THE REGULATION OF TECHNOLOGICAL INNOVATION: THE SPECIAL PROBLEM OF FIRE SAFETY STANDARDS

Prof (Emeritus) Vincent M Brannigan J.D.
Department of Fire Protection Engineering
University of Maryland College Park Md 20742 USA
firelaw@umd.edu

ABSTRACT

Regulators all over the world are trying to balance innovation and fire safety. The use of performance tests isolated from regulatory judgment always raises the question “Can you test your way to fire safety?” The more complex the fire safety problem, the more difficult it is to rely on a simple fire safety test, since the combination of elements which pass a simple test may demonstrate hazards in a complex design. Technological innovation poses the greatest challenge to any test based regulatory system since the ability to create a new product is not always connected with the ability to understand its risks and therefore to develop an appropriate test. Regulatory standards also can fail to capture the risk inherent in materials or processes which did not exist when a regulatory standard was adopted. All these problems can occur with the European system of decentralized non-discretionary regulation based on so-called performance tests. Resolution of the problem requires a more complex and effective system both for vetting tests and for determining when they can be used. The Single Burning item test can be used an example of the potential for problems in regulating modern engineered design in the EU.

1 SAFETY AND COMPLIANCE WITH REGULATIONS

From the time of the RMS TITANIC it has been known that reliance on inadequate regulations to control innovation can produce a disaster, but no systematic response has been generated analyzing the relationship among designers, test developers and regulators. Fire safety is a multi dimensional problem, but most test based regulations are simplistic and uni-dimensional. A key problem may be a lack of understanding of the inherent complexity of fire safety regulation. Part of the problem can be language, since regulatory tests are often described as *performance* tests, but the relationship between performance in the test and performance in the real world is normally unspecified. As a result designers often simply focus on passing the test. Regulators who are not experienced in the nuance of fire safety can make the same error.

1.1 MT BLANC TUNNEL FIRE

The problem of test based fire safety regulation can be shown by a simple example such as the Mt Blanc tunnel fire. At Mt Blanc in 1999, 39 people were killed in a massive fire which originated in a truck carrying margarine and flour. Some investigators and public officials expressed surprise that margarine could cause such an intense fire. After all, the regulations treat such material as ***Low hazard.*** But the Mt Blanc tunnel disaster can be traced to a simple, common and deadly misunderstanding common to regulatory authorities. Both tunnel designers and regulators shared a lethal confusion on the issue of what might be called "*ignitability"* versus *flammability* of the relevant materials. For the purpose of this example and deliberately ignoring many additional complicating factors dealing with burning rate:

Ignitability refers to the 'ease of ignition'. This is the tendency of a specific object to ignite easily when exposed to a flame. Ignitability is closely related to the chemical makeup, thermal inertia and physical structure of the object. Objects vary widely in their ignitability and there exists no accurate common test method for determining ignitability across all types of objects. (Babrauskas, 2003). Ignitability is therefore in no sense an "inherent" characteristic of a material but is instead a product of the combination of a specific sample and a specific test method.

Flammability or more accurately, <u>the effective heat of combustion</u> or Caloric potential is the contribution of the material as fuel to a fully developed fire in terms of BTU/pound or kilojoules per kilogram. It is a product of the chemical composition of the material and is analyzed in various types of calorimeters. Ordinary cellulostic and hydrocarbon materials have a fairly narrow 2-1 range. For example, wood is 20,000 Kj/kg, coal is 30,000 and oil is 40,000. Caloric potential is much closer to an inherent characteristic, but of course does not automatically give the burning rate of the material or a measure of its hazard.

Wood shavings and solid wood have similar <u>***flammability***</u> but shavings are far more <u>***ignitable***</u>. In formal analysis these are separate ***"attributes" (Brannigan 2005).*** Which of these attributes (or any others) is important to fire safety in any given case depends on the environment in which the object is placed and the fire scenario and burning rate which can develop. The difference between *ignitability* and *flammability* is therefore critical to safety and the regulatory process; but typical 'performance standards' routinely do not indicate which characteristic they are using. Some tests are a poorly defined mixture of the two but the relationship is unstated in many regulations. Some regulations even seem to assume ***ignitability*** and ***flammability*** are correlated but as Mt Blanc showed margarine may not be easily ignited, but once burning it has the same flammability as any other hydrocarbon fuel of its chemical composition. The US hazardous material regulations for liquids focus almost entirely on *ignitability:*

