Proposed Guidelines for the Fire And Panic Safety Performance Standard for Event and Exhibition Venues within the Framework of *Industrie 4.0*

André Luiz Gonçalves Scabbia & José Félix Drigo

Instituto de Pesquisas Tecnológicas de São Paulo

ABSTRACT

This article has sought to propose a new model that, once applied to events and exhibition venues, would create conditions for updating Fire and Panic Safety against the evolutionary process known as the Fourth Industrial Revolution, or Industrie 4.0. The evolution of standards addressed by this paper refers to including performance concepts to existing prescriptive standards. Industrie 4.0 presents new tools that have improved performance across public and private administration by reducing operating risks and favoring users of buildings, supervising technical professionals and Fire Department professionals by improving management and inspection. The article shows the difficulties and benefits that have been motivating this global transition in which users are put in the foreground. The paper was focused on buildings designed for public gatherings: sports and exhibition venues. In the course of the study, an interview is held with professionals engaged in the area, stressing the actions they would recommend for resolving or minimizing the safety issues posed to them, thus providing a basis on which to prepare guidelines. At the end, the importance of applying those concepts to Fire and Panic Safety is demonstrated, creating a model that leads to the development of current process that begin at the drafting of designs and extends to obtaining and maintaining the Final Inspection Record from the Fire Department.

Kyewords: fire safety; automation; technical standards; performance; job training; accreditation; maintenance; fire safety systems.

Classification: FOR Code: 290502

Language: English

London Journals Press

LJP Copyright ID: 392821
Print ISSN: 2631-8474
Online ISSN: 2631-8482

London Journal of Engineering Research

Volume 20 | Issue 1 | Compilation 1.0

Proposed Guidelines for the Fire and Panic Safety Performance Standard for Event and Exhibition Venues within the Framework of *Industrie 4.0*

André Luiz Gonçalves Scabbia[α] & José Félix Drigo[σ]

SUMMARY

This article has sought to propose a new model that, once applied to events and exhibition venues, would create conditions for updating Fire and Panic Safety against the evolutionary process known as the Fourth Industrial Revolution, or Industrie 4.0. The evolution of standards addressed by this paper refers to including performance concepts to existing prescriptive standards. Industrie 4.0 presents new tools that have improved performance across public and private administration by reducing operating risks and favoring users of buildings, supervising technical professionals and Fire Department professionals by improving management and inspection. The article shows the difficulties and benefits that have been motivating this global transition in which users are put in the foreground. The paper was focused on buildings designed for public gatherings: sports and exhibition venues. In the course of the study, an interview is held with professionals engaged in the area, stressing the actions they would recommend for resolving or minimizing the safety issues posed to them, thus providing a basis on which to prepare guidelines. At the end, the importance of applying those concepts to Fire and Panic Safety is demonstrated, creating a model that leads to the development of current process that begin at the drafting of designs and extends to obtaining and maintaining the Final Inspection Record from the Fire Department.

Keywords: fire safety; automation; technical standards; performance; job training; accreditation; maintenance; fire safety systems.

*Author*α: Doctor's Degree in Mechanical Engineering from Universidade de São Paulo.
σ: Doctor's Degree in Public Security from Academia da Polícia Militar do Paraná.

I. INTRODUCTION

This article proposes a new procedure model for official agencies and users of the Fire and Panic Safety (SCI) system going from the drafting of designs to obtaining and maintaining a Fire Department Final Inspection Record (AVCB).

The proposed guidelines are underpinned by the contemporary technical concept known as "*Industrie 4.0*"[1], or the "Fourth Industrial Revolution", which is a recently proposed industry concept encompassing key technological innovations in the fields of automation, control and information technology that, once applied to production processes, tend to make them more efficient, autonomous and customizable.

Because every technical procedure or process imposes a regulatory model, it calls for a change comprising application and performance assessment in buildings seeking to enhance quality in both the design and construction of a building as regards Fire and Panic Safety. Accordingly, minimum reliability expectations are created in respect of technical services performed so that, at the end of construction, the building will meet such initial expectations while making better use of the economic resources applied.

[1] The term "*Industrie 4.0*" has not been translated in this article because it is a registered trademark in Germany.

