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Fire safety regulation: Prescription, performance, and professionalism

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ABSTRACT

Fire safety regulation is changing as adherence to prescriptive requirements is being replaced or complemented by an approach based on performance based design (PBD). However, this shift in regulatory practice raises important issues concerning the ability of regulators to provide competent oversight of fire safety engineering. This stems from the inevitable 'expertise asymmetry' that exists between regulators and those who are regulated, and means that regulators must rely on, and trust, data and analysis that is produced by industry. This dilemma could logically be resolved if fire safety engineering was accorded the status of a self-regulating profession whose competence and ethics were trusted by regulators. However, there are two main barriers to this: doubts about whether fire safety engineering is yet sufficiently mature as a profession; and concerns about whether the probabilistic nature of fire risks make fire safety engineering unsuitable for self-regulation.

1. Introduction

Regulation has long been a feature of fire safety engineering, and one that is widely acknowledged to have greatly reduced fire casualties during the twentieth century. Initially implementation of this regulation was driven by major fires with common-sense interpretation of the factors involved leading to prescriptive requirements for new buildings. For example, following the Great Fire of London of 1666 regulations were introduced affecting the width of roads, the use of materials (brick or stone, not wood), the width of party walls, etc. [1]. This type of prescriptive regulation was augmented during the mid twentieth century by knowledge gained from standard testing, particularly as regards the fire resistance of materials and building elements. The main US standard furnace test, ASTM (American Society for Testing and Materials) E119, introduced in 1918, and the similar British Standard 476 test standards first promulgated in 1932, specify time-temperature curves according to which structural elements such as beams and columns are exposed under defined conditions in a furnace [2]. These standardised tests provided a mechanism by which crude measures of fire resistance, such as party walls needing to be two bricks thick (as set out in the regulations that resulted from the Great Fire of London), could be quantified into more comparable measures such as, say, 60 min fire resistance. Prescriptive regulation thus became underpinned by exhaustive schedules listing the required fire resistance of building elements [3].

It was always recognised that such standard testing provided comparability rather than an accurate representation of real fires, and post-war research (for example, at the Fire Research Station in the UK) sought better understanding of the fundamentals of fire and smoke phenomena and of the structural responses of buildings. This better understanding made it possible to argue that fire safety knowledge was sufficiently advanced for bespoke engineering solutions to present a viable alternative to prescriptive regulation. Moreover, practical application of this knowledge in modelling tools became attractive with the greater computer power that became readily available in the late twentieth century. Rather than any particular type of building being required to incorporate the prescriptive 'one-size-fits-all' fire safety features, buildings could then have fire safety solutions designed individually through a Performance Based Design (PBD) approach [4]. Such PBD fire safety engineering was seen as desirable because it could enable the use of innovative building designs and materials, allow the use of constrained or usually shaped sites that would otherwise be inhibited if strict compliance with prescriptive rules was required, enable fire risks to be addressed rationally, and in some cases be less costly than prescriptive solutions that for many buildings include large margins of safety.

However, this shift to PBD fire engineering has raised concerns about the regulation of fire safety solutions. In a PBD approach, who decides (and on what basis) what constitutes a sufficient level of fire safety [5]? Does the use of PBD mean that acceptable levels of safety become a matter for engineers' design choices rather than being societally mandated in regulatory requirements [6]? More specifically, if fire safety solutions are implemented and justified through the use of state-of-the-art knowledge and

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modelling tools, can regulators have sufficient expertise to understand what they are being asked to approve?

This paper addresses these concerns through comparison with regulatory practices in other industries (aviation and pharmaceuticals). The key challenge for regulation of complex technologies lies in the 'expertise asymmetry' between regulators and those that are regulated. Unless regulators are heavily funded to enable them to maintain high levels of technical competence this expertise asymmetry inevitably means that regulators must rely on data and analysis provided by those they are regulating. This means in practice that many industries in effect self-regulate to some extent, and raises the question of whether such a practice should be formalised for fire safety. One mechanism for doing this would be through the acceptance by regulators that professional accreditation of fire engineers provides sufficient assurance of effective fire safety solutions, and the potential for such an approach is considered through a comparison with regulation of structural engineering.

2. Regulation of technology

Advances in technology can produce many benefits, but typically there are negative consequences too, and the classic societal response has been to attempt to maximise the benefits while mitigating any harmful consequences through regulation. Regulatory effectiveness depends on there being sufficient understanding of how these impacts occur and how regulations would ameliorate harmful consequences while sustaining technology's benefits. Regulators thus need to know about the performance of technology. To what extent does a drug cause side-effects relative to its benefits [7]? Are planes safe enough to carry passengers [8]? Do genetically modified crops risk contamination of natural species [9]? Or, are building sufficiently safe as regards fire risks?

