Elevator Operation In a High Temperature Environment

by Robert W. Madison

HISTORY

The A17.1 Safety Code for Elevators and Escalators does not address directly "elevator operation in a high temperature environment."

Rule 211.3, Firefighters' Service: Automatic Elevators, addresses the operation of elevators in the event of a fire or smoke being present in the building corridors, as well as the operation of elevators by the firemen during a fire and rescue period. However, it concerns only the operation of the elevators and does not address the functioning of the elevator controls during high temperature periods.

Rule 101.5b addresses ventilation for machinery and control equipment. This specifically states, ". . . Machine rooms shall be provided with natural and mechanical ventilation to avoid overheating of the electrical equipment and to insure safe and normal operation of the elevator."

The safe and normal operation of the elevator is not addressed here; neither is the malfunctioning of elevator equipment due to high temperature in the machine room. The solution to this problem has been left to individual equipment manufacturers.

The Uniform Building Code does state: "for machine room ventilation the temperature should be kept to 104 degrees."

I am unaware of any code describing how the elevator operation is to be handled in the event of high temperatures in the machine room.

PRE-SOLID-STATE CONTROL SYSTEMS

Before the advent of solid state and microprocessor controls, the Ward-Leonard generator control type technology was the system used for geared or gearless elevators with speeds ranging from 200 fpm to 2000 fpm. Consequently, increased temperatures in the machine room caused the generator and motor field to overheat, thereby increasing their resistances. The generator field with increased resistances would reduce the voltage of the generator output, thereby slowing the car down. On the other hand, when the motor field resistance was increased, the speed of the car was inclined to increase. Since these two were prone to offset each other, the end result was greater instability than difference in speed.

At that time, elevator controls use a relay design and the coils of the relays heated up, causing time settings to change, altering the performance of some of the relays. However, the elevators could still work where the temperatures in the machine rooms reached 110 to 120 degrees. They tended to stray from their normal controls, i.e. came into the floor a little faster or slower, overshot the floor and releveled. However, while their stability was affected, the end result was that the elevator did level at the floor and the doors opened, permitting the passengers to exit the elevator. This conclusion is positive, since no passengers were trapped in the elevator and the elevator did not totally malfunction.

It was *not* standard practice at this time to have temperature controls in the machine room for measuring the temperature of the room and then shutting down or otherwise stopping the elevator when it attained a predetermined level. The type of feature used in the motor and generator circuits to detect overheating of the motor armature or the loop circuit in the elevator was an overload or thermocouple. These overloads, when tripped, would sometimes bring the elevator to an immediate emergency stop. In many cases, this would cause the elevator to stop between floors, trapping passengers.

Some of the devices were more sophisticated and, when the overload signal activated, a circuit would command the elevator to stop at the next floor, open its door, and then shut down. The elevator would remain shut down, parked, with its doors open, until maintenance personnel arrived on the job site for inspection and examination of the elevator. This phenomenon demonstrates the wide differences in approach to elevator operation as practiced by different manufacturers.

• One type of device stops the elevator in an emergency in the hoistway, even though it might be between floors.

• The other type of device brings the elevator to a stop at a floor opening its doors, permitting passengers to exit.

PRESENT-DAY CONTROL SYSTEMS

Controls are currently designed to utilize solid state drive applications for the direct drive of the elevator motor. These are powered SCR's or transistors of a solid state type with microchips dictating their operation and logic. A microprocessor controls the logical sequence of the elevator, programming where it is going, what floor it stops at, what elevators are available, the opening, closing speed of the elevator doors, and also controls and monitors many of the safety devices. While the A17.1 Code does address some of the safety devices having mechanical parts, in the final analysis, the microprocessor control is what commands the elevator to stop or assigns it to particular floors for certain emergencies.

Due to the complexity of these solid state controls and microprocessors, manufacturers are using heat-sensing or temperature-indicating devices in different parts of the circuits. When these devices show a dangerously high temperature or one above the range tolerating safe operation of the components, they somehow stop the elevator by preventing its further operation. These device can be categorized in two major groups:

(1) Those devices which will prevent damage to equipment.

(2) Those devices which prevent malfunctioning of a serious nature.

The choice of methods by which to stop the elevator — where and how it is stopped — is left to the discretion of the individual manufacturer. This area is not addressed by the A17.1 Code.

The operation of the elevator in high temperatures with microprocessors reaches a point where at first it becomes undependable, then it malfunctions, and finally it reaches a state where the device itself fails and it become impossible to predict the mode of its next output.