London Journal of Engineering Research

Said expectations can be met with a consistent level of safety over the course of a certain period of time, thereby either eliminating or minimizing hazards, and culminating in controlling the risk to which building users are exposed. This can be said to be a win-win situation, making the gain a social one.

The Fire and Panic Safety of a building can be constantly assessed against predetermined criteria and seeking results that meet the expectations of all of those involved. The assessment procedure must be carried out using tests that result in data and enable the performance of equipment, systems and processes to be measured.

1.1 Objective

The objective of this paper is to propose the application of a Fire Safety performance standard based on the principles of *Industrie 4.0*.

1.2. Methodology

The paper focuses on bibliographic research, seeking information in books, laws, standards and research sites as part of the process of gathering information and interviewing SCI experts as an investigatory source and using the hypothetical-deductive reasoning method.

II. EVOLUTION OF FIRE SAFETY STANDARDS

Since the early times of the republic, two phenomena have impacted the construction of the Brazilian society: the first is the dramatic population growth resulting from migration to urban centers, with significant figures; and the second refers to the speed of that migration. The exodus from rural to urban areas was so intensive that everything that has been done to organize the cities that received that population was and still is deficient (SEITO, 2008).

By analyzing the domestic growth in technology led by the State of São Paulo, one will find that, as it advanced, numerous catastrophes took place as a result of fire, with the lack of Technical Standards being one of the factors leading to such events.

This is made apparent by the fact that SCI standards have oftentimes evolved following disasters.

The São Paulo Fire Department began to work on fire prevention in 1909, when Decree No. 1.714 was published in March 18, 1909 making the "Regulations for Public Amusement Venues" official. However, the responsibility for fire prevention and firefighting fall almost exclusively on the Fire Department, and the passive protection requirements were primary and only a few, although the importance of creating requirements for public gathering places was already understood.

The 1978 amendment to the Building Code of the Municipality of São Paulo was due to the occurrence of two major fires: in the Andraus building, on February 24, 1972, with 32 floors and 115 meters high, leaving 16 dead and 329 injured, and in the Joelma building, on February 1, 1974, which had 25 floors and was opened in 1971, with the fire resulting in 187 dead and more than 320 injured ("O Estado de São Paulo" newspaper issue of May 1, 2018).

On March 3, 1983, the São Paulo State Government published Decree No. 20.811 to regulate SCI specifications.

December 14, 1993 saw State Decree No. 38.069 come into effect, whereby the Fire Department kept the SCI measures required under the decree and separated technical specifications for design and installation, which started being provided by Technical Instructions (ITs), allowing them to be more easily updated.

On August 31, 2001 State Decree No. 46.076 took effect, together with 38 Technical Instructions covering a variety of significant issues in greater depth.

State Decree No. 56.819 came into force in 2011, and Decree No. 63.911 on December 10, 2018.

A preliminary review shows that a major change has taken place from the previous to the current legislation, with the chapter titled "SCI Measures", in article 21, being an embryo of the framework discussed in this paper. Said article provides for the requirement for certification of products for

all Fire Safety equipment and systems, but no timeframe within which such requirement would take effect.

With the 2013 publication of ABNT Technical Standard NBR 15775, which refers to performance in housing applications, the prescriptive requirements for setting performance criteria were changed, which is very significant. Performance concepts being set forth in an ABNT standard is thus a social fact and should therefore motivate changes to other standards.

The argument put forward advances the proposition of this article, aiming to implement Fire and Panic Safety standards that include performance concepts and is based on the technological innovation found in *Industrie 4.0*.

Figure 01 shows the relationship between social facts and the evolution of Fire Safety standards, and the impact that motivated this regulatory change stems from its relevance at the time of the incident, given the death toll and the number of people injured as a result of the catastrophes. It is noted that something should happen with the advent of the Performance standard.

Figure 01: Evolution of SCI standards in the State of São Paulo

III. PRESCRIPTIVE AND PERFORMANCE STANDARDS

Brazilian standards have been historically based on prescription, defined as "a set of requirements and criteria specified for a specific product or procedure based on time-proven usage" (CBID, 2013), and Brazil's regulatory evolution tends to keep pace with changes in other countries.

Generally speaking, a prescriptive standard will describe how to design and build, and in most cases will lead to standardized solutions to different design situations, waiving an overall review of the required safety level and of the interaction among the safety systems being used (CLARET & MATTEDI, 2011).

