Are You Weatherwise... or are You Otherwise?

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Abstract

Transmission of sound through the atmosphere is affected by local conditions. Anecdotal accounts of the sound of cannon fire traveling great distances go back to the Civil War. The Royal Society published a paper near the turn of the century concerning the reports from the cannons fired in London at the funeral of Queen Victoria. Early computers were used by the U.S. Army at Aberdeen in Maryland in the 1950's to model airblast problems during munitions demolition. Today's blaster has to have access to weather information beyond a simple local forecast.

Surface winds, winds aloft and temperature profiles have a dominant role in neighbors reaction to blasting. Many ground vibration complaints are really airblast complaints. Blasters who maintain ground velocities under .1 inches/ second are often perplexed by complaints from distant neighbors, even when local monitoring shows airblast to be under 110 dB. This paper will help the blaster identify warning signs of high airblast conditions.

Introduction

The purpose of this paper is to identify weather related problems and list available resources to deal with weather problems. It's been said that, "Everybody talks about the weather, but no one does anything about it". Even though we can't change the weather, we can select the best time to do our blasting. Some mines shoot at a designated time each day or shoot as soon as the pattern is loaded and ready. If neighbors are experiencing too much dust, smoke and noise; weather watching might help.

Ms delays break up the airblast from a large shot into lower amplitude events. However, mother nature has a way of defeating the efforts of Blasters who don't pay attention to the weather. Shooting with adverse atmospheric conditions can cause the sound from the entire blast to arrive at a home simultaneously (super-sonic blast). Weather must also, of course, be considered, whenever electrical storms occur near blasting operations.

Weather Basics

Most of us have a natural curiosity concerning weather and follow daily forecast to help us plan our personal schedules. What are the key items that a blaster should pick out?

Highs and Lows

Watch areas of high pressure as they move from west to east. Stronger winds are common at the edges and light winds predominate near the center. The clockwise circulation means that winds will progress from northwest, through northeasterly, through east, through south and southwest if the center of the high passes north of you. If the center is to the south, winds will progress from northerly through westerly and then southwesterly. A simple weather guide such as ‘A Golden Nature Guide to Weather’ is a good start.

Lows are characterized by counter-clockwise circulation and rising air. Winds progress in opposite fashion as a high and skies are normally overcast. Winter-time blasting has a greater potential for airblast problems than warmer seasons. Lows crossing North America in the winter, generally, draw moisture from the Pacific Ocean or the Gulf of Mexico. The latter are often termed, "Colorado" lows and the former, "Alberta" lows; hinting at their typical paths. Alberta lows are typically much shallower in the atmosphere and wind shifts on the surface may not be reflected in winds a few thousand feet aloft. In other words, beneficial surface winds may help blow dust and smoke away from neighbors, but unfavorable winds aloft may focus and worsen the airblast at specific locations.

Weather Monitoring

A thermometer, a barometer and a wind sock should be available to every surface blaster who has neighbors close by. PC-based weather stations are available in the $1000 price range. Weather balloons can be launched to detect inversions and winds aloft. A Wyoming mine uses a cylinder of gas to inflate wind tracking balloons from the back of a pickup near the blast site to predict the path of the dust and smoke. Aircraft are used for measuring temperature profiles. The cost of a profile up to 5000 feet above ground level costs in the order of $50. Ground based profilers use sodar (sound radar) echoing techniques. A continuous measurement is available. The cost of these systems start at about $50,000.

Observation of Smokestacks

Local smokestacks are one the best indicators available. Surface wind direction and speed is evident. Winter conditions, when airblast is a greater problem, usually mean that water vapor will make the plumes very obvious. Inversions can often be observed as plumes rise near to vertical in the cold, underlying air, then level off and move horizontally as buoyancy is lost in the warmer air aloft. Watch on a clear winter morning as the inversion is broken up by the sun heating the surface. Often, by midday the plume will rise at an angle right from the stack; indicating the re-mixing of surface an aloft air.

