Technical Note

'Feeling a Door' to See If Fire Is on the Other Side

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Abstract

This paper considers door assemblies that separate a fire environment from a protected space. It analyzes three methods of "feeling a door" on the protected side that can assist in determining the existence of a direct fire threat on the other side. These methods are: 1) feeling the door surface to determine whether or not it is at an elevated temperature; 2) feeling, smelling and visual inspection of the door edges to determine possible smoke flows from an adjacent fire environment; and 3) feeling the door-knob to determine whether or not it is at an elevated temperature. It is determined that a practical and effective strategy can be developed which uses all three methods to establish the existence of a fire threat without direct exposure to the fire environment. Of all methods discussed, the most reliable single indicator involves touching the base of the door-knob.

Introduction

One Item on the Research Agenda of the National Association of State Fire Marshals is to examine the contention that "'feeling a door' to see if fire is on the other side" can be supported technically. This paper presents an analysis of this. For the purpose of discussion we will interpret the contention in a broad sense. Thus, we take the words "feeling a door" to mean examining a door and its edges by touch, smell**, and/or visual inspection.

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**Throughout this paper it should be recognized that use of the sense of smell may not apply to fire fighters because of their need to use self-contained breathing apparatus (SCBA). Similarly with a touch test which would typically require removal of protective gloves.

Key Words: Detection, doors, fire fighting, fire hazard, smoke barriers, smoke transport

In the entire discussion to follow it is assumed that the exposed surface of the door in question is subjected to a flashover fire environment. In particular, the environment is assumed to be so severe that if one opened the door for a direct "test" of conditions, the action could not be reversed.

It is reasonable to consider three methods of ‘Yeeling a door“ that could indicate the existence of the conjectured direct fire threat

1. feeling the door surface to determine whether or not it is at an elevated temperature;
2. feeling, smelling and visual inspection of the door edges to determine possible smoke flows from an adjacent fire environment; and
3. feeling the door-knob to determine whether or not it is at an elevated temperature.

Each of the above methods will be discussed separately.

Feeling the Door Surface to Determine Whether or Not It Is at an Elevated Temperature

As indicated in Figure 1, door types found in common use are either wood or metal. ("Press-board" construction is included in the wood category.) Wood doors can be hollow or solid. Metal doors can be hollow or insulated. (As is most typical, metal doors will be considered here to be of steel construction.) Solid wood doors have either a solid wood or "composite" core. Insulated metal doors are insulated to perform effectively under severe environmental conditions, i.e., for economy in building heating and cooling, or under fire conditions. When metal doors are insulated "for economy," a styrene insulating material is typically used.

Hollow Wood Doors

Direct fire exposure of a hollow wood door would lead to bum-through of the door structure in a few minutes. In the final phase of burn-through, when the fire is directly attacking the one remaining door panel, an easily-sensed surface temperature rise will exist, but only for a fraction of the time

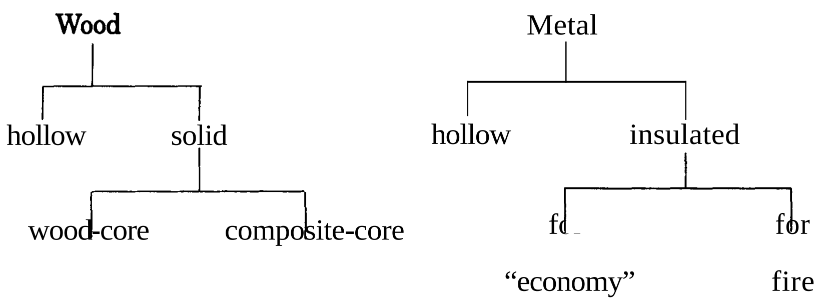

Figure 1. **Classes of Doors.**

prior to actual flame penetration. In general, the hollow wood door cannot be expected to provide any significant protection from the conjectured fire threat.

