TEMPEST

White Paper

Tempest Projector Enclosures in Hot and Humid Outdoor Environments

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As projector manufacturers strive for ever more lumens in ever-smaller and more efficient packages, projector thermal management design has become an increasingly key success factor in their design process. This is even more the case as we see the industry shift to laser phosphor light sources, which have advantages in ownership cost and service intervals, but which may actually be less efficient at turning power into projected light. All this has led manufacturers of some of the highest power projectors on the market to lower their environmental temperature limits – for example the lamp-based 45,000 lumen Barco HDQ had a 35°C limit, and Christie's D4K40-RGB laser is 40°C – but with the strong caveat that light levels will be reduced progressively over 25°C (77°F). While the projector manufacturers may admit privately that these limits may safely be exceeded for some small portion of the total projector duty cycle, projector control software has also become more aggressive at policing these limits, causing owners to be more sensitive in adhering to them.

This has obvious consequences for outdoor installations in enclosures that have historically depended on circulating large volumes of outside air to remove lamp exhaust air and radiated heat from the projector housing, without the use of active cooling. With a typical ΔT in Tempest outdoor enclosures of 1-2°C between outside air temperature and projector inlet temp, it is obvious that a projector with a 35C top intake limit will start crying foul in an enclosure with, say a 2C ΔT and an outside temperature of 34°C. In some cases, the projector color balance can vary significantly with temperature swings, so this brings with it a need to maintain not only a low operating temperature, but also a *consistent* one.

Daytime and Showtime Temperature Management

It is important to distinguish between temperature management during show conditions, generally after sunset, with somewhat lower outside temperatures, and daytime, possibly under direct sun, but with the projector in standby mode, and not contributing to enclosure heating by more than a few watts in most cases.

Showtime

Clearly, the imperative must be to maintain an acceptable operating temperature for the projector at showtime, within its safe operating temperature range, when its light engine is running. From a system design standpoint this means determining the likely worst case outside temperature for the desired location, at the desired time of day/night. When compared with the projector's environmental limits, the enclosure specifier may then choose from a range of strategies to maintain such safe operating temperatures for the foreseeable conditions. It may be that exceptionally high temperatures may occur from time to time, and they may be harder to predict. Strategies may include:

1. Relying on the projector to limit its power output (and therefore heat load) when it reaches its safe upper temp limit (some projectors will do this automatically; others may require help…)
2. Providing additional cooling headroom in the enclosure design.
3. Overriding the projector top temp warnings, based on a duty cycle calculation that *x%* of projector lifetime at *y%* overtemp will not significantly harm the equipment.

Tempest AC Assist

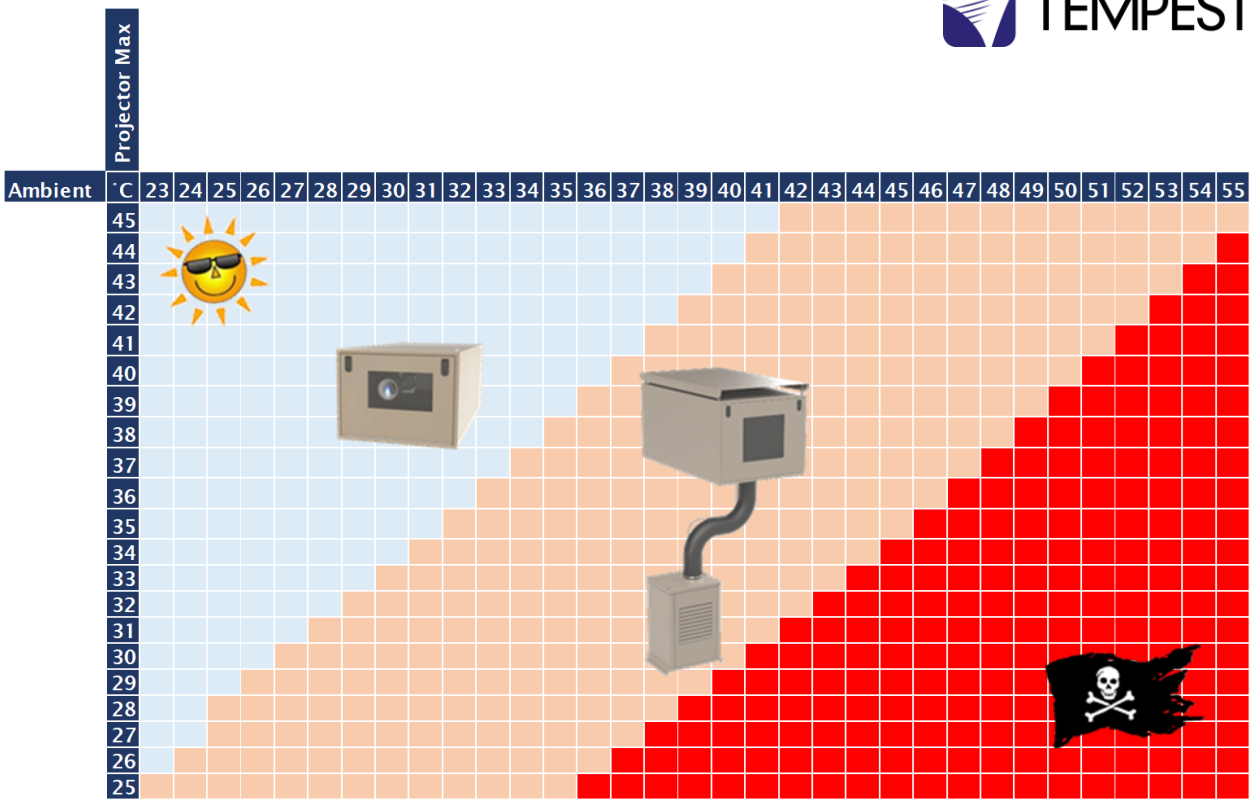
To this end, Tempest recently installed our first (beta) AC Assist installation in Dubai, in an installation with fourteen 45,000 lumen Barco HDQ projectors (environmental limit 35C/80%RH), running in night time temperatures of 35-38C, and very high humidity in the Summer months.

