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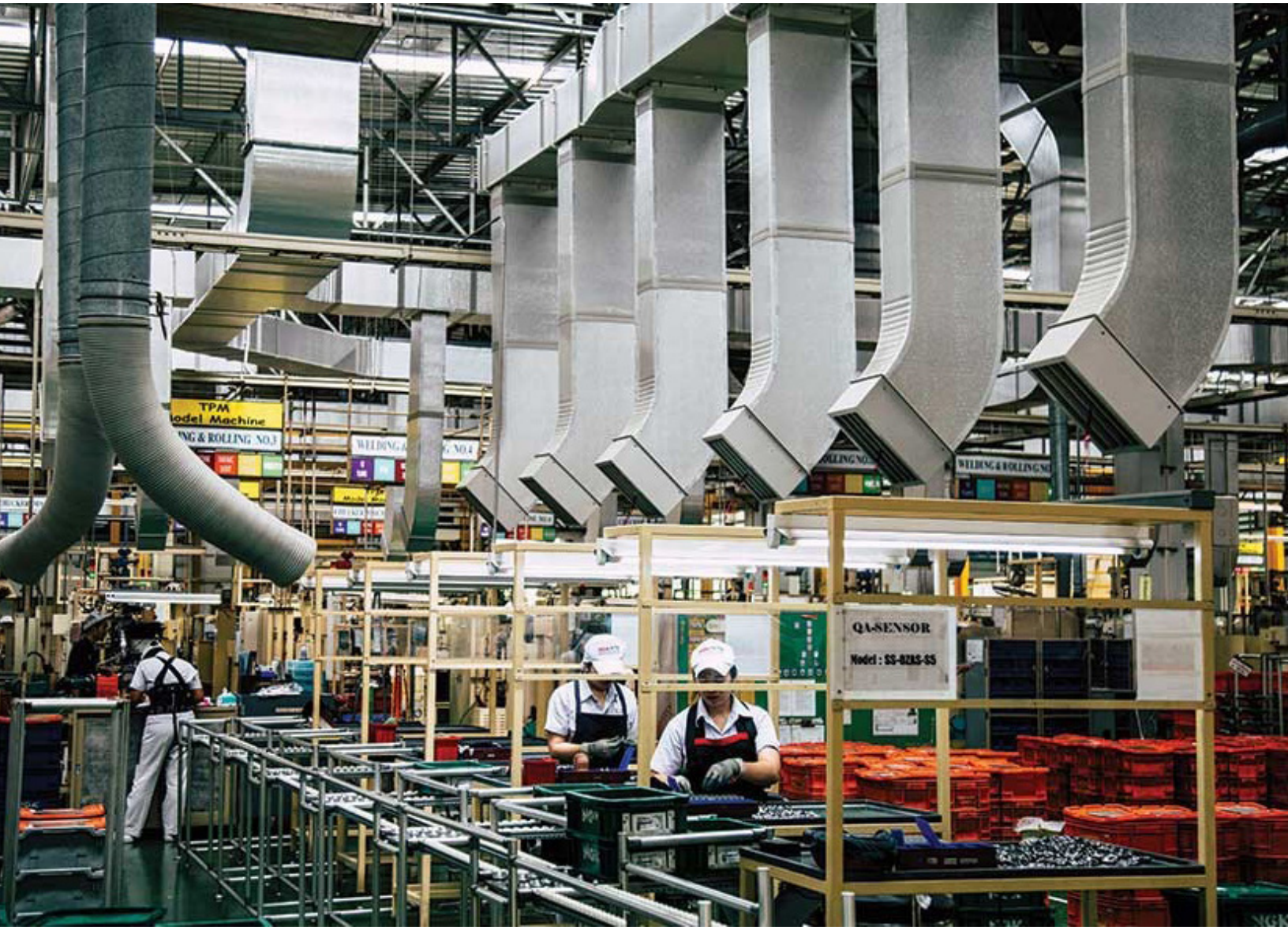
a cooling + ventilation series



Written by John Mullins, P.E. + Scott West, P.E.