Hollow Metal Doors

Hollow metal doors can be expected to maintain their structural integrity for a significant time interval, of the order of several minutes to several hours (fire-rated doors). Because of the use of relatively thin-gage front and rear panel components, the temperature of a fire-exposed panel, on its unexposed side, can be expected to rise to several hundred degrees C within the order of a few seconds.* Radiative heat transfer between the typically high emissivity/absorptivity inside surfaces of the two panels which form the hollow core of the door would likely be very effective in quickly raising the unexposed panel to temperatures levels easily discerned by touch.

Solid-Core Wood Doors

The insulation properties of solid-core wood doors are so effective that it would take several minutes subsequent to fire exposure for the unexposed surface of the door to reach a level of elevated temperature, say of the order of 60°C (140°F), that could be easily detected by touch.**

Metal Doors Insulated for Fire

Away from door edges, the insulation used to fill the core of metal fire doors can be expected to be even more effective than the above-mentioned solid woodcore insulation in delaying any significant temperature-rise response of the unexposed side. However, near the door's edges the thermal response of the surface of the unexposed side of the door would be dominated by conductive heat transfer through the near-continuous metal edging which connects the exposed and the unexposed door panels. This thermal response would be significantly more intense than the above-mentioned response due to conductive heat transfer through the core

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*For example, consider an initially 20°C (68°F), 0.001 m (0.04 inch) thick steel panel with a fire-exposed surface of 700°C (1300°F) and assume that the unexposed surface can be reasonably modeled as insulated. Then the unexposed surface will reach a temperature of 500°C (900°F) in less than 1 s.

**For example, consider an initially 20°C (68°F), 0.04 m (1.6 inch) thick solid-core wood door where the surface of the virgin wood on the fireexposed side of the door is 300°C (572°F), a characteristic pyrolysis temperature for wood, and where the unexposed surface can be modeled as insulated. Then the unexposed surface will reach a temperature of 60°C (140°F), i.e., a temperature rise of 40°C (70°F), some time between 6 to 16 minutes. (This estimate assumes that a thickness of at least 0.025 m (1.0 inch) of the virgin wood still exists, and that the thermal diffusivity of the wood can be approximated by that of spruce across the grain, i.e., $0.25(10^{-6})\ m^2/s$ [Carslaw, et al]). Note that a more precise estimate of the time is beyond the scope of this article.

insulation (although probably not as strong as the earlier-discussed radiative transfer mechanism in hollow metal doors). Because of edge conduction, an easily detected elevated temperature can be expected near door edges within a minute from the time of full fire exposure of the door.* For this reason, touch testing near the edges of fire doors can be effective.

Metal Doors Insulated for Heating/Air Conditioning Economy (Normally Exterior Doors)

When metal doors are insulated "for economy," the typical insulating materials used would not maintain structural integrity at elevated temperatures greater than approximately 300-400°C above ambient. Rather, when subjected to such temperature levels, melting and/or significant pyrolysis of the insulating core material would tend to occur. For this season, when subjected to the conjectured fire exposure, metal doors insulated "for economy" would tend to rapidly take on the characteristics of the hollow metal door. An analysis of the rapidity of the core degradation is beyond the scope of the present discussion. Without the result from such an analysis, the action of feeling the surface of non-fire-rated insulated doors away from the edges to determine the existence of an exposure fire condition on the opposite side must generally be considered as unreliable, i.e., the response would be somewhere between the hollow metal door and the metal door insulated for fire. However, near its edges, a metal door insulated for economy would be expected to respond in the same manner as a fire-rated metal door and touch testing there would be similarly effective as a fire indicator.