> ..flash point was selected as the basis for classification of flammable and combustible liquids because it is directly related to a liquid's ability to generate vapor, i.e., its volatility. Since it is the vapor of the liquid, not the liquid itself, that burns, vapor generation becomes the primary factor in determining the fire hazard. The expression "low flash - high hazard" applies. Liquids having flash points below ambient storage temperatures generally display a rapid rate of flame spread over the surface of the liquid, since it is not necessary for the heat of the fire to expend its energy in heating the liquid to generate more vapor.(CFR]

The use of the term "*low flash-high hazard*" implies that *"high flash"* **is** *"low hazard*". This is exactly the assumption made by the tunnel regulations. Since liquids that don't meet the test based flash point requirements don't have to be treated as dangerous goods it is easy to see how the margarine in the Mt Blanc Tunnel fire could escape regulation. While ignitability may be a relevant attribute, it is not the only one. At Mt Blanc the effective heat of combustion was equally or more important. To a fully involved fire, kerosene and olive oil are very similar. Even after the Mt Blanc fire, experts and regulators were still trying to deal with this problem.:

> *The caloric potential of trucks can vary widely, according to their cargos. Therefore, some cargos, not classified as hazardous in the strict sense of the rules, generate when burning caloric potentials close to those of inflammable liquids (classified as hazardous cargo). This is especially the case with … The caloric potential… To about 900 GJ (all margarine cargo) (Task Force, 1999).*

Given that a gasoline tanker is 1000 GJ, a margarine truck of 900 GJ represents a massive hazard - although one that was not captured by the test based regulations. The designers were just as blind to the fire hazard. For example, one of the proposals from the expert group on tunnel fires is:

> *To study the possibility of classification as dangerous goods of certain liquids or easily liquefied substances with calorific values comparable to that of hydrocarbons (Expert Group, 2001).*

One might easily ask why anyone ever overlooked this key issue, and how many other technical standards show the same confusion as to which attributes are necessary to an analysis of the fire safety problem.

The Mt Blanc fire and similar major disasters raise at least three key issues that affect the development and use of test based regulatory systems.

1.2 *CONFUSING "CAUSE OF THE IGNITION" WITH THE "CAUSE OF THE DISASTER"*

A major public problem with fire safety standards is confusion between the ***cause*** of the fire and the ***cause*** of the fire ***disaster***. For legal, political, financial, and public relations reasons the source of the "ignition" is often pinpointed as the ***cause*** of the disaster. As above, this can lead to a focus on ignitability in safety regulation. But from a fire safety design perspective the ignition is rarely the *cause* of the overall disaster. Ignition is simply the initiating event. The disaster occurs because the event cannot be controlled. As one example, whatever caused the ignition of the HINDENBURG, it remains that the disaster occurred because of the inability to control fire in the mass of hydrogen gas.

Most disasters show a very complex interaction among a number of objects, systems and individuals . Sophisticated analysis of disasters shows just how complex the chain of causation can be in a specific accident. But regulators face an even more complex task since they have to analyze and interrupt these chains of causation before they occur and across the entire spectrum of scenarios. Regulating an effective response to a variety of ignitions is often difficult and expensive. In practice it has often been much easier to assume that the ignition will not occur, or if it does occur it is someone else's responsibility, or that the ignition will be small, located in the most favorable place or that the fire will always grow slowly despite the unknown characteristics of the available fuel. After a disaster, blaming the ignition source for the ultimate catastrophe is normally an attempt to divert attention from the failure to plan effectively for a spreading fire. As a rule, preventing ignition in uncontrolled environments is normally impossible, so fire safety systems have to be robust enough to absorb an ignition without catastrophe. Fire safety regulation has to be built on the concept to containing the possible ignitions before a disaster ensues.

