from alcohol and other depressant drugs for at least 10 hours prior to ascent. This reduces the risk of dehydration and irritation of the arteries of the brain if they are forced to respond to hypoxia.

**AVOID MARIJUANA:** It stays with an individual for several days and can be an unpredictable, extremely potent constrictive agent for the coronary arteries. It has caused sudden death by shutting off the blood supply in the hearts of even young, healthy people without warning.
AVOID TOBACCO SMOKING: Nicotine constricts arteries and affects the body's adjustment to the need for increased blood flow.

EAT CONSERVATIVELY: Avoid heavy meals before ascending to the summit, since this tends to tie up a significant part of the available blood flow. Choose light meals of high-carbohydrate and easily digested items such as pasta, rice, or other starches. Avoid skipping meals or eating or drinking nothing but sugared snacks or drinks; sharp changes in blood sugar can trigger increased altitude stress. Avoid gas producing food the day before and the day of the ascent.

AVOID UNPROTECTED EYE EXPOSURE: Reduce the effects of glare and bright sunlight by wearing dark lenses, preferably with UV-coated lenses. This reduces fatigue and may prevent the loss of 50% of night vision for up to two nights after glare exposure of only 1 hour.

WEAR SUNSCREEN: The sun at altitude can be very damaging to your skin and increase the risk of skin cancer. At a higher altitude it is easier to get sunburned because there is less of the earth's atmosphere to block the sunlight. UV exposure increases about 4% for every 1000 ft. (305 m) gain in elevation. Wear sunscreen with an appropriate SPF rating, as well as SPF lip balm. Wear a hat, preferably wide-brimmed, and protective clothing to reduce UV exposure at altitude.

DRESS IN LAYERS: check the weather and use this information to dress appropriately. Because the sun is especially powerful, it can feel much warmer than the actual temperature during the daytime and then become cold quickly after sundown.

### 3.5 Medical Examinations

If working above 3000m, Chilean law requires annual medical evaluations of Chilean nationals for medical conditions that may exacerbate AMS. Non-Chilean employees do not need medical evaluations for working at altitude as they are protected by U.S. HIPAA law. However, non-Chilean employees should consult with their medical provider about working at altitude.

Chilean legislation states that a worker exposed to chronic intermittent hypoxia is one who performs work at 3,000 meters above sea level for more than 6 months, with a minimum stay of 30% of that time in high-altitude rotating shift systems and rest at low altitude. Chilean law defined different types of medical evaluations depending the characteristic of the work:

- Pre-occupational evaluation: 1 year maximum.
- Occupational evaluation: up to 3 years if under 40; up to 2 years if under 55 and equal or over 40; and up to 1 year if over 55 years old.
- Evaluation for Extreme Altitude (over 5.500 m): up to 1 year.
- Evaluation for Sporadic or Punctual Exposure: up to 1 year.
- Evaluation of Chronic Intermittent Hypobaric Surveillance: up to 3 years if younger than 40 years; up to 2 years if under 55 or over 40; and up to 1 year if over 55 years.

### 4 Training

Personnel shall be trained in the hazards of working at altitude as discussed in this standard.
Personnel who are required to use respirators or personal oxygen generators at high altitude must receive training specific to both the required respiratory protection, and the conditions under which the respiratory protection will be used. The organization will provide general training and supplemental oxygen equipment related to this standard.

The immediate supervisor must determine if the general training meets the level of training required for the work area. If it does not, the supervisor is responsible for ensuring on-the-job training is completed for any specialized respiratory protection, including working at altitude.

5 Periodic Evaluation

Management shall conduct periodic evaluations of the workplace to ensure that the provisions of this standard are being implemented to reduce or eliminate identified hazards. The evaluations shall include regular consultations with personnel who use respirators and their supervisors, site inspections, and a review of records.

Problems identified shall be noted in an inspection log and addressed with these findings reported to Safety Personnel. The report shall list plans to correct deficiencies in the respirator program and target dates for the implementation of those corrections.
Appendix 1: High Altitude Sickness/Signs and Symptoms

The following general guidance is for individuals who work at telescope sites and those who may have to respond to individuals exhibiting minor and major symptoms and signs of AMS:

<table>
<thead>
<tr>
<th>AMS - Minor Emergency</th>
<th>Steps to Take</th>
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<tbody>
<tr>
<td>Symptoms</td>
<td></td>
</tr>
<tr>
<td>Mild shortness of breath</td>
<td>Rest</td>
</tr>
<tr>
<td>Dizziness</td>
<td>Administer emergency medical oxygen (fixed-flow type)</td>
</tr>
<tr>
<td>Light headedness</td>
<td>Descend to lower altitude</td>
</tr>
<tr>
<td>Headaches</td>
<td>Inform Telescope Management</td>
</tr>
<tr>
<td>Visual Change</td>
<td>If symptoms persist, proceed to a medical facility where an evaluation can be done.</td>
</tr>
<tr>
<td>Palpitations</td>
<td></td>
</tr>
<tr>
<td>Chest Tightness</td>
<td></td>
</tr>
<tr>
<td>Nausea</td>
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<table>
<thead>
<tr>
<th>AMS - Major Emergency</th>
<th>Steps to Take</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms</td>
<td></td>
</tr>
<tr>
<td>Severe Unrelenting Sudden Headaches</td>
<td>Evacuation!</td>
</tr>
<tr>
<td>Shortness of Breath (at rest)</td>
<td>Follow the Emergency Procedures for Medical Evaluation and Transport</td>
</tr>
<tr>
<td>Chest Pain</td>
<td>Examine the victim</td>
</tr>
<tr>
<td>Abdominal Pain</td>
<td>Call medical emergency provider with the following information:</td>
</tr>
<tr>
<td>Visual Disturbance</td>
<td>• Your Location</td>
</tr>
<tr>
<td>Slurred Speech</td>
<td>• Describe how the accident or illness occurred</td>
</tr>
<tr>
<td>Loss of Coordination</td>
<td>• Describe the victim’s symptoms</td>
</tr>
<tr>
<td>Paralysis</td>
<td>• Indicate the urgency needed for treatment</td>
</tr>
<tr>
<td>Seizures</td>
<td>• Describe the weather conditions</td>
</tr>
<tr>
<td>Collapse</td>
<td>• Establish the primary meeting place based on the Emergency Plan</td>
</tr>
<tr>
<td>Slow or Rapid Heart Beat</td>
<td>• Describe the vehicle used to transport the victim</td>
</tr>
<tr>
<td>Labored Breathing</td>
<td></td>
</tr>
<tr>
<td>Cough with blood tinged sputum</td>
<td></td>
</tr>
<tr>
<td>Unrelenting Nausea or Vomiting</td>
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