Feeling, Smelling, and Visual Inspection of the Door Edges to Determine Possible Smoke Flows from an Adjacent Fire Environment

After being exposed to the conjectured fire threat for a few seconds, all types of door assemblies, with the possible exception of smoke-tight fire door assemblies, will have non-trivial gaps, say, of the order of 0.001 m (1/32-1/16 inch) or larger, between the door edges and the door frame. Feeling, smelling, and visual inspection of these gaps for smoke flow would often be very effective in determining the existence of the fire environment in the adjacent space. In this regard, some fire door assemblies may be designed with fire-hardened door-gap seals which may be effective in significantly

*For example, consider an initially 20°C (68°F), 0.04 m (1.6 inch) thick door with front and rear panels connected by a continuous metal edge. Assume the fire-exposed end of the edging to be 700°C (1300°F). Assume further that lateral losses through the edging are insignificant and that its unexposed end can be modeled as being insulated. Then the unexposed end of the edge will reach a temperature of 60°C (140°F), i.e., a temperature rise of 40°C (40°F), in approximately 13 s.

limiting smoke flow. These are more popular in Europe than in the United States.

Smoke flow from the fire space to the protected space would be most significant through gaps at the top portion of the door assembly. Smoke flows would typically be entirely absent near the floor, where flow through the gaps would be from the protected space to the fire space. Relative pressurization of the spaces, say as a result of stack effect or of operating ventilation systems, could significantly alter the intensity and, more important, the direction of flow through the gaps of the entire assembly. For this reason, sole use of the smoke-flow sensing method can be unreliable in establishing the existence of a fire threat.

Feeling the Door-Knob to Determine Whether or Not It Is at an Elevated Temperature

Metal door-knob assemblies are typically used in all types of door construction. These provide nearly-continuous, relatively-high-thermal-conductivity/diffusivity-paths for conductive heat transfer between the fire environment and the protected space. "he response of the base of the door-knob assembly on the unexposed side of the door would be very similar to the above-discussed response of the door surface near a metal door edge, where the door edge was at the door-knob elevation. (Push/pull-type hardware used in place of a doorknob assembly may not provide the required relatively-short and/or nearly-continuous metallic conduction path.)

As in the case of edge conduction, an easily detected elevated temperature can be expected at the base of the door-knob within a minute from the time of full fire exposure of the door. For this reason, touch testing of the base of a door-knob can be generally effective.*

Summary

For door assemblies that separate a fire environment from a protected space, all three discussed methods of "feeling a door" on the protected side can assist in determining the existence of a direct fire threat on the other side. There is, however, one essential principle for safety; namely, while a hot door is always indicative of a relatively new or ongoing serious fire environment on the other side, a cold door does not assure the opposite. A serious fire can exist beyond some doors that are cool to the touch.

The effectiveness of the method of feeling the door surface to determine whether or not it is at an elevated temperature will generally increase with.

*Lateral heat transfer from the exposed surfaces of the shaft of the doorknob may be larger than the corresponding lateral heat transfer in the case of edge conduction (see previous footnote). But the conservative one-minute estimate is still expected to hold.

height above the floor. Touching the door surface away from the door edges would be very effective for hollow metal doors, but ineffective for insulated metal fire doors and for solid wood-core doors. Touching the door surface near the door edges can always be effective in the case of doors with metal edges.

The method which can provide the greatest fire detection sensitivity is that of feeling, smelling, and visual inspection of the door assembly edge gaps to determine possible smoke flows from an adjacent fire environment. When smoke flows exist, the flow rate for a give gap size will typically increase with increasing elevation. However, because of possible relative pressurization between the fire space and protected space, smoke may not flow through gaps of the door assembly at any elevation. For this reason the smoke-flow sensing method is not always reliable. Also, fire doors may be effectively designed to minimize such smoke flows.

Whenever near-continuous metallic door-knob assemblies are used in a door construction, touch testing of the base of the door-knob can be generally effective in identifying the existence of a fire threat,

Based on all the above, it is clear that a practical and effective strategy can be developed which uses all three methods to establish the existence of a fire threat and to do so without direct exposure to the fire environment. Of all methods discussed, the most reliable single indicator involves touching the base of the door-knob.

References

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