Performance standards, on the other hand, will more often address the qualitative aspect, asserting social needs and specifying the level of commitment to Fire Safety.

Therefore, the "use of terms like *adequate*, *appropriate* and *reasonable* afford flexibility to the designer and provide general guidelines for selecting the safety level to be adhered to" (CUSTER & MEACHAM, 1997; CLARET & MATTEDI, 2011).

The concept of performance applied to Technical Standards has been the subject matter of discussions since the 1960's, when it was originally introduced at the second congress of the Council International for Building (or CIB), which took place in 1962 (KERN; SILVA; KAZMIERCZAK, 2014).

In 2000, the Thematic Network PeBBu (Performance-Based Building) was created in the European Union (EU) to consolidate all previous papers on the issue (HUOVILA et al., 2005). Subsequently, a series of technical standardization directives where adopted. Chief among them are the Eurocodes developed by the European Committee for Standardization. It is a set of structural standards for building designs and civil engineering works from a structural and geotechnical viewpoint (CALDENTEY et al., 2008).

The application of performance concepts laid down in technical standards expands the creation opportunity for designers, whereas prescriptive standards limits them to the requirements to be met. Accordingly, it enables innovative solutions to arise from the architectural design to the fixtures and finally to procedures for using the systems (CUSTER & MEACHAM, 1997).

What changes with the application of performance concepts to standards is the behavior of components and systems in use in buildings, as the expectations of both designers and users over a period of time are identified and directions are given on how to meet them. However, the conceptual shift from a traditional design to performance-based design poses several problems, two of which, according to Claret & Mattedi (2011), are verifiable at first sight: adjusting the technical resources available to design professionals, and acculturation of those professionals faced with the new design philosophy.

The implementation of the concept of performance in SCI standards culminates in assigning greater depth to building requirements, as they are not limited to only requiring that a certain equipment item be installed. They go beyond that, setting performance expectations and functional goals, while proposing introduction of the acceptable safety levels expected by the State, in its capacity as a representative of society.

IV. THE FOURTH INDUSTRIAL REVOLUTION

Certain changes have occurred in Brazil since the first version of NBR 15.575 was issued in 2008, targeting housing buildings with up to five floors. Even though its requirements fell behind those of international standards, the domestic market proved unprepared to embrace them, creating the need for investment in the development of the manufacturing sector so that what the standard contemplated could be achieved.

That was the reason why its effective date was postponed, which was followed by the appointment of a new ABNT Technical Commission and the drafting of a new standard, which took effect in 2013 (MELLO, 2010). As a result, upon publication of the standard, all professionals involved in the process were trained to work in compliance with it.

"That involves change in today's design and construction practices: the practice of designing with a focus on performance must be incorporated since the design stage, as the concept of performance also involves durability and sustainability issues, which are currently growing concerns." (OLIVEIRA; MITIDIERI FILHO, 2011).

Many SCI risks can be either resolved or minimized in the design, and the key factors to be considered are:

a) Heat and smoke: preventing ignition.
b) Fire spread speed: fire barriers.
c) Incompatible exits: sizing and compartmentalization.
d) Unprepared people: basic and specific guidance.
e) Proper sizing and proper SCI equipment and system specification can generate mid and long-term savings by avoiding installation, maintenance and functionality problems.

Currently, there is evolution in sight in the digital world and in automation, and it must be incorporated into SCI, as the speed at which a large volume of data is analyzed for more accurate and more logical decision-making makes it indispensable in the field of safety. Furthermore, *Industrie 4.0* concepts are the most modern treaties on production processes that can be used in line with SCI.

In 2011, representatives of various industry segments in Germany agreed on principles designed to strengthen competitiveness in the manufacturing sector, and the *"Industrie 4.0"* concept began to take shape after that (KAGERMANN, LUKAS and WAHLSTER, 2011).

In that same year, Germany's Federal Government announced that the development of *Industrie 4.0* principles would become part of its "High-Tech Strategy by 2020 for Germany" project, with a view to achieving leadership in technological innovation for this period. Thereupon, the *"Industrie 4.0 Working Group"* was formed to develop visions and recommendation concerning the implementation of the *Industrie 4.0* concept (KAGERMANN, LUKAS and WAHLSTER, 2011).