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ALL EMPLOYERS ARE REQUIRED TO GIVE THEIR EMPLOYEES A WORK ENVIRONMENT THAT IS FREE FROM HAZARDS THAT ARE LIKELY TO CAUSE DEATH OR SERIOUS HARM. ONE SUCH HAZARD THAT IS OFTEN THOUGHT OF LAST BUT IS QUITE CRUCIAL IS HEAT STRESS.

Heat stress is especially high risk in warehouses and light industrial buildings that are in hot, humid climates. In this series, HFA breaks down what all employers need to know about managing heat stress in both operating and environmental conditions, which will in turn aid in enhancing productivity, overall health & wellbeing, reduce turnover, and minimize workplace accidents. There is also a proven financial advantage to maintaining a healthy (and happy) workforce, that an uncomfortably hot building will work against.

As an A+E firm recognized for a variety of national, regional, and local clients who have a number of buildings and warehouses they need to keep safe and productive, we wanted to share the engineering measures that can help minimize heat and promote a comfortable workplace.

Those measures primarily consist of:

- **Ventilation with outdoor air**
  - *Remove hot air captured inside*
- **Improved air movement**
  - *Fans increase cooling and evaporation of sweat from skin*
- **Reduction of radiant heat**
  - *Barriers put in place to minimize heat from roofs and equipment*
- **Cooling/dehumidifying the space**
  - *Through a variety of air conditioning options*

As we continue, we remind you to think about the factors to consider when selecting engineering measures and/or addressing workplace management and activities. Each space in a building could have different requirements.

The main factors to consider are:

- **Climatic conditions**
- **Irradiance of the building from the sun**
- **Building and/or surrounding construction**
- **Worker activities**
- **Availability of cool water**
- **Break periods**
- **New hires**

It is recommended that new and existing buildings be evaluated by computer modeling and then validated by on-site measurements. A computer model will make recommendations based off comfort, productivity, and life cycle costs for the full variety of the above-mentioned measures.

Throughout this article, we will give guidelines that focus on the Cooling Options available and the Requirements that go along with them.

COOLING OPTIONS

One of the most difficult building types to find the right balance of affordable construction verses operational and occupant temperature comfort is the warehouse. While generally used for storage, we know people work throughout warehouses and distribution centers (DCS). Providing cooling and ventilation can be a challenge, especially in the climates characterized in the southeastern United States.

OSHA (THE OCCUPATIONAL SAFETY & HEALTH ADMINISTRATION) REQUIRES 'THERMAL COMFORT' TO ENSURE HEAT STRESS DOES NOT BECOME A DANGER TO WORKERS.

HFA typically recommends increased cooling and ventilation requirements for one basic reason. During our 29 years of business, we have found that increasing the requirements leads to a higher level of productivity from the employees in the warehouses and distribution centers we design. There are various design strategies that can be used to improve thermal comfort and employee productivity to varying degrees while mitigating capital costs including Ventilation with Enhanced Air Speed and Spot and Full A/C Cooling. A warmer, more humid building requires a higher number of employee breaks, so cool down your building for more productive, happier employees.

VENTILATION WITH ENHANCED AIR SPEED

In warm climates that only use ventilation for cooling, we recommend enhancing the air speed. It can lead to increased

convective and evaporative heat transfers from the workers which in turn leads to improved comfort conditions. Common warehouse ventilation strategies involve using perimeter louvers for intake and power exhaust fans. This can be a big benefit if placed where it can take in air near the dock doors where most workers spend much of their time. It also ensures air flows from down low near the occupied level up to the roof and out of the exhaust which works with the buoyancy of air.

Supply fans can also be used and may result in fewer wall penetrations. The majority of ventilations designs draw air in from the perimeter and exhaust out the top or make use of a unidirectional arrangement on one side while exhaust is located on the other side. We recommend ventilation rates of 3-6 air changes per hour in climate employing this type of ventilation.

Another common method used to increase air movement is to make use of high volume, low speed (HVLS) circulation fans. HVLS fans can be designed to hit up to 200ft/min of velocity in an occupied zone. To put it in perspective, most air-conditioned offices are designed for 50ft/min or less of air speed. Increasing the air speed to 200ft/min will lower the effective temperature in the space by 7-8 degrees.