Manufacturers have rated temperature control values for different parts of their equipment. The microprocessor itself is usually situated in a cabinet which may or may not have a built-in fan for ventilation. Some devices sense whether the fan is working or not and, if it is not, then the device will shut the elevator down. Some have temperature devices in the cabinet itself and, if this temperature reaches a predetermined level, this then shuts the elevator down.

In solid state controls, individual components themselves can be measured. For example, in the case of SCR's, the heat sinks have temperature controls; when these reach a high enough level, the elevator is immediately stopped. The various devices protecting individual components authorize the stopping of elevators by different methods.

TYPES OF STOPS

Present manufacturers are utilizing two basic methods. The *first* method is an emergency stop. Here the devices are used chiefly for the protection of the SCR's themselves, under the premise that, once the temperature has risen to a dangerous level, it will accelerate at such a rapid rate that no time is available to stop the elevator with any certainty that the device will not fail. When the decision is made for the elevator to make an immediate stop, this immediate stop could leave the elevator between floors, thereby trapping the passengers inside the elevator car.

The *second* type is of a non-emergency type, whereby the elevator stops in its normal manner at the next available floor. This is where the manufacturer deems that there is no danger of immediate destruction to the equipment by that unreliable operation will be forthcoming. This type of device is used where the manufacturer has confidence that the system can function well enough to stop the elevator at the next available floor, open its doors, and then shut down.

RELIABILITY OF ELEVATORS OPERATING IN HIGH TEMPERATURES

As stated earlier, when the temperature increases within the microprocessor, malfunctions or erroneous information can appear in the microprocessor, causing the elevator to operate in an improper manner. Most of the safety circuits and devices have redundant features or rely on equipment with a high temperature rating. Long before these circuits or logic determination are affected, the early stages of misoperation can be detected in the microprocessor.

It is possible for the manufacturer to determine what temperature will cause the equipment to be prone to, or on the threshold of, misoperation, and to take this into account in the design of the equipment. Elevator operation can be considered acceptable and proper when this threshold of misoperation is approached and then the elevators are sent to, or caused to stop at, a floor, opening their doors for passengers to safely exit and then all further operation is prevented by elevator shutdown.

The immediate stopping of the elevator in emergency conditions to save equipment is unacceptable, as there is generally sufficient time to allow the elevator to run until it arrives at floor level and stops. The worst scenario is that the component itself might fail by shorting itself out, which would then cause the elevator to stop immediately — as it would have anyway. In this situation, the passengers are unavoidably trapped.

SHUTDOWN CAUSED BY HIGH TEMPERATURE

The manufacturer determines at what temperature each of its temperature-sensing devices will operate to prevent misoperation or unsafe operation of the microprocessor controls or burn out or destruction of many of the system's components. While this determination is left to the manufacturer, how or where the elevator stops will be specified by the Code.

My strong recommendation is that equipment not be shutdown or stopped in an emergency mode because, in this case, the stopping of the elevator between floors is likely.

At all times, the elevator should make a normal stop, proceeding at the very least to the next available floor. The manufacturer is capable of rating and designing the equipment so that the threshold temperatures of the sensing devices can promise safety and reliability for the short period of time that it takes the elevator to proceed to the next floor level. The elevator can then stop and open its doors for the passengers to exit, park, and shut down.

HOW SHOULD THE ELEVATOR CODE ADDRESS HIGH TEMPERATURE OPERATION?

How the elevator is stopped, where it stops, and what operations exist in the shutting down of the elevator should be addressed by the A17.1 Code since it has the responsibility of describing how the riding public will best be served by a coordinated and specified operation of the elevators.

There are no requirements for elevator operating in high temperature environments in the A17.1 Code. It is my opinion that this problem should not be addressed by the Code. The manufacturers alone are in the best position to know the limits of their particular equipment relative to high temperature environments and the range in which their controls can operate satisfactorily. For an elevator code to address this problem, it would have to be applicable to a wide variety of situations and, as the industry technology changes, the threshold temperature of operation would also be changing. The manufacturer has the technology to establish the threshold temperatures for safe and proper elevator operation.

PROBLEMS WITH ELEVATORS WHICH ARE SHUT DOWN

The proper procedures for stopping elevators when temperatures exceed the range required for their reliable operation are now established. However, the cause of the high temperature may be a fire located in the building. The elevator code has established emergency procedures, priorities, and operations for elevator during a fire in a building, one of the criteria being that all elevators are moved to the lobby or the "designated" or "alternate" landing.

The question now arises whether this elevator—which has been ascertained to be at the threshold of misoperation or malfunction—can be returned to a form of service where it is semi-automatic and returned to the fire recall floor. In some cases this may take an average of 30 seconds of running and stopping time for a 20-floor total run.