According to Nascimento & Muniz Jr. (2018), in a nutshell, the concept that has been discussed can be said to have proposed to the industry, encompassing key technological innovations in the fields of automation, control and information technology applied to production processes and seeking to make these more and more efficient, autonomous and customizable according to the following principles:

a) Real-time operating capacity;
b) Virtualization;
c) Decentralizationof decision-making attainable through a cyber-physical system;
d) Focus on services, using software architectures to conduct services in line with the concept of Internet of Services (IoS);

e) Modularity of production according to the demand, providing flexibility for easily changing machine tasks; and
f) Interoperability, which refers to communication among all network participants (HERMANN, PENTEK and OTTO, 2015).

According to FOCCOERP (2018), this industrial revolution has been motivated by three major changes in the industrial manufacturing world, with such impacts as reduced costs, energy saving, increased safety, environmental conservation, reduced errors, elimination of waste, transparency in business, higher quality of life and customization to an unprecedented scale, namely:

a) Exponential rise in computer capacity;
b) A huge amount of digitized information; and
c) New innovation strategies (people, research and technology).

According to Griesinger (2016), by reviewing a survey conducted by Brazil's National Confederation of Industry (CNI), one learns that most of the Brazilian industry's efforts are concentrated on the manufacturing process stage as follows: 73 percent of the companies that said they use at least one digital technology do so at the process stage, 47 percent use digital tools at the supply chain development stage, and only 33 percent use them in new products and new business developments.

What is clear is that it is a growing process that is not going to stop, which motivates discussions as to how to incorporate SCI into the *Industrie 4.0* concept, which was initially conceived to make manufacturing more efficient, but later was also considered as a way of improving efficiency in safety.

This articles proposes a discussion on how to use this tool in SCI, using *Industrie 4.0* concepts with a view to imparting greater efficiency to the entire Fire and Panic Safety process in both design preparation and construction, in the operation of fire prevention and firefighting systems, in equipment and systems maintenance, and in equipment and systems operation monitoring and maintenance tasks, enabling the expected performance to be at acceptable levels throughout the service life of each piece.

A survey was conducted with SCI experts focusing on IT-12/2019, which refers to sports and exhibition venues—an important São Paulo Fire Department Technical Instruction because it is the one allowing greater involvement of people in risk areas.

In addition, historical facts demonstrate that malpractice, recklessness and negligence can cause large numbers of victims in events of fire in public gathering venues, the latest of which being the fire at the Kiss night club in Rio Grande do Sul, resulting in 241 dead and 123 injured.

V. GUIDELINES

The proposals under discussion focused on IT No. 12/2018 – Sports and Exhibition Venues – Fire and Panic Safety Requirements. Said IT applies to buildings that fit in the definitions of divisions F-3, on stadium, gymnasiums, rodeos, arenas and similar venues, and F-7, on temporary buildings for audiences, circuses, bleachers and similar structures, whether or not permanent, whether closed or open, whether indoor or outdoor, as per State Decree No. 63911/2018.

The proposed guidelines have been prepared with some freedom in terms of the timeframe for applying them, i.e. some may be applied immediately, but others may take some time to become viable.

The guidelines that are currently more viable have been incorporated into a proposed amendment to IT 12/2019, which is to be sent to the São Paulo Fire Department.

The aforementioned survey with SCI experts discussed the following topics of the standard: Emergency Plan; Evacuation Plan; Exit Time; Sufficient Outflow of people to an outdoor area; Public Sizing; Directions to the public on behavior in case of emergency; Responsible Person identified and present during the event; Event Documents; Access Control (capacity); and Safety.

The discussion of such topics is based on the "pillars" of *Industrie 4.0:* Internet of Things; Augmented Reality; Big Data; Intelligent Robots;

Cloud Information; Virtual Simulation; Additive Manufacturing; Horizontal and Vertical Systems Integration; and Cyber Security.

The results of the interviews were analyzed and condensed in search of the most feasible of them. For the drafting of the proposed amendment to IT-12, the results were considered as those with a possibility of immediate application or those which would require small investments from those responsible for the buildings.