AC Assist – Challenges and Solutions

Tempest has long taken the position that AC-based active cooling is too dangerous to use in projector enclosures, for three main reasons:

- Cold-shock – in a warm environment the introduction of cold air may cause lamp shock and stress electronic circuits
- Vibration – especially in long throw applications, where any lens movement will be magnified by the throw distance.
- Condensation – We have seen dramatic levels of condensation in situations where cooled air (say 19-20C) is introduced into an enclosure in a much warmer environment.
- System designers must be aware that condensation, while most visible on, say the inside of the enclosure port glass, will be present on any similar surface inside the enclosure, when the temperature and RH levels are high. Over time this will lead to corrosion and/or mineral deposit buildups throughout the enclosure, *and the projector it contains.*
- The keys here are to use AC Assist only with a built-in dehumidifier, which lowers the overall RH at the same time as cooling the air, and – critically – only when the projector is running.
- By careful selection of the spot cooler rating, the AC assist solution can reduce the projector inlet temperature by 10-12C, resulting in projector inlet temperature at a very acceptable 25C in a 37C ambient.
- Control – Tempest has developed an AC Assist controller that will switch on the AC Assist unit only in the desired circumstances (projector lamps are on, inlet temp is approaching or above projector inlet temp limit).
- Blending – the AC Assist unit feeds cooled (and dehumidified) air into a hose adapter on the enclosure filter clamp, so the cooled air passes through the same HEPA filter as outside air, with which it is effectively blended, preventing cold shock and condensation. During the day, the enclosure may pull outside air through as required without disconnecting the AC Assist unit. The filter's salt fog and dust protection is maintained at all times, and the use of Tempest's Positive Pressure option is not compromised.

By adopting these strategies, AC Assist is now a practical solution in situations where showtime outside temperatures approach or exceed projector environmental limits. The following chart may be helpful in developing appropriate cooling strategies for specific locations and projectors:

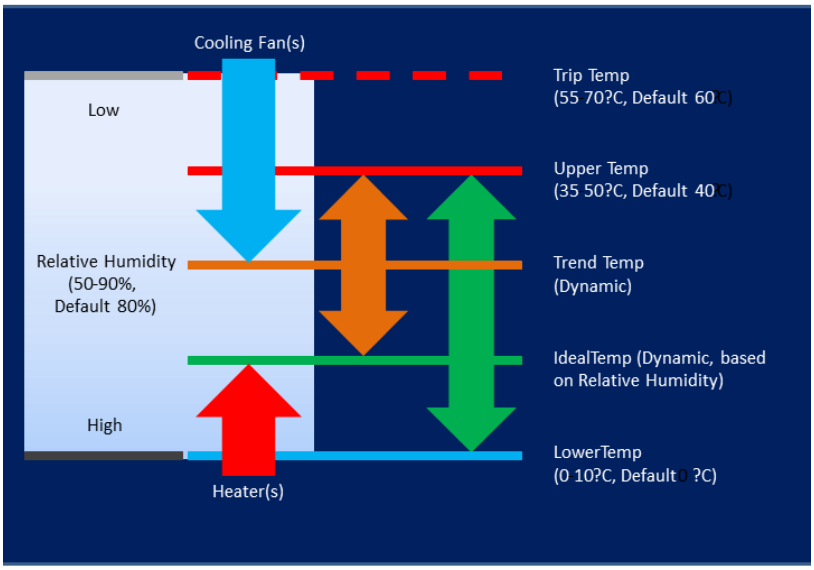


Note that the ambient temperatures shown here are showtime, not daytime temps.

