OUTDOOR CABINETS FOR BATTERIES

Climate Control and Ventilation

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Heat and Cold

Batteries are rated at 25°C, 77°F let them get hot in a metal cabinet in the sun and they age rapidly. At 92°F they age two days in one, at 107°F four days, at 122°F eight days, at 137°F 16 days.

Batteries shouldn't get terribly cold either. A battery at 32°F has only 85% of its capacity at 77°F while if it drops to -10°F it has only 50% of its capacity at 77°F.

The Extremes of North America and Siberia

Unfortunately plain metal boxes left outside at the mercy of the summer sun and the cold winter air can reach temperatures as extreme as the temperatures I have mentioned. 137°F in the summer, -10°F in the winter in the same box at the same place. These huge extremes in the same location are only found within the huge Northern hemisphere continents of North America and Asia. Asia is even more extreme than North America.

Location	Latitude	Coldest Monthly Average	Hottest Monthly Average	Difference	Coldest Ever Recorded	Hottest Ever Recorded	Difference
Winnipeg Manitoba Canada	49°54'	-3	67	70°	-48	108	156°
Des Moines Iowa	41°35'	21	76	55°	-30	110	140°
San Francisco CA	37°47'	50	62	12°	27	101	74°
Munich Germany	48°08'	34	67	33°	-9	101	110°
Peking China	39°57'	23.5	77	53.5°	-9	109	118°
Harbin China	45°45'	-4.8	74	78.8°	-42.5	102	145°
Verkhayaush Siberia	67°34'	-57	57	114°	-89	98	187°
Singapore	1°18'	80	82	2°	68	97	29°

Bury the Cabinet

The first thing that comes to mind to escape heat and cold is to bury the cabinet. This is generally a good plan. It is a better escape from cold than heat. Below the frost line you can be confident of batteries not falling below 32°F. The batteries themselves generate heat which helps against cold. To escape high temperatures you must be more careful. The ground over the buried battery vault will keep batteries cool in summer only if it is moist. It is not cool beneath bare desert or city parking lots. Moisture helps the batteries two ways. It evaporatively cools the ground surface and it makes the surrounding soil conductive so heat will be carried away rather than building up in the vault. See Baruch Givoni (Ref. 1) for interesting ideas using gravel and grass for underground cooling.

Battery Metabolism

Batteries give off heat, not very much if trickle charged at c/1000 to c/2000 but even this small amount of heat can be enough to keep the batteries warm in winter and to soon cook them in the summer if they are very well insulated. Our body metabolisms would raise our own temperature about 2°F an hour if no heat escaped. A couple of hours of perfectly insulating clothes and you would be dead. A battery on float at c/2000 has a much lower metabolism so within the same perfect insulation its temperature would rise only about 1 ½°F each day. Of course when the batteries are called into action – discharging to the load then later being charged back to full capacity you have an abrupt rise in temperature. About 25% of the energy used to charge the battery becomes heat within the battery and only 75% returns as electricity or discharge. A deep discharge – charge cycle raises the temperature about 15°F.

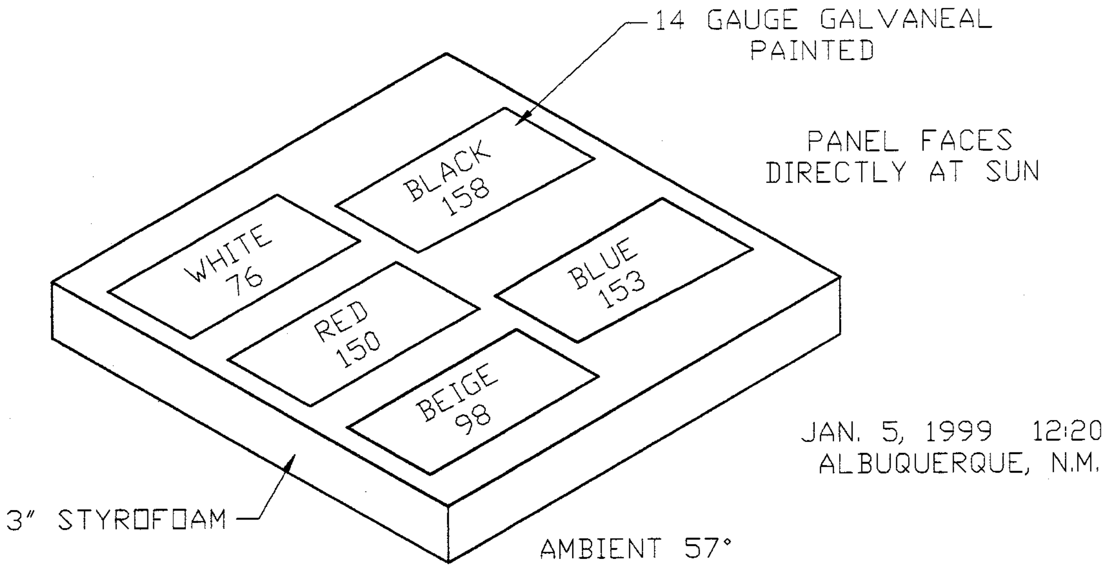
Insulation

Insulation is a useful means of protecting batteries against cold because it saves the battery's own heat. Insulation is also good at protecting against heat but it is more tricky. During hot weather we would like to insulate batteries during the day then expose them to the cool night. This can be done in several ways without moving the batteries. Insulation also has to do with scale. Big battery banks like big buildings or very fat people find it easy to stay warm (even without much insulation) and hard to stay cool because of their own metabolism.