VI. CONCLUSION

This paper was not concerned about addressing equipment and systems; rather, we have sought to propose process changes that globally involve Fire and Panic Safety. To that end, sports and exhibition venues were selected for the study because they are areas that bring together significant number of people, and, therefore, the results must be of great importance.

Technical standards have evolved rapidly, trying to keep up with the pace at which the world is transformed by technology, as a standard seeks to parameterize transformation by creating rules that apply to the production, sale and use of a manufactured product.

Performance standards are viewed as a regulatory evolution because they allow architects and engineers to work more freely in building and construction, making innovative processes and products more viable.

Accordingly, having a standard focused on performance helps professionals direct the use of new processes and products. SCI constantly experiences such technological changes, and it also requires looking for methods of adopting measures that will foster a better incorporation of innovation. This field has been making great strides because equipment and systems have been introduced in the marketplace featuring praiseworthy performance figures.

To be able to develop a line of reasoning for drafting proposed guidelines, we worked based on a concept that was in line with contemporary technological changes. It is thus observed that technology has been going through a substantial transformation process that has been dubbed the "fourth industrial revolution" and that speed in data collection, data transmission, problem analysis and diagnosing and introduction of solutions has defined the position of companies or even countries in the evolution ranking of their manufacturing.

The study was focused on Technical Instruction No. 12/2018 of the São Paulo State Fire Department, which refers to sports and exhibition venues and to Fire Safety requirements.

We sought to include in the working context the occurrence of catastrophic events in Brazil to demonstrate how the regulatory framework has evolved in the State of São Paulo. It is known that numerous States currently have the same regulations as São Paulo in place, and there are ongoing efforts towards unifying SCI standards nationwide. Therefore, it is our understanding at this time that addressing São Paulo standards means influencing a large portion of Brazil.

The end product of those efforts is presented in a proposed amendment to IT-12 prepared using performance concepts within the *Industrie 4.0* framework.

The proposed IT combines existing SCI principals with the *Industrie 4.0* dynamic, thereby facilitating the application of the standard to the technical community. The method proposed herein, which is focused on effective SCI application and management in buildings, favors significant improvements for all of those involved in the process.

Lastly, it is proposed that other standards be studied so that the evolution reflected in this paper can reach all Fire and Panic Safety areas.

REFERENCES

1. BABRAUSKAS, Vytenis. Performance-Based Building Codes: What will happen to the levels of safety?. 2000. Available at: https://www.researchgate.net/publication/237701289_PErformancebased_Building_Codes_What_Will_Happen_To_The_Levels_Of_Safety.Accessed on January 20, 2017.