One must keep in mind the time between the shutting down and the return to the fire recall floor, we can call "interim time," may allow for an increase in the temperature in the machine room which, in turn, increases the malfunction probability of the microprocessor beyond the probability manifested in the initial stage of high temperature detection.

It seems logical and prudent that, if the elevator is to be shut down at the time it is on the threshold of misoperation, the decision to move it to the lobby recall floor should be made at the first opportunity instead of bringing the elevator to a stop at the nearest available floor and then having to move it again, wasting valuable time. At the time of discovery, the elevator should be required to proceed directly to the fire recall floor and stop there, opening its doors in accordance with the recall operations of the fire emergency service. The elevator, once put out of service by this means, will be left at the fire recall floor, where:

(1) The fire department personnel will be aware of the elevator's location; and

(2) It will not be in a position of serving as a potential hazard if a fire exists below it, whereby flames could travel from one floor to another through its open hoistway doors.

If the elevator is stopped at some upper floor with open doors, this would be a severe and grave danger, because flames would have no problem jumping up the hoistway. Leaving or parking a car at an upper landing with its doors open is unwise and should be prohibited.

The additional time required for a car to travel to the lobby recall floor rather than stop at the next available floor would probably average less than 30 seconds, considering that all the elevators are in operation. Even in buildings as high as 60-80 stories, these elevator could make an express run of 40-60 stories in 20 seconds because they would be running at a speed of 1800 to 2000 fpm, enabling them to complete the operation in well under the 30 second average time.

USE OF SHUTDOWN ELEVATORS FOR FIREFIGHTERS' SERVICE

It has been reported repeatedly by sources whose authenticity cannot be verified that fire department personnel have stated, "just give us the elevators and we'll run them, even in the fire." They reportedly felt adequate to handle the operation of the elevators during the fire to remove guests from a building. While I believe this was related with the utmost sincerity, it is a hazardous position indicating a rather unrealistic approach on the part of that particular fire department's personnel.

When a manufacturer or designer ascertains that the operational requirements of the microprocessor are being strained and have reached a point where they are in imminent danger of malfunctioning and has added devices to shut the elevator down, this strongly dictates avoiding use of the elevator until the temperature in the machine room has been reduced to below the point of this threshold. Without these temperature-sensitive devices, the elevator could shut down indiscriminately in the hoistway or enter a malfunctioning mode, causing grave and critical damage.

Having eliminated these possibilities by installation of temperature-sensing devices, it is unwise to contemplate re-using the elevators while such a condition exists, with the equipment now having been designated unreliable and prone to malfunctions.

CANCELLATION OF HIGH TEMPERATURE SHUTDOWN OPERATION

Once the temperature sensing devices that dictate shutdown have operated, this information should be stored in a permanent, self-locking memory and, after the elevator has returned to the lobby fire recall floor, the elevator must be parked for maximum passenger safety. All further operation needs to be prevented by a special lockout device which is not subject to the temperature limitations of the microprocessor. With a microprocessor, there is a possibility that an additional rise in temperature could cause it to fail in such a way that there would be a false indication that the temperature is actually safe. The device must be prevented from sending back erroneous information indicating that the temperature requirements are in conformance with manufacturer standards.

CONCLUSION AND SUMMARY

New solid state controls and microprocessors provide extremely improved high temperature environmental monitoring to insure the safe operation of these controls in elevator performance.

This temperature obstacle is recognized by manufacturers and designers. Currently, elevator operation is halted when components or microprocessor systems are exposed to high temperatures. The elevator is directed to stop and park in order to insure—and I reiterate this point—*maximum passenger safety,* and also to provide the related equipment with protection from damage.

It is proper and acceptable that the manufacturers do use these heat sensors, however, it is imperative that the Code dictate how and where the elevators are to be stopped.

The choosing of the "lobby recall firemen's floor" is appropriate and desirable. This operation solves many problems, such as:

(1) entrapment between floors;

(2) leaving the elevator at an upper floor with its doors open, which could cause flames to jump from one floor to another;

(3) the uncertainty of the firemen in a real emergency as to the location of an elevator that is not present at the lobby; and

(4) the securing of the elevator for inspection to see that it is empty of passengers in a fire emergency.

Once the high-temperature sensor has initiated the stopping and parking of the elevator, there should be a self-locking feature independent of the microprocessor controls and high temperature requirements to insure that the elevator stays locked out and shut down at the fire recall floor until it is positively ascertained, preferably by inspection, that the elevator can be returned to service.

Once this elevator has been recalled to the fire floor, it should not be available for the firefighters to use during the emergency period, unless it has been determined as described above, that the temperature level in the machine room has been reduced.

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