Color

Color is the most effective way of protecting against high temperatures within a cabinet struck by sun. A white surface can stay cool even in the sun. At night the same white surface is good at cooling, just as good at radiating heat to the cold sky as dark colors for white paint is a selective surface. In a clear climate like Albuquerque a white surface will cool more at night radiating to the sky, than it heats during the day from the sun. A pure white cabinet exposed to the sun and the sky will on average stay cooler than a similar cabinet placed beneath a shade where it can not see the sun or the night sky.

The drawbacks to depending on white paint are the public who generally don't like large white cabinets in their neighborhood, and our atmosphere which soon turns white paint gray or brown. In extremely hot climates the public may be accustomed to bright white paint. Use it if you can. Batteries in uninsulated metal cabinets that are bright white stay close to the average of day and night temperature. Even light brown or green will take away the special advantage of the selective surface white paint. White paint is also cooler than shiny aluminum, chrome, or other metal. Dark painted surfaces, insulated behind, reach temperatures over 100°F above air temperature. I have only seen this on winter days when the sun in the northern hemisphere is 7% stronger than during summer.



Shading

In hot climates shading benefits all colored cabinets. A second skin an inch from the cabinet so air can circulate will bring the temperatures down. A shade farther away with better air circulation is better, shade of a tree is best because the leaves are evaporatively cooled and don't re-radiate heat on the cabinet.

Temperature Control by Selective Ventilation

Battery users are leery of bringing outside air into their cabinets. Yet it is worth it to get dust and bugs for the temperature control that selective ventilation provides. Thermostats turn a fan on when outside air temperature falls below the inside battery temperature. (The same fan can be used to ventilate H_2.) Cool air rushes through the cabinet taking heat with it. Batteries should be spaced an inch or two apart for good air flow. The fan should draw approximately 3cfm for each square foot of exposed battery surface. The fan should suck the air rather than blow it so heat off the fan goes directly outside.

Batteries are massive and if cooled by night air they are able to coast through a hot day without overheating if the cabinet is well insulated. If water containers are added temperatures can be brought even lower. Selective ventilation can also be done using natural convection dampers.

Weak selective ventilation can be achieved with no dampers or fans by two or more openings at the top of a cabinet. Flow occurs when outside temperatures are below inside.

Natural Cooling by Water

Still another way of selective natural cooling is used by the author's company, Cool Cell. Here water instead of air is the heat transfer medium and temperatures even below ambient occur because of night sky radiation. (Ref. 2)

Mechanical Refrigeration

Electric A/C cabinets can easily be heated by electric resistance heaters and also cooled by refrigeration.

Compressors, which keep most of our refrigerators and all our vending machines cool can also efficiently cool battery cabinets. Thermal electric devices have also been used for cooling batteries. Thermal electric devices are solid state with none of the moving parts which causes people to shy away from compressors, but thermal electric devices must use fans to operate their heat exchangers. The fans plus the very poor efficiency of the thermal electric device blight an otherwise promising cooling method.

A third method to use is absorption cooling as in gas powered refrigerators. These can work without fans and without compressors. Unfortunately they are also not very efficient.

Ventilation

Batteries give off explosive hydrogen when they are charged. If you stifle a battery cabinet or vault in an effort to keep it warm or cool you turn it into a bomb. There must be sufficient ventilation to keep the hydrogen concentration below 6%, the lower explosive limit. Some naively believe that hydrogen, because it is light, rises to the top of a cabinet like oil on water and therefore can be released through small openings. Hydrogen has very small molecules which move and diffuse rapidly; hydrogen is everywhere in a cabinet. If batteries are overcharged all the current goes to splitting water into hydrogen and oxygen. One kilowatt will produce three liters per minute of H_2 or .106 ft^3. To keep hydrogen concentrations below 3 1/3% each volume of H_2 needs to be flushed by 30 additional volumes of fresh air. If a battery charger may go berserk as during thermal runaway and convert itself entirely to creating hydrogen we must be sure at least 30 x .106 = 3.2 cfm of fresh air is introduced for each kilowatt of charging current. A hydrogen sensor can turn a fan on for ventilation or passive means can be used. It is best if the ventilation occurs only when hydrogen is present otherwise the batteries may get too hot or too cold. Hydrogen rich air is lighter than plain air, the density differences can power ventilation so that the hydrogen level never rises to explosive levels. When batteries inside a cabinet are warmer than outside air, thermal and innate (from the presence of hydrogen) convection combines to ventilate a cabinet if there are merely high and low vents. Fresh cold air flows in at the bottom, hydrogen rich warm air out at the top. Since overcharging is usually accompanied by hot batteries high and low vents are usually safe as ventilators. If hydrogen is being created while the outside air is hot and the cabinet air is cold the two effects cancel and there is poor ventilation. Cool Cell markets two passive devices that overcome the shortcomings of the high and low vents, both their unreliable performance and their bad thermal effects. (Ref. 3)

Why ever use VRLA batteries? I have just replaced eight heavily loaded wet cells after 7 ½ years in one of our Cool Cell cabinets in a very hot climate. These inexpensive batteries worked perfectly and might have lasted another year. After this success with wet cells I do not understand why anyone would ever buy a VRLA battery. I believe they have problems too severe to ever justify their purchase. They are four times as expensive yet last only half as long as wet cells.

References

1. Givoni, Baruch, *"Passive and Low Energy Cooling of Buildings,"* Van Nostrand Reinhold, 1994.
2. McKay, J.R., Estes, R. C., Kinsey, R., *"Use of a Water Plenum and Thermosiphon to Control Peak Temperatures in Outdoor Cabinets,"* Bellcore, Intelec 1992, Washington, D.C.
3. Baer, Stephen C., *"Two Means for Riddance of Hydrogen,"* Zomeworks, Intelec 1996 – Bat.