However, the extent to which regulators need to understand the performance of technology varies according to the type of regulation. Three approaches are typically used, with regulation focused on: (1) achieving certain measurable outcomes (e.g. a level of pollution in industrial effluent); (2) policing the use of prescribed techniques (e.g. the use of 'best available technology' for a particular industrial process); or (3) being able to assess prospective performance as satisfactory (e.g. will an aircraft design be reliable enough that each safety critical system will suffer no more than one failure in every billion hours of flight). The first of these regulatory approaches measures actual outcomes retrospectively and does not require the regulator to have in-depth knowledge of the processes being regulated. However, such an approach requires some tolerance of unsatisfactory outcomes. Whereas it may provide a suitable approach for regulation of effluent from paper mills or breweries (most of whose discharges are only harmful to ecosystems in excessive concentrations), such an approach has not been seen as suitable for the regulation of airliner reliability, drug safety, or indeed fire safety. Although individuals or organisations that are held responsible for fire casualties or damage can be prosecuted, fire safety regulation has not been predicated on retrospective measurement of fire outcomes.

Instead fire safety regulation has traditionally sought to attain satisfactory outcomes through prescriptive regulation that requires the use of specific approaches for any given type of building. Prescriptive fire safety regulations thus specify required building characteristics such as the fire resistance of structures (as rated in furnace tests), enclosed stairways of particular sizes, maximum travel distances to stairs, whether sprinklers should be used, and so on. Effective though these prescriptive regulations appear to have been, they have come to be seen as increasingly onerous and often irrational. In particular, because the prescriptive approach specifies particular solutions it can limit innovation in architectural design and use of new materials, and present insuperable barriers to developments in constrained sites. For example, Norman Foster's innovative design of Stansted airport envisaged a large, high-ceilinged space that would not have been allowed by the traditional prescriptive approach, instead requiring first principles fire safety engineering to convince regulators that the building was safe (see below).

In recent decades this prescriptive approach to fire safety regulation has been supplanted or complemented by a regulatory approach based on assessment of prospective performance in what is widely known as Performance Based Design (PBD). The introduction of PBD as a regulatory option addresses the dissatisfaction with the 'one-size-fits-all' approach of prescriptive regulation, and has been made possible by the belief that fundamental fire safety knowledge has progressed sufficiently to enable bespoke fire engineering solutions to be designed and assessed.

An important advantage of regulation focussed on prospective performance is that it facilitates innovation. Rather than strict prescriptive rules that have to be followed, the regulatory requirements are expressed in terms of overall performance. For example, in aviation regulation the Federal Aviation Administration (FAA) makes it clear that its regulatory approach seeks to ensure aircraft reliability without specifying particular technological approaches: 'As much as possible, regulations do not constrain designers a priori by specifying details such as material properties or the design of individual structures. Instead, designers are given a free hand to incorporate new materials, structural concepts, etc., so long as they accept the responsibility for showing that systems with innovative design features meet the FAA's stringent reliability requirements' [10].

However, the challenge of this type of regulation is for the regulator to have sufficient competence to understand the proposed approaches sufficiently well to provide the desired oversight. While technologies are generally getting more complex, and reliant on more specialised knowledge, there is a contrasting reduction in the willingness of many governments to pay for regulatory oversight. There is thus an 'expertise asymmetry' in which regulators will inevitably have less understanding of the technology than those whose work is being regulated. Given the trend towards deregulation (certainly in the USA and UK), there seems little prospect that regulatory authorities will have their funding increased in order to reduce this expertise asymmetry. In the UK fire deaths have fallen significantly in recent year, making it impossible to argue in the face of competing demands on resources that government should spend more on fire safety regulation [11].

Of course, it is likely that some fire disasters may still occur even with the very best regulation of prospective performance. The extent to which fire risks can be eliminated through the appropriate use of such knowledge may depend on the nature of the technology. Where technologies involve complex, tightly-coupled systems such as nuclear power stations, Perrow argues that 'normal accidents' are inevitable (though rare) [12]. Perrow's argument is that minor variations in technological performance and practice will occasionally align in a sequence of events leading to disaster because, as summarised by Downer, 'trivial but irrepressible irregularities – the background static of normal technological practice-when taken together have inherent catastrophic potential' [13].

It is an intriguing question (beyond the scope of this paper) as to how many fires can be seen as 'normal accidents', and whether the move to PBD makes such systemic failure more likely. Advocates of PBD would argue that first principles fire safety engineering enables elegant solutions that can reduce complexity. However, in practice many applications of PBD appear to be 'sticking plaster' solutions applied to achieve regulatory