

Performance-based Fire and Gas Systems Engineering Handbook

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Introduction

Fire and gas systems (FGSs) are a subset of instrumented safeguards – instrumented systems, such as safety instrumented systems (SISs) or burner management systems (BMSs), that detect hazardous conditions, provide early warning, and take appropriate mitigation actions to safeguard people and assets. Implementing FGSs in a process plant has been a challenging endeavor for many years. Process plants – which can include a wide variety of industries such as oil and gas, refining, petrochemical, power generation, specialty chemicals, and pharmaceuticals – often present a much wider array of hazards than are encountered in traditional building fire protection engineering. Process plant hazards include fires, combustible gas releases, and the possibility of acute toxic gas hazards. The plant environment is often outdoors, which adds complexity in making informed decisions about hazard detection and mitigation.

The more traditional method for FGS design is prescriptive standards. Prescriptive standards, such as those from the National Fire Protection Association (NFPA) and the European norms, define what type of equipment is required, where it must be installed, and how it must

be maintained and tested. The most widely-used prescriptive standards are the *National Fire Alarm Code NFPA 72* and *European Norm EN 54*. The Fire Alarm Code and associated standards are really designed to protect occupied buildings, such as office buildings, hospitals, and schools. They are not geared toward the specialized requirements of processing flammable and toxic materials. As a result, alternative methods are increasingly being used to improve FGS design. These performance-based methods, which utilize hazard and risk assessments to make informed decisions, allow for optimal FGS design in areas where the more traditional prescriptive standards are inadequate, inefficient, or don't exist for the design-basis hazards. The process industry requires additional guidance to address the gaps within prescriptive FGS standards.

All instrumented safeguards, including FGS, need a *basis of safety*, which is the underlying technical justification used to make decisions about the design of the equipment that will promote safe operations. A systematic process should be used to choose the right basis of safety for FGS design, and the selection should be done in a manner that is transparent, well-understood, and well-documented. Code compliance has historically provided adequate technical justification for a safe design, but prescriptive codes for fire detection are not well-suited to process plants. The problem requires a flexible approach that establishes how the system should perform before a design is chosen. Performance-based design starts with defining process hazards and measuring the magnitude of each risk; only then will you be able to select an FGS design that will provide adequate performance.

In this performance-based FGS design process, the type and number of detectors are determined, the correct technology is selected, and the detectors are placed in proper locations; all design choices are in line with the underlying basis of safety. In addition, the basis of safety should specify the requirements for testing and maintaining FGS equipment to achieve good mechanical integrity. Mechanical integrity requirements include the type of preventive maintenance tasks that

will need to be performed on the equipment and the frequency at which those tasks are to be performed.

Performance-based standards for the design of fire and gas detection equipment are rapidly being adopted as the preferred solution to bridge these gaps. Performance-based design principles have already been used successfully in safety instrumented system (SIS) design through the IEC 61511 and ANSI/ISA-84.00.01 standards. There has been widespread acceptance of these standards and successful implementation for safety instrumentation in general. As a result, numerous operating and engineering companies strongly desire to use the performance-based concepts and techniques in these standards to design their emergency shutdown system, the traditional SIS, as well as their fire and gas detection systems. The International Society for Automation (ISA) developed a working group under the ISA84 Standards Panel specifically to address performance-based FGS design. Working Group 7 created ISA technical report ISA-TR84.00.07, *Guidance on the Evaluation of Fire, Combustible Gas, and Toxic Gas System Effectiveness*. ISA published the report in 2010 to provide guidance on how fire and gas systems can be designed in accordance with the principles of IEC 61511; however, nothing in the report mandates the use of IEC 61511 for FGS design. Application of the technical report ISA-TR84.00.07 is at the discretion of the user.

In general, the IEC 61511 standard specifies that performance targets for each safety instrumented function (SIF) must be based on the risk associated with the hazard that the SIF is intended to prevent. This approach works well for safety instrumented systems, but it falls short for fire and gas detection systems. This is because FGSs, in general, do not prevent a hazard; they mitigate a hazard, making the magnitude and severity smaller instead of preventing it altogether. As a result of the fundamental differences between hazard prevention and hazard mitigation systems, additional analysis is needed in order to accurately assess the risk and to ensure the effectiveness of the proposed FGS design. For example, instead of just assigning a safety integrity

level (SIL) target or safety availability to the instrumented function in the FGS, performance-based FGS design strongly recommends that detector coverage be quantified, verified, and validated.

ISA-TR84.00.07 was specifically written for the process industries and was not intended to encompass every fire and gas detection application. In a typical process plant, only the areas of the facility that contain process equipment are intended to be covered by the report. ISA-TR84.00.07 is also not meant to completely replace prescriptive design codes, which are still going to apply to many areas in a facility. For example, the fire alarm system in the control building, motor control centers, and other occupied buildings should be designed using requirements from the applicable fire alarm code, such as NFPA 72.

Disclaimers

A performance-based approach to FGS design is often suitable for process areas because FGSs in these areas are not adequately addressed by applicable national codes that contain prescriptive requirements for fire alarm systems. Nothing in this handbook is intended to suggest that prescriptive standards are invalid or should not be followed where required by law. In process plants, supplementing the national standards and codes with performance-based design is consistent with the principles of recognized practices and standards.

A well-designed FGS will detect a large percentage of hazards which may occur that are within the basis of design. Some fire, combustible gas, and toxic gas hazards may not be detected or detectable by a system developed using the techniques discussed in this book. It should be understood that there are limitations to the effectiveness of even a well-designed FGS.

The intent of an FGS is not to prevent hazardous situations, but rather to mitigate an already hazardous situation. Therefore, a well-designed FGS that performs adequately on demand may still not prevent a situ-

ation resulting in loss of life or asset damage. Nothing in this handbook is intended to suggest otherwise.

The authors strongly recommend that release prevention should be the primary goal of any risk management activity. Nothing herein is intended to suggest otherwise. The authors recognize that FGSs have a critical role in mitigating the consequences of accidents that do occur, but the authors do not intend to suggest that FGSs should be solely relied upon where release prevention is first feasible and achievable.

There are no requirements to apply ANSI/ISA-84.00.01-2004 Part 1 (IEC 61511-1 Mod), *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*, in situations where the primary intent of a safety function is to mitigate rather than prevent a hazard.