FLYWHEEL COOLING
A COOLING SOLUTION FOR NON AIR-CONDITIONED BUILDINGS

Dick Abernethy, President
R. R. Abernethy, Inc.
FAN-JET Cooling Systems
Carrollton, Texas

ABSTRACT

"Flywheel Cooling" utilizes the natural cooling processes of evaporation, ventilation and air circulation. These systems are providing low-cost cooling for distribution centers, warehouses, and other non air-conditioned industrial assembly plants with little or no internal loads.

The evaporative roof cooling system keeps the building from heating up during the day by misting the roof surface with a fine spray of water - just enough to evaporate. This process keeps the roof surface at 90°levels instead of 150° and knocks out the radiant heat transfer from the roof into the building. The system is controlled by a thermostat and automatically shuts off at night or when the roof surface cools below the set point. The same control system turns on exhaust fans to load the building with cool night air. Air circulators are installed to provide air movement on workers during the day. Best results are achieved by closing dock doors and minimizing hot air infiltration during the day.

The typical application will maintain inside temperatures that will average 84° - 86° when outside ambient temperatures range from 98° - 100°. Many satisfied users will attest to marked improvements in employee moral and productivity, along with providing safe storage temperatures for many products. Installed "Flywheel" systems' costs are usually less than 20% of comparable air-conditioning equipment. By keeping a built up roof cooler, the system will eliminate thermal shock and extend roof life while reducing maintenance.

VENTILATION CONCEPT

To best understand "Flywheel Cooling" of non air-conditioned buildings we need to be aware of the fundamental climatological history of our particular "hot and humid" environment. The Dallas/Fort Worth data shows, for example, that the coolest hours of the day are late at night or just before dawn. "Flywheel Cooling" really describes the time control for the building's ventilation equipment, usually suction type exhaust fans. The fans are programmed to come on during the cool set time and essentially purge the "hangover" heat from the building and "load" it with cooler air. A minimum of 4 to 5 air changes per hour is usually all that is required, as we are ventilating only and are not concerned with air circulation at this time. Naturally, for proper ventilation, make up air must be provided and supply louvers must be designed for the correct volume (CFM's) of air being discharged from the building. As the correct approach to "Flywheeling" occurs at night when the building is unoccupied, motorized louvers are usually installed with screens and "burglar bars."

Additional care should be exercised in the design control and installation of the "Flywheel System" to avoid the possibility of drawing in water if the system is operating during heavy rains. More recent installations in large apparel, dry grocery, soft goods, and pharmaceutical distributions centers have enthalpy controls that turn off the fans during heavy rains or extremely high humidities (Fig. 1). Now that the building is "loaded" with cooler nighttime air, we want to store it and minimize or eliminate infiltration of the hotter outside air during the day. This requires an educational approach for most employees to encourage them to close most dock doors during the day. Common sense tells us when ambient levels reach 90° - 100° our ventilation systems will simply introduce this warmer air to our interior building envelope. Heat transfers to cold. Isn't this why we keep our dock doors closed during the winter? In the food and pharmaceutical industries, this is seldom a problem as they are concerned with insect and rodent infiltration and keep their warehouses closed. For the rest of us, it will require proper indoctrination. This is where a well-planned circulation system pays off.

AIR CIRCULATION

Air circulation is concerned with air movement across a body, as opposed to ventilation which is concerned with the movement of a volume of air (CFM) as outlined in the basic "Flywheel" approach. Air circulation involves air velocity as measured by feet per minute (FPM). The key to a good air circulation system is proper equipment selection. Too much velocity can be as objectionable as not enough. This is especially true with more sensitive employees and where there are a lot of shipping papers, etc. Due to this, you are better off to choose a line of equipment with a wide variety of performance and portable or fixed mounting options. Many of the most effective circulation systems evolved from a trial and error approach; therefore, local availability and service, as in most things, are the key.

"Cyclonic Circulation" is usually an effective method of moving air. Fans are usually mounted 3 feet above head height and one fan boosts the other. This can actually provide three to four times as much capacity due to the cyclone-like movement of air.