2. Caldentey, Alejandro Pérez et al. España y los eurocódigos: La necesidad de converger. 2014. Available at: <https://www.resea-rchgate.net/publication/45157612_Espana_y_los_eurocodigos_la_necesidad_de_converger>.Accessed on January 10, 2018.
3. Câmara Brasileira Da Indústria Da Construção. Desempenho de edificações habitacionais: guia orientativo para atendimento à norma ABNT NBR 15575/2013. Fortaleza: Gadioli Cipolla Comunicação, 2013. 311 p.
4. CLARET, Antônio Maria; MATTEDI, Domênica Loss. Estudo da prescritividade das normas técnicas brasileiras de Segurança Contra Incêndio. 2011. Available at: <https://www.researchgate.net/publication/277125137>.Accessed on January 24, 2017.
5. CUSTER, Richard L.P.; MEACHAM, Brian J. Introduction to Performance-based fire Safety. Quincy: Society of Fire Protection Engineers, 1997. 260 p.
6. FOCCOERP. *Industrie 4.0*, 2018. Available at: https://www.foccoerp.com.br/wpcontent/uploads/.../ebook-industria-4.0-ok-1.pdf. Accessed on January 1, 2019.
7. GRIESINGER, D.. Pesquisa revela perfil da *Industrie 4.0* no Brasil. 2017. Available at: <http://agenciabrasil.ebc.com.br/pesquisa-e-inovacao/noticia/2016-05/pesquisa-revela perfilda-industria-40-no-brasil>. Accessed on October 30, 2018.
8. HERMANN, Mario; PENTEK, Tobias; OTTO, Boris. Design Principles for Industrie 4.0 Scenarios: A Literature Review. 2015. Availableat:<https://www.researchgate.net/publication/307864150_Design_Principles_for_Industrie_40_Scenarios_A_Literature_Review>. Accessed on December 6, 2018.
9. HOUVILA, Pekka et al. Performance Based Building. Helsinki: VTT- Technical Research Centre of Finland, and RIL- Association of Finnish Civil Engineers, 2005. 216 p.
10. Instituto Brasileiro De Geografia E Estatística. 2010 Census. Rio de Janeiro: IBGE, 2010. Available at: <https://censo2010. ibge.gov.br/resultados.html>.AccessedonFebruary 5, 2016
11. International Code Council - American National Standards Institute. Icc/Ansi - A117.1: Accessible and Usable Buildings and Facilities. 1st ed. Washington:International Code Council, Inc, 2009. 158 p.
12. Joelma E Andraus: Fogo E Tragédia Em São Paulo. São Paulo, May 1, 2018.Available at: <https://acervo.estadao.com.br/noticias/acervo,joelma-e-andraus-fogoetragedia-emsp, 70002290695,0.htm>. Accessedon January 11, 2018.
13. KAGERMANN, Henning; LUKAS, Wolf Dieter; WAHLSTER, Wolfgang. Industrie 4.0: Mit dem Internet Ding auf dem Weg zur 4.: Industriellen Revolution. Meinung Vdi Nachrichten, Berlin, No. 13, p.2-2, April 1, 2011. Monthly. Available at: <https://www.google.com.br/search?source=hp&ei=EL8DXffxGuWl5OUP25iPmAc&q=kagermann+lukas+%26+wahlster+2011&oq=KAGERMANN%2C+LUKAS+E+WAHLSTER%2C+2011&gs_l=psyab.1.0.0i22i30.1764.1764..8145...0.0..0.241.241.2-1.....0....2j1..gwswiz.....0.yku4iSDdCyY>. Accessed on December 8, 2018.
14. KERN, Andrea Parisi; SILVA, Adriana; KAZMIERCZAK, Claudio de Souza. O processo de implantação de normas de desempenho na construção: um comparativo entre a Espanha (CTE) e o Brasil (NBR 15575:2013). São Paulo: Gestão e Tecnologia de Projetos, v. 9, No.. 1. P. 89-101, January-June 2014. Availableat:http://www.revistas.usp.br/gestaodeprojetos/article/download/89989/pdf_11/. Accessed on January 18, 2018.
15. MARQUES, F. A corrida da *Industrie 4.0*. Availableat:<http://revistapesquisa.fapesp.br/2017/09/22/a-corrida-da-industria-4-0/>. Accessed on October 30, 2018.
16. MELLO, Michel. NBR 15575/2008 - Norma de Desempenho prorrogada. 2010. Available at: <https://www.cimentoitambe.com.br/nbr-155752008-norma-de-desempenhopror rogada/>.Accessed on October 19, 2017.
17. NASCIMENTO, Luis de Oliveira; MUNIZ JÚNIOR, Jorge. *Industrie 4.0*– Transformação eDesafios para o Cenário Brasileiro. Unespciência: Engenharia de Produção, Guaratinguetá, No. 93, p.1-5, February 1, 2018. Monthly. Available at: <http://www.unespciencia.com.br/revista/ UC093/

UC93_Industria.pdf>. Accessed on January 15, 2019.
18. OLIVEIRA, Luciana Alves; MITIDIERE FILHO, Claudio Vicente. O Projeto de edifícios habitacionais considerando a norma brasileira de desempenho: Análise aplicada para as vedações verticais. Gestão e Tecnologia de Projetos. São Paulo, p. 90-100. November 25,2011. Available at: <www.journals.usp.br/gestaodeprojetos/article/download/51022/55089>.Accessed on January 11, 2018.
19. SEITO, Alexandre Itiu et al. **A** Segurança Contra Incêndio e Pânico no Brasil. São Paulo: Editora Projeto, 2008. 484 p.
20. YORK, Rachael. Accessible and Usable Buildings and Facilities: Update from the 2009 to 2017, Edition & what you need to know. 2018. Available at:<https://s23.a2zinc.net/clients/acbm/DHI2018/Custom/Handout/Speaker0_Session9741_1.pdf>. Accessed on December 12, 2018.