1.3 *DISAGGREGATED REGULATION OF COMPLEX INTEGRATED PROBLEMS*

The recent draft WTC 7 report highlights a common problem. The regulatory system for buildings only subjects relatively small components to the tests. The approvals for the individual components are then aggregated together to make claims about the entire structure that have not necessarily been shown to be accurately predicted by the test. The tests themselves are also inadequate so that combining the results together and aggregating them for the building is a very dubious proposition:

> The ASTM E119 test does not capture critical behavior of structural systems, e.g. the effect of thermal expansion or sagging of floor beams or girders connections and/or columns. The thermal expansion of the WTC 7 floor beams that initiated the probable collapse sequence occurred at temperatures below approximately 400 degrees C. Thus to the extent that thermal expansion rather than loss of structural strength, precipitates and unsafe condition, thermal expansion effects need to be evaluated. The current fire resistance rating system, which does not include Thermal expansion effects, is not conservative 4.5.3 (NIST WTC REPORT 2008)

The reports specifically notes to failure to consider system effects:

> Current practice for the fire resistance design of structures, based on the use of ASTM E119 standard test method, is deficient since the method was not designed to include key fire effects that are critical to structural safety. Specifically current practice does not capture (a) important thermally induced interactions between structural subsystems, elements and connections-especially restraint conditions; (b) System level interactions, especially those due to thermal expansion since columns, girders, and floor subassemblies are tested separately; (c) the performance of connections under both gravity and thermal effects (d) scale effects in buildings with long span floor systems (NIST)

Perhaps tellingly the report adds:

> The United States does not currently have the capability for studying and testing these important fire induced phenomena critical to structural safety. 5.1.2

The result is predictable

> The Current height and area tables in Building codes do not provide the technical basis for the progressively increasing risk to an occupant on the upper floors of tall buildings that are much greater than 20 stories in height (Nist p60 fn 7)

The bottom line is that the regulatory test used for fundamental fire safety in the USA simply cannot do the job assigned to it. More importantly, the designers and builders may not “know what they don’t know”.

1.4 THE TITANIC DEFENSE and COMFORTABLE ASSUMPTIONS

After every major disaster the responsible parties normally proclaim the *TITANIC* defense of "***We complied with all government regulations".*** While some of these responsible parties may be charlatans who knew all along that the regulations were inadequate for the hazard, others may be genuinely surprised when regulatory compliance does not generate safety. Such persons make the *comfortable assumption* that legal compliance is sufficient for technical safety. Many are astonished to find out that fire code compliance is normally not designed to protect the building or its contents. Comfortable assumptions are routine in areas where safety precautions are not directly related to the primary objective of the designer. In such cases errors may not be self correcting in the design process, especially if the ***TITANIC*** defense can be used in litigation.

Fire safety can often be analogized to a bicycle lock. To bicycle designers, locks are distinctly secondary to performance. Locks do not help the designer satisfy primary customer requirements Locks do not make bicycles faster, lighter or easier to use. Bicycle locks simply make sure the bicycle will be there the next day. The cost and inconvenience of designing and using a bicycle lock would therefore generally be viewed as a negative by those designing bicycle systems. If possible it would be handed off to someone with implicit or explicit instructions to minimize the expenditure on systems which do not satisfy primary requirements. In such a case a designer who minimizes the bicycle lock problem may have a competitive advantage.

As a result any process that encourages a designer to minimize the time, cost and attention paid to fire safety requirements will tend to be favored by architects and builders. In many cases "Comfortable assumptions" minimize the effort of the designer or the expense of the fire safety precautions. "Comfortable assumptions" are extremely popular both with designers and with those who pay the costs, and are therefore unlikely to be challenged by overall project management. For example the UN "Tunnel Expert's" analysis of tunnel fires contains the following language **:**

> After consultation at the European level, it is proposed that a fire power of 30 megawatts should be taken as the basis for dimensioning the ventilation system in tunnels……..A fire power of 30 megawatts (heavy goods vehicle fire with a not very combustible load) has been set for the dimensioning of ventilation in case of fire.

The report indicates that 30 MW is the smallest possible fire size for a single loaded heavy goods vehicle. The margarine truck in Mt Blanc was several times this fire power, and fires can involve other trucks. "Complying with the code" rather than performing a separate safety analysis represents one approach criticized in the WTC 7 report.

Many fire safety test methods produce fairly simplistic output measures that encourage comfortable assumptions. In many cases once an acceptable test score is reached the designer can "check off" that box and move on to the next problem. Many designers also "Push the envelope" by making the "comfortable assumption" that as long as each component of a system is "acceptable" it does not matter whether the material "barely passed" a relevant test or was clearly above the minimum standard, or how many such components are combined into a system. Pass/fail tests and similar standards tend to encourage design at the edge of the envelope, where performance is tweaked to ensure a result acceptable to the regulator.

