# SAFE EGRESS FROM DEEP STATIONS
## Flawed Criteria in NFPA 130

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Abstract

The design of railway stations includes the consideration of emergency evacuation requirements. These are written in NFPA 130, a standard of the National Fire Protection Association. If a standard is faulty or inappropriate in any way, the flaw has far reaching consequences. The Code 130 is an example of a flawed code. As such it deserves our immediate attention and improvement. The code fails to properly measure egress rates from deep stations. The paper reviews the reasons for this and indicates corrective action.

SCOPE

The design of railway stations includes the consideration of emergency evacuation requirements. These are written in NFPA 130, a standard of the National Fire Protection Association. The NFPA is a body designed to create such standards. It works with experts who develop a consensus view of the appropriate guidelines. The NFPA is not a governmental organization and has no rule making authority. Any authority it has is created by governmental units that may adopt it as a requirement for construction within the jurisdiction of that governmental unit.

Despite this indirect authority, the NFPA standards have a major influence in construction and design. If a standard is faulty or inappropriate in any way, the flaw has far reaching consequences.

The Code 130 is an example of a flawed code. As such it deserves our immediate attention and improvement.

EXAMPLE OF THE PROBLEM

In New York City, the MTA is planning the East Side Access Project. This will create a deep underground terminal. As many as 5000 persons will be in the terminal at one time during the evening rush period. Safe emergency egress is a major problem. However, using the NFPA 130 criteria, it appears solvable. This is an illusion, however. The following discussion will make that clear and propose constructive action.

CONTEXT

The code is entitled *Standard for Fixed Guideway Transit and Passenger Rail Systems*.[1] References to it will be detailed in the end notes of this paper. The code content is indexed by a number and sub-number system. Thus Chapter 5 may have subparts 5.4, then 5.4.2, then 5.4.2.1, etc.

The Code 130 covers many design elements including Stations, Trainways, Emergency Ventilation, and Vehicles. Our immediate concern is with station evacuation.

EVACUATION REQUIREMENTS

For a transit or railway station, the code assumes a track and platform system. The need for evacuation is premised on a fire or the presence of toxic matter in the air. The platforms may be on an elevated structure, at grade or underground.

The maximum time allowed for clearing the platform of all riders is 4 minutes.[2] The maximum time to clear the entire system (including platforms) is 6 minutes.[3]

Such evacuation is conducted from the platforms to a “point of safety”. This is defined as “an enclosed fire exit that leads to a public way or safe location outside the structure, or an at grade point beyond any enclosing structure, or another area that affords adequate protection for passengers.” [4]

This definition has three alternatives. The first two are physical: “outside the structure,” “beyond any enclosing structure.” The third is ambiguous and uses the vague term “adequate”.

PHYSICAL DESIGN REQUIREMENTS

Egress paths include stairs, escalators and elevators. Elevators are not normally considered in egress computations due to their inherently low capacity.

Escalators are limited in quantity to one half of the exit paths at any one level.[5] Of these, one is assumed to be out of service.[6] Furthermore, the out of service escalator must be the one most critical to evacuation.[7]

Escalators running in the direction of emergency egress are permitted to keep running.[8] When running toward the emergency, they must be capable of being stopped.[9] No suggestion is made that such escalators once stopped can be restarted. This is very sensible in that safety requires very cautious assumptions as to what will work when needed.

No assumption is made that the capacity of escalators should be considered when operating in the egress direction. Such capacity may be higher than that of a stair, but it is not considered. This is wise in that the emergency may include power losses which stop such an escalator despite the operational advisory that it can remain running if already doing so.

STAIR/ESCALATOR EQUIVALENCY

For a particular station layout, computations are required to test evacuation timing. For this purpose, stairs and escalators are treated as equivalents. They are both vertical paths. That is, escalators have the same capacity and velocity numbers as do stairs of similar width. This is entirely appropriate in the emergency context.

*Major issues arise, however, when we examine the computations required and the factors specified in the code.*

TESTING FOR SAFE EGRESS

The code demonstrates an arithmetic routine for computing the egress time. Linear factors are multiplied and added. Passengers are assumed to distribute themselves to stairs in proportion to the capacity of the stairs, thereby maximizing the system egress performance. All queues are assumed to be used so that they all clear at the same moment. This is reasonable only where the exits are well distributed along the platform.