Test Shots

A small amount of explosives are laid out near the blast on the surface and shot. Sound level meters are placed at potentially sensitive locations. The author is aware of test shots ranging from as little as 2 pounds and as much as 50 pounds of explosive. The following attenuation equation estimates the air overpressure in psi; given a weight (lb.) of explosive and the distance in feet. This calculated value can then be compared to the measured value to determine whether the current atmospheric conditions are increasing or decreasing the sound transmission to neighbors.

psi = 206 (distance/(lb)1/3)-1.4 db = 20 log10(psi/3 * 10-9)

Cold weather, close spacing and fast caps

Supersonic airblast (Fig. 1) can result from tie-ins that have proved successful in warm weather. The problem is exacerbated by shorter times and wider spacings. Consider a real-life example from a surface iron ore shot where 32 ms connectors were being used on a 30 ft by 30 ft (9 m X 9 m) pattern. A pattern was expanded to 32 ft by 32 ft (9.8 m X 9.8 m) using the same timing. This blast was shot with ambient temperatures of about 0 oF. The speed of sound is about 1087 ft/sec (331 m/s) and changes by about 1 ft/sec per degree F (.6 m/s per degree C) and is described by the following equation: V = 331 * (T/273).5

where: V = Velocity in m/s T = Temperature in degrees C

The shock wave travels away from the hole at 331 m/s (1086 fps). The sound reaches the next hole in 29.5 ms. So any cap firing under 29.5 ms would result in overlapping sound arrivals. How often does that occur? Recent cap testing confirms that standard deviations may be is typically around 3 ms and in one sample, as high as 12 ms. Using the 3 ms value; 32ms minus 29.5ms equals .83 standard deviations, which results in a confidence factor of 80%. In a 100-hole , single-row shot, 20 pairs of holes will report as doubling the pounds per delay. The lesson here is that minor design changes in conjunction with temperature changes can cause airblast problems.

FIGUREONE

Helpful Weather Sites on the Web

http://www.intellicast.com/LocalWeather/World/UnitedStates/NorthernPlains/Minnesota/Duluth/RadarSummary/ http://www.intellicast.com/LocalWeather/World/UnitedStates/SurfaceAnalysis/
http://www.intellicast.com/Travel/World/UnitedStates/TEMPcast/d1_00/
http://www.intellicast.com/Travel/World/UnitedStates/WINDcast/d1_00/
http://www.intellicast.com/Travel/World/UnitedStates/THUNDERcast/d1_00/
http://www.intellicast.com/Travel/World/UnitedStates/PRECIPcast/d1_00/
http://www.intellicast.com/LocalWeather/World/UnitedStates/NorthernPlains/Minnesota/Duluth/Precipitation/ http://www.awc-kc.noaa.gov/awc/awc-fd.html (winds aloft)
http://weather.noaa.gov/weather/ccus.html (AWOS)

Winds Aloft

Sound travels at different speeds depending largely on air temperature and on the speed that the air mass itself is traveling. Surface winds can be sharply different than winds aloft. It is not uncommon to have the difference to be 180 degrees. The net effect can be to slow the surface sonic velocities while accelerating velocities at altitudes. The velocity difference causes the front of the pressure wave to turn toward the ground. Thus, the sound destined to attenuate at altitude, instead travels back toward the surface where it could arrive at the same instant as the direct surface sound. Wind aloft forecasts are available at; http://www.awc-kc.noaa.gov/awc/fd_winds/chicago_fd3.html

Temperature inversions

When warm air overlies cold air; meteorologist called it an inversion. The lapse rate is a term used to describe the profile of temperatures versus height above ground level. A normal lapse rate is a cooling of about 3.5 degrees F per 1000 feet of altitude. Two factors cause this: the sun heats the earth's surface rather than the atmosphere directly and adiabatic compression (the weight of the atmosphere compressing the lower air the most) causes warming near the surface. There are conditions that reverse the temperature profile to cause a phenomenon called a temperature inversion.(Fig. 2)

FIGURETWO

A diurnal inversion occurs overnight as cold air settles due to its greater density. Five factors that promote diurnal inversions include:

Clear skies Allow rapid heat loss through radiation to the night sky. Light winds Reduces mixing of stratified layers of air. Snow cover Insulates ground to retain heat under the snow. Long nights Simply allows more time for inversion to form. Mountains Block winds and form 'sumps' for cool air.