2 PROBLEM OF REGULATING INNOVATION

The three problem areas noted above, misunderstanding the cause of disaster , disaggregated regulation and comfortable assumptions occur in many areas of fire safety. However when dealing with innovation the problem becomes even more complicated

Regulation tends to work most effectively in areas that are technologically stable. Regulators build up experience and understand the problems with a regulation. But whenever innovation is occurring in an industry there is enormous potential for disaster if designers or regulators do not classify and specify the problem in sufficient detail to make sure the regulatory system can function despite the innovation. Take for example the issue of *bicycles* being allowed on highways. The regulators may have a specific concept of a bicycle.

Figure 1 bicycle in traffic

However while the regulators are writing rules defining the bicycle , the designers are busy developing a totally different concept of a bicycle.

Figure 2 Recumbent bicycle

The recumbent bicycle is a pedaled two wheel vehicle but just as clearly the recumbent bicycle represents an “innovation problem” The rider can no longer see and be seen in traffic. Even if it meets a technical definition of a bicycle it no longer represents the same safety hazard.

Innovation risk describes the ability to create a product that meets the technical requirement of a regulation but represents a novel hazard. It is a risk in any type of performance testing. The problem is how to trap the risk of an innovation in a performance-test based regulatory program.

The normal answer is to have a regulator with adequate discretion and expertise examine each innovative product or situation to determine whether the regulatory test is adequate to describe the risk arising from the new product. But such an approach conflicts directly with the political philosophy of a performance based test for approving products in a single market. Innovation risk is a major limitation on the development and use of performance based tests. Gaps in the current system can be exploited and grow if proper attention is not paid to the overall regulatory system.

2.1 Single Burning item

The SBI is used to give a "rating" to "construction products" based on their "reaction to fire". In general under the Construction Products Directive products with the CE mark based on the SBI can be sold anywhere in Europe. In examining the documentation, the SBI appears to be designed to serve three potentially inconsistent public policies. The first is fire safety, the second is the European concept of the free movement of goods, and the third is innovation.

Once a product gets a rating in the SBI test, the product supposedly meets the declared requirements of fire safety. Several discontinuities are possible with this system. The first is determining whether individual "construction products" can ever be meaningfully given a "fire safety" rating. As noted above fire safety is a very complex matrix. How does the SBI "fit" in the fire safety matrix? Fire hazards and fire safety do not arise from standalone "products" , but from the combination of such products into assemblies and buildings and from the use of such buildings by the public. The hazard of the product does not exist separately from the context or end use for the product. The standard acknowledges the importance of end use by requiring the test to be conducted in its "end use application" But that requirement only applies to the construction of the specimen. The end use as a practical matter also includes the fuel load and many other factors.

For example the SBI test system uses a 30 kw burner. What if the end use is in an environment where the impinging fire is larger? Does the test "scale up" for larger fires? Suppose a material can be "engineered" so that it passed the SBI test but represents a substantial hazard if exposed to a 100 kw fire? What if the product is tested "covered" with another product on a claim that the covered state is the "end use"? Who polices that the material is always covered? Why should a single material get a rating if the rating is based on the test of an assembly?

Perhaps experts on the SBI understand its limitations. But regulatory tests are used by a variety of people, especially non expert who believe that problems are solved since they complied with all regulations.

2.2 DESIGNERS AND REGULATORS: WHO IS RESPONSIBLE FOR SAFETY?

The problem of testing for safety is compounded if the precise legal relationship between designers and regulators is not understood. Exactly who is responsible for safety? And what does that responsibility really mean? At one extreme the designer is given complete autonomy for design but the designer is held responsible for any failure. This "performance-based" approach dates to the Code of Hammurabi:

> If a builder has built a house for a man, and has not made his work sound, and the house he built has fallen, and caused the death of its owner, that builder shall be put to death.

At the other extreme the regulator not the designer has both the ultimate authority for approving a design and carries legal and financial responsibility for such a decision. Some public works fall in this category since the regulator is also the government. Many countries take a sort of middle ground where compliance with regulations is required but designers are still expected produce a socially "acceptable" design, and be responsible for failure despite compliance. This can be called the "dual track" approach which requires the designer to comply both with regulations and exercise some kind of "reasonable care'.