EVAPORATIVE ROOF COOLING

The key to completing the "cooling triangle" to achieve maximum cooling results is the evaporative roof cooling system. By evaporating water on the roof's surface during the day, the surface temperature is reduced 40°- 60°. The heat transfer that is usually conducted throughout the roof's insulation and radiated into the building is virtually eliminated. Ceiling temperatures are usually reduced to not more than 90° and the giant heat radiator becomes a cooling panel. Numerous papers and case histories have been presented and published over the years that establish creditability of this approach (Fig. 2). More simply stated, a roof cooling system with only 80% efficiently allows 20% heat transmission into the building. This is a factor of 4. This increases the thermal resistance of the roof insulation 4 times in the cooling mode. There is no better or more cost effective approach to eliminate the tremendous solar heat load that radiates into a building through the roof than with a properly designed and engineered roof cooling system. This completes the "triangle" (Fig. 3). Literally, millions of square feet of non air-conditioned buildings within our "hot and humid" region can attest to the practicality of this proven cooling method.

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RESULTS

Typical results vary from a minimum of 8° - 10° cooler temperatures in buildings with roof cooling only to 15°- 20° cooler with "Flywheel Cooling." Most distribution centers and warehouse operations in Texas and the surrounding area will maintain 83° - 85° interior temperatures when the outside ambient exceeds 100° (Figs. 4, 5, & 6).

COST

The most economical industrial air-conditioning systems (roof mounted DX units) will cost $1,000 per ton installed. On a new building, this can run at least $3.50 to $5.00 per square foot and as much as $2.00 per square to operate and service. On a typical 100,000 square foot BUR, a good quality evaporative roof cooling system can be installed for 12% to 15% of the cost of air-conditioning. The operating cost (water only) is no more than 10% - 12% of electricity. Many buildings have existing ventilation equipment already in place; therefore, it may only be necessary to add louvers. Electrical wiring is also a major expense, so there are more variables in estimating the ventilation system. In most cases, the ventilation system is approximately equal to the cost of the roof cooling system. Maintenance of the system at $.015 to $ .02 per square foot is a real bargain compared to maintaining compressor equipment. Most reputable companies offer annual maintenance service contracts.

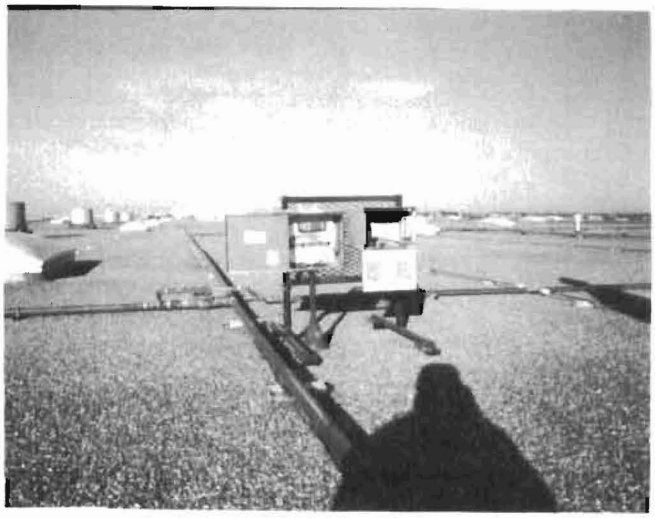

Figure 1 Enthalpy Controls
(Photo courtesy of Fan-jet Cooling Systems, R. R. Abernethy, Inc., Carrollton, TX)

OTHER CONSIDERATIONS

Worker productivity traditionally slumps in the summertime (Fig. 7). Documented case histories from many installations reinforce the investment of "Flywheel Cooling." As worker morale soars and productivity improves, there are fewer mistakes, less absenteeism, and improved plant safety.

Heat sensitive products, especially in the food and drug industry, are safely stored without refrigeration. One major pharmaceutical manufacturer actually has set a temperature alarm to go off at 93°in their warehouses, AND has never had a problem since installing evaporative roof cooling and "Flywheel" ventilation.

Roof life and maintenance on built-up roofing greatly improves with evaporative roof cooling as normal expansion and contraction is reduced and thermal shock from sudden afternoon showers is eliminated as a result of the pre-cooled roof surface.