A frontal inversion (Fig. 3) occurs when a warm front pushes warm air over cooler air. Cold air remains as a wedge against the ground as lighter, warm air slides over top. Freezing rain is a sure sign of a frontal inversion as precipitation begins as rain and falls into colder air and freezes.

FIGURETHREE

Thunderstorms

Since this weather problem has been widely discussed , I will not spend as much time on it. Every blasting operation must have contingencies for electrical storms. Detection methods include; Personal observation of the sky. Tune an AM radio off of any local station and raise volume Hand-held lightning detector (radio receiver) Roof or pole-mounted electric field mill Time-of-arrival or azimuth/distance commercial grid detector Thunderstorm detection can be a cost effective investment. Note that lightning can be seen up to 70 miles away at night. If employees are clearing out from loaded holes based on visible lightning, production is being lost. Often, the decision to return to work is difficult. The same equipment will benefit plant operations where conveyers are loaded light in case of a power outage during a storm to insure that the belt doesn't have to be shoveled off to be able to startup.

Surface winds Blasting with winds blowing directly toward nearby neighbors should be avoided when possible if problems have been experienced. Dust and noise are concentrated in the downwind direction. This is an area that most TV and radio forecast have insufficient detail for blasting purposes. The best forecasts are available for pilots and anyone else knowing the right phone numbers and web sites.

Terminal forecast (TAF)

Terminal Aerodrome forecast (TAF) are updated every eight hours. Time is given in Greenwich Mean Time (GMT) and the winds are in azimuth/nautical miles hour format. For Example: 22020KT means winds from 220 degrees at 20 knots. Use the following address to find the TAF for the closest airport:

http://www.awc-kc.noaa.gov/awc/taf/msptafhib.html

To decode the abbreviations use the information available at the following web site.

ftp://ftp.ksc.nasa.gov/www/external/faa/files/FLTPLN/mtrdcdr.pdf
ftp://ftp.ksc.nasa.gov/www/external/faa/files/FLTPLN/mtrdcdr2.pdf (requires Adobe Acrobat Reader)

AWOS

The automated weather observation system (AWOS) has been developed for general aviation purposes. However, it is available via computer or phone throughout the U.S. It is updated on the computer every 20 minutes. On the phone, a computer-generated voice gives current conditions updated by the minute. If you are near an airport with AWOS, you can also receive the information via radio by tuning to the local navigation frequency (known as the VOR in aviation jargon). Call your local airport to get the phone number for AWOS.

References

Blasters’ Handbook, 17th Edition, International Society of Explosives Engineers, Cleveland, OH 1998 p. 639

Eloranta, J.W. 1992, Cap Testing at the Minntac Mine. proceedings of the eighteenth conference of Explosives and Blasting Technique, Orlando, Florida, January 19-23,1992. International Society of Explosives Engineers, Cleveland, Ohio, pp. 205-211

Jansen, K. ,Lerick, T., Kniviila, B., Andrews, A. B. "Refinements in Blasting Practices at Minntac Mine" Proceedings of the 10th Conference on Explosives and Blasting Techniques, International Society of Explosives Engineers, Cleveland, Ohio , 1984

Perkins, P., Lorrain, P. H. and Townsend, W. H., Forecasting the Focus of Air Blasts Due to Meteorological Conditions in the Lower Atmosphere, Report #1118, Ballistic Research laboratories, Aberdeen Proving Ground, Maryland. 1960

Private Pilot Manual, Jeppesen Sanderson Inc., Denver CO. 1977.