The worst case is where compliance with the standard fully satisfies the designer's legal responsibility but the inadequate standard produces socially unacceptable design. The result is a "black hole" where disasters can occur and yet no one accepts responsibility. Leading designers and regulators managed to combine to create the Kaprun ski train disaster, but at the end of the day no one actually felt responsible for the overall safety.

The key question is whether compliance with regulatory test methods and standards is actually enough to produce safety or is merely a method of complying with the code. This is a particular problem with innovation, since the test itself contains no indication of which materials can be usefully tested in the SBI. In a test based single market where regulators do not have adequate discretion designers must be held to a high enough standard that they will affirmatively analyze the fire safety of a problem and not merely rely on a test result. To do so they will need far better information than exist today on the process of creating and using regulatory tests.

3 CREATING AND USING REGULATORY TESTS

The key failure in the regulatory use of science and technology is often the failure to document the analysis and assumptions by regulators and designers in the process of creating a regulatory test. The Construction products directive states that the "fundamental requirement" is "Fire safety" and the single burning item test is described as the "reaction to fire" test. It is of course the "*reaction to a very small fire in a very specific test environment under highly specified circumstances".* Whether the performance of a material in such a test is relevant to any real world fire is a matter to be demonstrated, not assumed. But the SBI nowhere sets out the structure of the assumptions underlying the regulatory use of the test. This makes it difficult or impossible to measure the innovation risk .

3.1 Four step model of test development and use

The process used for actually creating and using regulatory tests is not well understood. Brannigan and Buc 2005 proposed a three step process derived from work by Bijker. This paper extends that work to a fourth step. It is not suggested that these steps are routinely followed in a logical progression or sequence. The process may go forward and backward or iterate. However each step is critical to understanding the limitations of regulatory tests.

3.1.1 Defining the "technological frame"

The first step is defining the ***technological frame*** for regulation. The technological frame describes the problem that people think they are dealing with in creating a regulation e.g. High rise building fires conjures up a "technological frame". "Technological frame" was developed by Bijker (1995) to describe sets of beliefs about technology in its functional environment. There will normally be multiple technological frames depending on the viewpoint of the innovator, the regulator and affected parties.

Fire has been part of the technological frame of buildings since the beginning of recorded history. However the public beliefs about fire in buildings are colored by a wide variety of experiences, not limited to real world fires but also including movies and other fictions. Different cultures also have different patters of interacting with buildings . The frame includes this question of technical culture and also includes self imposed limitations of vision. Sometimes people exclude key areas from the frame arbitrarily. Leslie Robertson, chief design engineer of the World Trade Center is quoted as saying " *I don't know if we considered the fire damage that [an airplane crash] would cause. Anyway, the architect, not the engineer, is the one who specifies the fire system.*"

The scope of the technological frame is critical. Arson and terrorism for example were not routinely part of the technological frame for high rise buildings prior to 9/11. Because frames are described in natural language by individuals of varying backgrounds they are always difficult to define in a rigorous way. One recurring problem is the attribution of expert status in defining the frame to those who make the objects. However as the TITANIC and many other disaster show, expertise in making an object may have nothing to do with expertise in its risks.

3.1.2 Creating the "Technological Model"

Technical regulation almost always requires the creation of some form of model. Technological models used in the regulatory process rarely have the testability or rigorous analysis found in mathematical models or simulations, but they can still be described as models. The model is a derivation of the technological frame. (Brannigan and Beier 2005) As used here, a regulatory "technological model" is a derivation based on one or more technological frames that defines the specific scientific and engineering data, principles and assumptions thought to be relevant to controlling the technology. As with mathematical models and simulations, regulatory model building is a process in abstraction and simplification where complex problems are reduced to a more tractable form. Eventually certain characteristics are included in the model and others are not. The concentration on *ignitability* rather than *flammability* for the definition of dangerous goods is an example of a model. The technological model of the SBI, such as it has been documented, is essentially based the room corner test as a reasonably full size mock up of the real world. It is therefore a "model of a model"

Including or excluding a characteristic in a technological model for regulation is often a process of concurrence by interested parties rather than rigorous analysis. Since the models are rarely published or preserved, it is often difficult to analyze the thought process or possible errors in the process. Public participation in the model building process may be very limited, which can speed up the process but always runs the risk that key parts of the frame will be ignored.