REFERENCES

1. Houghton, F.C., H.T. Olson and Carol Gutberlet, "Summer Cooling Load as Affected by Heat Gain Through Dry, Sprinkled and Water Covered Roof," ASHVE Transactions, Volume 46, 1940, p. 231.

2. Monroe, Division of Tenneco, Inc., from the procedings National Plant Engineering, Maintenance Show and Conference, Chicago, IL., 1984

3. Waco Apparel Company Case History Test Results, Waco Texas, July, 1984.

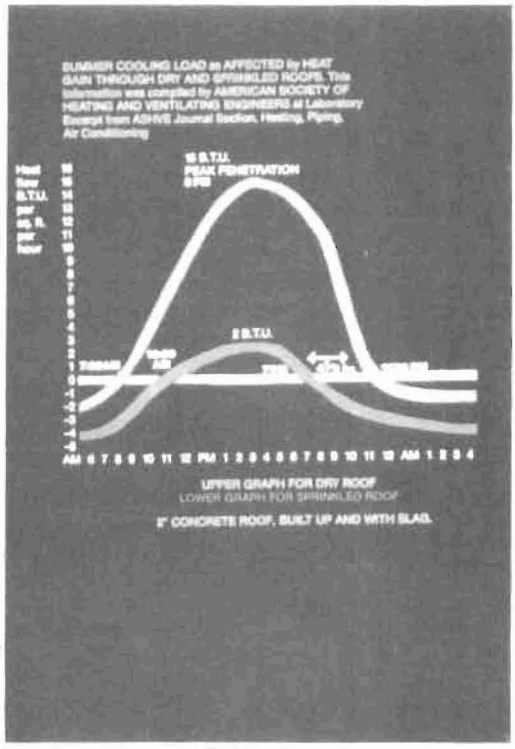

Figure 2 Relation between time and heat flow through inside surfaces.
Dry Roof vs Sprayed Roof
ASHVE Test[1]

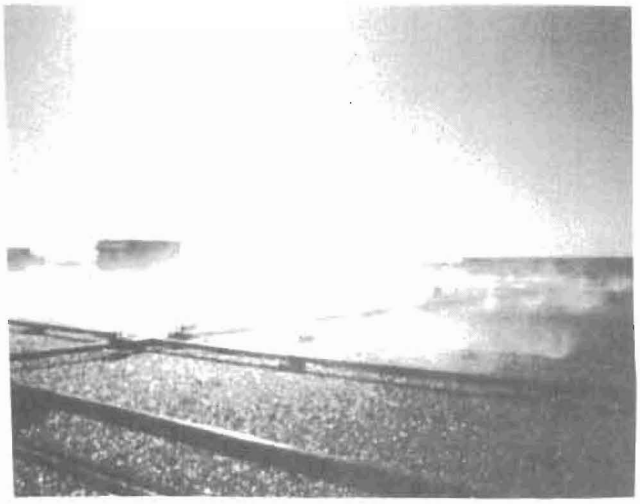

Figure 3 Roof Cooling System in Operation
(Photo courtesy of Fan-jet Cooling Systems,
R. R. Abernethy, Inc., Carrollton, TX)