Daytime Temperature Control

Tempest enclosures with DEC3.x and DEC4 controllers (that means everything shipped since 2011 up to the present time) employ Tempest's Goldilocks operating System (GOS, patents pending), to control temperature and humidity, WHEN THE PROJECTOR LAMPS ARE OFF. ***None of these settings has any bearing at all when the projector is running with its lamp(s) on***.

GOS does its best to maintain a 'Goldilocks zone' temperature and humidity range, with temperatures between UPPER and LOWER temp settings, and relative humidity below the RH setting.



GOS dynamically converts RH% into absolute humidity, calculates risk of condensation, and, if present, calculates a (higher) temperature at which the risk is negated, then uses the enclosure heaters to raise the internal temperature to that target level. IT IS IMPORTANT TO UNDERSTAND THAT HEATERS ARE **NOT** USED IF EITHER (A) THE PROJECTOR LAMP IS ON, OR (B) ACTUAL INTERNAL TEMP IS HIGHER THAN THE DEC'S UPPER TEMP SETTING. This is normally fine, since high risk condensation periods are usually in the early hours of the morning, when neither condition applies.

This system has been working very well for several years in many climate types.

Over-Aggressive User Settings

Some users have attempted to correct overheating by setting UPPER TEMP limits too LOW. This is understandable, but misguided. Firstly, these settings have NO EFFECT when the projector is running, so setting an UPPER TEMP of, say 30C, has NOTHING TO DO with the projector's operating environmental limit of, say 35C. The UPPER TEMP setting is merely the temp at which the enclosure fans will start to blow (with projector lamp off), to prevent the enclosure overheating under hot sun. But it also has the effect of preventing the heaters from operating to combat condensation. So in warm and humid climates, setting the UPPER TEMP too low may have the very undesirable effect of turning off condensation protection.

Tempest recommends setting the UPPER TEMP about 5C above typical summer daytime temps – the factory default setting is 45C for this reason, and in most cases should not be changed.

Tempest further recommends setting the RH% value at 85-90%. This still gives GOS enough headroom to prevent condensation (100%RH), without excessive use of heaters.

Again, it must be restated that these process only take place when the projector lamps are not running. When the projector is in show mode there is more than enough heat to go around and condensation is not an issue.

Sun Shades

Tempest has developed a sun shade accessory for G4 enclosures which creates an air gap between the top of the enclosure and the shade, reducing internal daytime temperatures by around 5C.

It is important to note that the sun shade has no bearing at all on the showtime operating temperature inside the enclosure.

Projector Standby Mode or Off?

During the day, most projectors are held in standby mode, ready to start up as soon as needed come showtime. In this situation, it will be necessary to confirm that the temperatures experienced by the projector power supplies is not exceeded. Tempest does NOT recommend running AC Assist at any time when the projector lamps are off, due to condensation risk, so this is not advised to maintain safe standby temperatures.

A better strategy may be to power down the projector when not in use, if it is likely to see actual daytime temps above its standby limit. Without power connected, the projector reverts to its storage temperature limit, usually 60-70C. Powering on and off remotely may not be possible using the projector control system, but it can certainly be accomplished by controlling the enclosure's lamp relay, using either DMX or Tempest TEMPS protocol through a show control system. This may be achieved simply in most show-control environments, either using DMX (DEC4 systems require the 51.485 RS485 comms board), or Tempest's TEMP protocol over Ethernet (DEC4 systems require 51.EN Ethernet Comms board, DEC3.x systems require 51.ENB Ethernet Bridge – see product manual for details).

Conclusion

In most cases, Tempest Cyclone and Blizzard enclosures will continue to work well to protect projectors in virtually all climate types. In extremes of heat and humidity, the following additional steps may be considered:

1. Add Sun Shades to mitigate high daytime temperatures under hot sun, and/or
2. Power projectors down in daylight hours, using the DEC power relay, operated by a show control system using DMX or TEMPS protocol
3. In extremely high show time temperatures, consider Tempest AC Assist.

Tempest takes very seriously its claim to world leadership in enclosure technology, and is 100% committed to ongoing engineering efforts to assure our customers of optimal operating conditions in every conceivable climate type.

Tim Burnham
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