The routine output of the model building process is an agreement on the use of a relatively small set of variables that are thought to be relevant to the policy issue in the technological frame. These variables may be defined individually or as a set with unknown interactions among the variables In some cases the ready availability of a test method for the variable leads it to be included in the model.

3.1.3 Developing the Test Method

The variables identified in the model building process are then further refined to create the regulatory test itself . In some cases the test can pre-exist the model and the key activity is selecting the test. A regulatory test methodology is applied to a test sample and produces an output that defines the sample in terms of the regulatory requirement. At this stage of development regulatory or "forensic" concerns begin to dominate the process of test development. Regulatory tests often give clear cut discrete outputs even if the underlying reality is a continuum. This process can be called *bright lining* and can contribute to a false sense of security. The real difference between a bare pass and a clear pass may not be captured in the test. Reproducibility in the lab may also come to dominate predictability in the real environment, so the role of real world variables may be eliminated to get consistent results on the test. The SBI test was abstracted from the room corner test and emulation of the room corner test was the critical goal *at the specified size of the burner*. But what if the real impinging fire is larger ? Proving that the test method actually predicts performance is a very complex task.

3.1.3.1 Validation and Verification of Regulatory Tests

Validation and verification are terms routinely used in software regulation and can also be used to describe the process of demonstrating the suitability fire safety regulatory tests.

Verification means that the test actually properly classifies the variable it is assumed to test. Verification is a necessary but not sufficient condition for a test.

Validation establishes that the variables being tested are actually relevant to the safety hazard.

Validation is by far the more difficult task and must be conducted continuously over the lifetime of the test or standard.

The recent scandal with melamine in milk in China easily shows the problem of verification and validation. The protein level in milk is not measured directly, instead the variable "nitrogen" is measured. Melamine is added to fool the regulatory test by releasing nitrogen. You can easily ***verify*** that the regulatory test measures nitrogen, but the measurement is not ***valid*** in predicting protein. In this case melamine would be considered an innovation. A bad one , to be sure, but still an innovation. The performance test was fooled by the innovation.

3.1.4 Reification of test results

Reification is defined as an abstraction being treated as if it is a "real" entity. (Gould 1981) In the specific case regulatory fire tests it is the inappropriate treatment of the output of a test as a description of the properties of the object in the real world. The ***Reification*** fallacy is believing the test scores describe an inherent ***attribute*** of the material and the test is simply a ***measure*** of that attribute, rather than the test score is a joint product of the test method and sample which may or may not reflect an actual ***attribute*** of the material.

Reification is the fallacy that if you get a consistent measurement, you must be measuring something independent of the test. But this cannot be assumed, it must be proved, generally by showing that independently constructed tests show similar results. Mass or caloric potential or specific gravity can be demonstrated in a wide variety of different tests. But what does the SBI test?

For example if the SBI is described as testing the *fire resistance* or *flame resistance or even reaction to fire* of a product or material the test result is being ***reified***. The statement assumes that such a attribute exists separate from the test and the test is just measuring it. For example an industry publication claims:

> "The fire resistance of construction products according to the new Euroclasses was assessed with a SBI (Single Burning Item) test. Finnish Thermowood Association Handbook"

This is clearly a reification error. SBI results, if anything are simply the reaction of a small sample to a specific test fire scenario. They are properly described as a ***classification*** not a measurement i.e. ***a harmonised system for classifying the reaction to fire performance of construction products.*** No broader claim is made in the documentation.

> *The Single Burning Item is a method of test for determining the reaction to fire behaviour of building products (excluding floorings) when exposed to the thermal attack by a single burning item (a sand-box burner supplied with propane). See website*
> *http://ec.europa.eu/enterprise/construction/internal/essreq/fire/frg/sbianounc.htm*

The SBI classifies, it does not "measure". It is a regulatory result which cannot, without further analysis, be used in an engineering or technical analysis, or to claim that a product is safe or a combination of such products will produce safety. The problem of reification of test results is compounded if the score is reported as a natural language word such as "low hazard" or other descriptive terms. It is simply a test result in a specific test.