A contrary example of the problem is from my experience at Penn Station NY. A full train arriving in the morning rush hour on track 2 took 9.5 minutes to clear the platform. I took these stopwatch measures in 1986. The time matched the predicted values based on a computer simulation which predicted 9 minutes. The passenger load was about 800. Three exit stairs were available for egress. The problem was that the passenger load was well distributed along the length of an 8 car train – but the three exits were all located at the west end of the platform. A large queue developed for the most easterly exit. The queue size was such that it filled the full width of the platform. No one could get around that queue.

Persons near the base of the crowded stair were just a few seconds from flowing up the stair. They would not move to the two open west stairs as this would have delayed their personal exit. Yet, by standing where they were, they blocked any possible flow around the queue to available and unused exits.

In other words, the passengers were optimizing their personal well being, and could not or would not move to other locations for system optimization.

Passengers do not behave so as to optimize the **system** egress time. They optimize their **personal** egress time. The arithmetic procedure used in the code should be replaced by a more subtle calculation. A simulation is needed, not a static arithmetic calculation.

## CAPACITY AND SPEED

The code specifies both capacity and travel speed factors. The capacity is related to vertical path obstacles (like stair/escalators) which can only handle so many persons per minute. This may develop a queue and a waiting time to enter the path. Such waiting time is part of the overall timing analysis.

For movement in the upward direction, a capacity is given as 1.31 persons per minute per inch of width.[10] Thus, a 36 inch wide vertical path has a capacity of 47.16 persons per minute. When combined with the passenger load to be handled, it helps to define a queue time.

Additionally, there is travel time for the egress. Time is allowed for walking to exits as well as time on a vertical path. The latter is specified as 40 vertical rise feet per minute in the upward direction.[11] Thus, a vertical path climb of 10 feet, uses 1/4 of a minute or 15 seconds.

Separate factors are given for downward movement. These give higher capacity and speed values to reflect the easier motion in the downward direction.

## CODE SCOPE AND INAPPROPRIATE USAGE

The factors give in the code are presented as <u>constants</u>. There are no variations that reflect the **amount** of motion in the vertical direction. Thus to climb 70 feet uses the same capacity and speed rates as for 10 feet. *This is clearly not correct. Everyone knows from personal experience that one slows down during a long climb*. The slower rate of climb also reduces the vertical path <u>capacity</u>.

The code, therefore, is written in the context of **limited amounts** of vertical movement. When applied outside of that context, it gives a distorted view of egress reality.

Many new projects are built with the intent to provide deep stations far from the point of safety. Great depth facilitates the use of tunnel boring machines and the avoidance of surface level costs. However, it greatly enlarges the safe egress problem.

To use the existing code to evaluate egress for a **deep** station is entirely inappropriate. Indeed it is dangerous to future generations. The code should be revised to make the capacity and speed factors <u>variables</u> (not constants). They should vary as a function of the vertical distance itself. The new function can be empirically determined and implemented very quickly.

Studies of the rate of climb should include the effects of blockage of the stairs by persons who are forced to stop due to lack of stamina. These random stoppages are critical to blocking the flow, reducing the egress rate and, more critically, expanding the queue at the <u>base</u> of the path. The wait time in the queue expands rapidly as the system egress performance deteriorates.

## CONCLUSION

For project managers, their staffs and consultants to ignore this issue is typical but not tolerable. When it comes to safety, we tend to minimize today's cost rather than invest in a long term risk avoidance. Only after the catastrophe do we commit ourselves to wiser actions. The 130 code was written to deal with emergencies caused by accident or hidden design flaws. Since 9/11, of course, risk is expanded as we must now include malevolence as a cause.

In any case, we all know that a long climb to safety from a **deep** station is a slow process. We must deal with that reality. Critical variables cannot be treated as constants.

## Endnotes

1. National Fire Protection Association, *NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems*. Quincy, MA: National Fire Protection Association, 2003 including Tentative Interim Amendment (TIA 03-1)
2. Maximum platform clearing time 5.5.3.1
3. Maximum station clearing time 5.5.3.2
4. Point of Safety 3.3.35
5. Limit on escalator use at 50% versus stairs 5.5.3.3.2.5
6. Assume one escalator as out of service 5.5.3.3.2.6
7. Escalator out of service is the most critical one 5.5.3.3.2.7
8. Escalator in egress direction may continue to operate 5.5.4.1 (2)
9. Escalator running reverse of egress direction 5.5.4.1 (3)
10. Capacity of vertical path in the upward direction 5.5.3.3.2.4 (1a)
11. Speed in the upward direction 5.5.3.3.2.4 (1b)

## Reference

National Fire Protection Association, *NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems*. Quincy, MA: National Fire Protection Association, 2003 as subject to Tentative Interim Amendment (TIA 03-1)

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