Small swivel propeller fans can also be used to ensure tractor trailers receive proper air movement for those loading and unloading the vehicle. Whether large scale HVLS or smaller swivels fans are being implemented, enhancing air speed is recognized as an economically appealing cooling option.

SPOT/PARTIAL COOLING

Spot cooling is most effective if warehouse employees have fixed workstations where they spend most of their time. It provides an oasis effect, giving workers heat relief and helping minimize higher break counts and duration.

Two main avenues of spot cooling are portable spot coolers and ducted spot cooling for permanent workstations as seen above.

HFA recently provided a client with DCs in Mexico partial cooling of perimeter spaces where the workers spend the majority of their time in the warehouse. Direct expansion unitary equipment was placed on top of lower height parts of the buildings like the shipping office. These units run constantly in the summer months discharging a high volume of condensate that needs proper drainage. For use in the United States, local energy code requirements may require a recirculating unit with heat recovery instead of an outside air unit. Either way, these units can be designed with a smaller tonnage capacity than fully conditioning a warehouse.

FULL WAREHOUSE COOLING

In various locations the design conditions for outside air temperature (the area's projected hottest day, at the hottest hour) can be quite high. A fully cooled building will be needed if a warehouse or fulfillment center decides to retrofit an automated fulfilment system. This automation will add significant internal heat from motor loads and would probably include equipment with limited maximum temperature requirements.

The general requirements for these cooling options can include recommendations for avoiding heat stress in the workplace and can be downloaded here. We now shift to discuss a variety of methods that can be used to determine environmental heat exposure in existing building applications.

DETERMINATION OF ENVIRONMENTAL HEAT EXPOSURES– MEASUREMENT METHODS

The Wet Bulb Globe Thermometer (WBGT) should be used to asses environmental heat exposures such as Effective Temperature (ET), Corrected Effective Temperature (CET), or Wet Globe Temperature (WGT), which are then converted to estimated WBGT values. However, when air and vapor impermeable protective clothing is worn, the dry bulb temperature is a more appropriate measurement than the WBGT because impermeable clothing does not transfer humid heat loss, but only dry heat loss.

All-in-all these temperature readings may be used to determine the degree of heat stress the worker is experiencing in the work environment and allow a professional to determine how to best address prevention to heat stress injury.

Measurements should be taken as close to the workers' general work area as possible and taken on an hourly basis, during the hottest portion of each shift. If a worker moves between two or more areas, the measurements from each additional area should be taken with the same guidelines. Hourly WGBTs should be calculated for the full range of tasks including ALL rest periods. Once calculations are made, an individual environmental factors profile should be made for each hot area to be used as a guide for determining when engineering controls and/or changes in work practices or alternate control methods should be used.

No matter if a worker is performing light, moderate, or heavy work, a metabolic heat screening should be performed. The workers' heart rate should be recorded to determine if heat exposure is above the recommended exposure limit (REL). If the REL is exceeded, heat production levels should be measured by indirect calorimetry if possible. Although not always feasible to test on-site, REL measurements can also be gathered by monitoring those performing at similar work levels in a controlled setting.

HEAT ALERT PROGRAM

At HFA we believe a huge factor in controlling heat stress is recognizing and predicting conditions that are likely to be dangerous.

A written heat alert program should be developed and implemented in case of heat advisories or heat waves. A heat wave is indicated when the maximum daily temperature is above 95F or when the daily maximum temperature exceeds 90F and is 9 degrees or more above the previous day's max temperature. The alert program should notify workers and supervisors that conditions greater than the REL are expected and to follow the heat stress plan to adjust operations, break regimens, and hydration intake.

Thermal comfort for warehouses, supply chain distribution facilities and industrial spaces are of particular importance for hot, humid climates. Space ventilation and conditioning in these environments must be healthy and safe at a minimum with further consideration recommended for additional comfort and productivity enhancing measures. There are several design strategies that sit between basic OSHA ventilation requirements and full comfort cooling that warrant engineering and economic analysis in order to choose the optimal approach for your facility.

Do you have questions about which cooling option is best for your warehouse or upcoming project?

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