Reification can lead to disaster. As Mt Blanc shows, if margarine was rated as below a threshold and kerosene above the threshold in a flashpoint test, reification is the error of assuming that in all fire environments margarine is "safe" and kerosene is "dangerous". Reification is also the error in the shift from saying a material "gets a "non flammable" rating in a specific test" to "it's a non flammable material" and therefore it's "safe."

Any such generalization is simply not a logical assumption. Even in reliable tests, scores have a very complex relationship to the material being tested and the environment being considered. In fire tests nothing can be assumed about the outcome of a test unless the test developer has demonstrated what the outcome of the test "means" in the specific context the following. As one example ASTM requires the following caveat in all fire test Standards:

> *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.* ASTM

The practical hazard of reification in the real world is the blind reliance by non specialists on ratings obtained in a specific test designed for a specific purpose. Reification can cause a disaster in a regulatory environment where designers merely rely on test results rather than having those test results evaluated by people with both expertise and discretion to control the inappropriate use of the test. As the WTC 7 Report states:

Current practice also does not require design professionals to possess the qualifications necessary to ensure adequate passive fire resistance of the structural system. In current practice Architects rely on catalogued ASTM E119 test data to specify the required passive fire protections that is needed for the structure to comply with the building code. They are not required explicitly evaluate the fire performance of the structure as a system.

Unless the regulatory system clearly imposes the responsibility for the structure on the design professional to exercise proper discretion, reification of the test results so that "passing the test" is considered "safe to use anywhere" is almost inevitable. This is the real downside to a test based regulatory environment. The trade-off for the single market is that designers and operators must accept and understand that there may be no connection whatever between regulatory approval and safety.

3.2 POTENTIAL PROBLEMS

Several other types of problems can be found in the use of regulatory tests other than those noted above.

3.2.1 Errors from language

Natural language is an inherent problem in test development. Often parties may use common language but not have a common concept behind the language. A "rare risk" to a physician might be several orders of magnitude higher than a rare risk to an environmental engineer. Compromises of language in "consensus committees" can lead to later disputes over the meaning of a term such as *end use* in the SBI. Since the technological models are neither rigorously defined or routinely published the probability for error increases.

3.2.2 Losing track of the frame or model

The most common problem is simply that the frame and model are simply forgotten after the test method is created. The SBI for example contains little documentation of the rationale for the choice of burner size that would allow a regulator or designer to determine if results on the SBI are relevant to a variety of environments. In particular, what is the relevance to an exposure fire?

3.2.3 Inappropriate Treatment of Innovation

There is no technical reason whatever to assume that any performance test is valid for material that was not part of the technological frame and model that supports a test. The SBI has a curious and technically unsupportable presumption in favor of the validity of the test whether or not the innovation was part of the frame. Any party suggesting that the SBI is an inappropriate test bears the burden of proof.

> "The inappropriateness of an existing reference scenario has to be demonstrated and an alternative proposed. The fire hazard condition and its relevance shall also be indicated, together with a suitable large scale test that can be shown to be representative of the proposed new hazard scenario." (SBI Guidance)

This presumption of validity however politically appealing, is inappropriate in the regulatory analysis. While suitable for a material which fails the SBI and is asserted to be safe it is unjustifiable for a material passes the test despite the fact that it was not part of the Frame and model for the test.

4 CONCLUSIONS

4.1 There is a fundamental inconsistency in using performance tests on innovative products without interposing an adequate regulatory presence to determine whether the test gives meaningful answers with regards to the innovative product.

4.2 Performance tests can only be used to "score" materials in the specified test. Unless fire tests are validated for broader use they cannot be used to ascribe inherent attributes to materials or objects.

4.3 If a test is proposed as a measurement it must relate to some inherent property or variable whose existence can be demonstrated in other methods than the test at issue. Technical precision in describing that variable is critical,.

4.4 Validation and Verification of fire tests are separate activities For verification the test has to be demonstrated to be a robust means of measuring the variable. Repeatability of a test is a necessary but insufficient criteria for use in regulation. Validation requires demonstration of the accuracy of the variable in addressing the real world problem it is designed to solve.

4.5 Public safety in the single market requires designers and operators to take on and be fully responsible for the safe design of their buildings. They can not pretend that compliance with the CPD will automatically produce safe buildings.

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