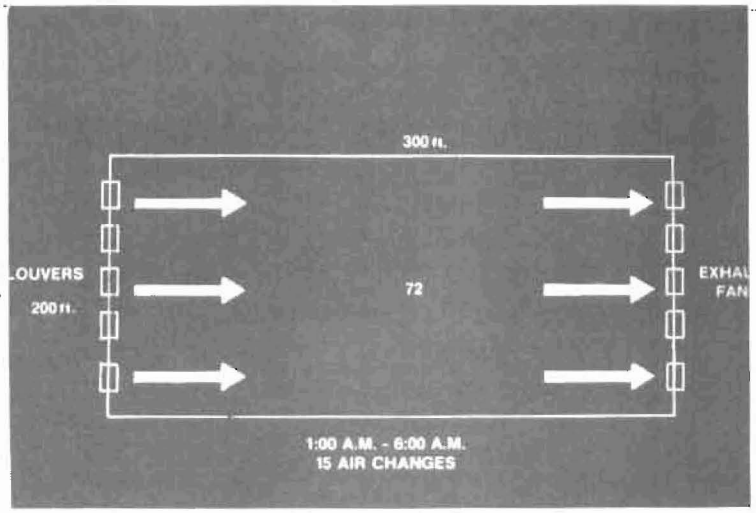

Figure 5 Schematic Air Flow/Air Changes Within Building[3]
Waco Apparel Company

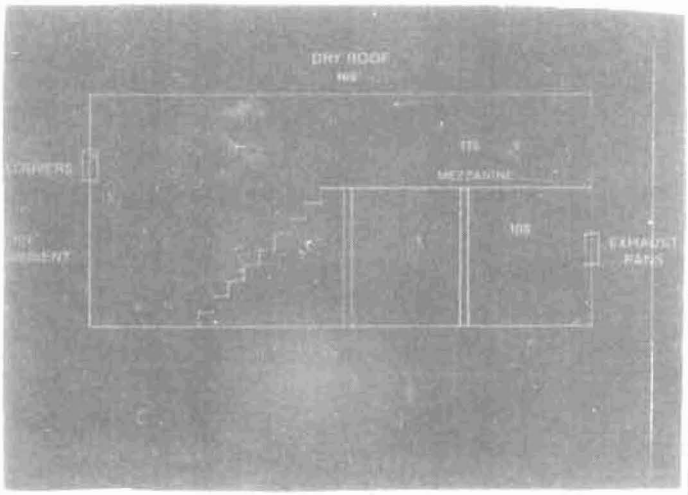

Figure 4 Tested Dry Roof Temperatures
Before Flywheel Cooling[3]
Waco Apparel Company

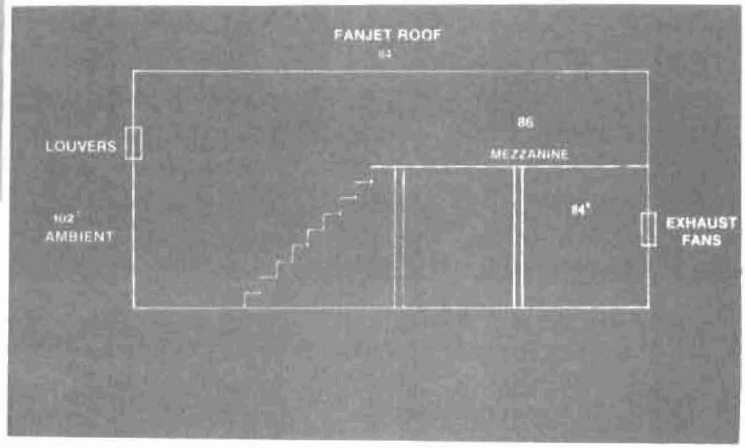

Figure 6 Tested Roof Cooling & Ventilation
After Flywheel Cooling System[3]
Waco Apparel Company

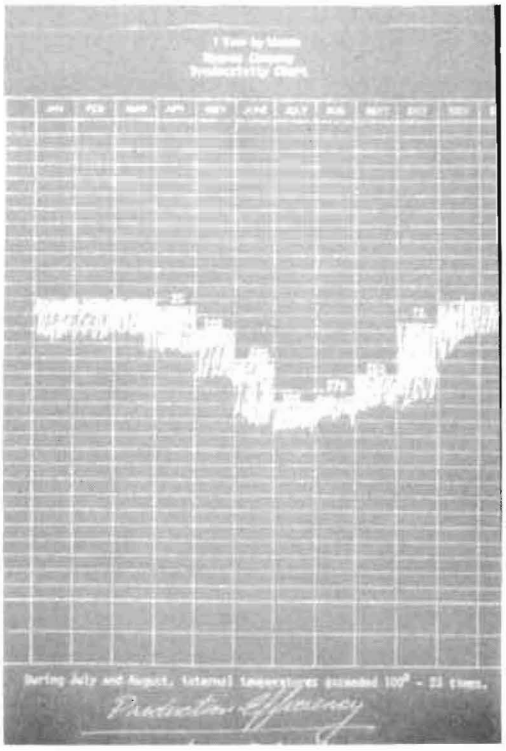

Figure 7 Worker Productivity Chart
Monroe Company[2]