ISA-TR84.00.07-2010
Technical Report

Guidance on the Evaluation of Fire, Combustible Gas and Toxic Gas System Effectiveness

Approved 15 January 2010

ISA-TR84.00.07-2010 — Guidance on the Evaluation of Fire and Gas System Effectiveness

ISBN: 978-1-936007-43-1

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Foreword

ISA-TR84.00.07-2010 is intended for use in evaluating the effectiveness of fire & gas systems (FGS) in process industry applications. It addresses the implementation of FGS to reduce the risk of hazardous releases involving safety impact.

NOTE Users may choose to apply the concepts in this technical report to environmental and / or operational loss scenarios.

ISA-TR84.00.07-2010 is provided for information purposes only and is not part of ANSI/ISA-84.00.01-2004 (IEC 61511 Modified) (ref 2.1).

ANSI/ISA-84.00.01-2004 and IEC 61511 are performance-based standards that provide the minimum requirements for designing and managing a safety instrumented system (SIS). As part of the safety lifecycle, the functional and integrity requirements are established for safety functions that reduce the risk of hazardous events identified using a hazard and risk analysis. Guidance is provided in Part 3 of either ANSI/ISA-84.00.01-2004 or IEC 61511 on the various methods used to evaluate risk and allocate risk reduction to identified safety functions. An underlying assumption in all of the methods is that the identified safety functions are capable of achieving the allocated risk reduction in the operating environment.

The scope of ISA84 covers "programmable electronic system (PES) for use in safety applications." Accordingly, ISA84 develops standards and technical reports to provide guidelines for the implementation of automated (or instrumented) systems in safety applications. The purpose of ISA-TR84.00.07 is to provide guidance on how to establish and verify the functional and integrity requirements for identified FGS functions. FGS functions that are identified as Safety Instrumented Functions may be implemented according to the requirements of either ANSI/ISA-84.00.01-2004 or IEC 61511.

THE EXAMPLE RISK ANALYSIS METHODS AND RISK CRITERIA CONTAINED IN THIS TECHNICAL REPORT HAVE BEEN PROVIDED SOLELY AS EXPLANATORY MATERIAL AND SHOULD NOT BE INTERPRETED AS RECOMMENDATIONS.

ALSO, THE EXAMPLE FGS ARCHITECTURES, DETECTOR COVERAGES, AND MITIGATION EFFECTIVENESS REPRESENT POSSIBLE SYSTEM CONFIGURATIONS AND SHOULD NOT BE INTERPRETED AS RECOMMENDATIONS. THE CONFIGURATIONS USED IN ACTUAL APPLICATIONS ARE SPECIFIC TO THE OPERATING ENVIRONMENT AND PROCESS CONDITIONS IN WHICH THEY ARE USED. AS SUCH, NO GENERAL RECOMMENDATIONS CAN BE PROVIDED THAT ARE APPLICABLE IN ALL SITUATIONS.

THE USER OF THIS TECHNICAL REPORT IS CAUTIONED TO CLEARLY UNDERSTAND THE ASSUMPTIONS AND DATA ASSOCIATED WITH THE METHODOLOGIES IN THIS DOCUMENT BEFORE ATTEMPTING TO UTILIZE THE METHODS PRESENTED HEREIN.

Users of ISA-TR84.00.07 will include:

a) Manufacturers who are applying the performance-based concepts to FGS functions, in addition to other applicable good engineering practices.

b) Hazards and risk analysis teams that are allocating risk reduction to FGS functions.

c) FGS designers who want to understand the impact of detector coverage and mitigation effectiveness on the integrity of FGS functions.

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Introduction

The ISA84 standards committee formed a working group to study the analysis and design processes that are commonly used in the process industry for Fire & Gas Systems (FGS) and to provide guidance on how these processes can be adapted to incorporate performance-based concepts.

FGS are a subset of industrial automation and control systems that are employed in the process industries for the purpose of detecting loss of containment of hazardous materials from the process and initiating response to mitigate the release impact. Loss of containment can be a small leak or a catastrophic release. It may be detected directly by measuring the presence of the released materials (e.g., gas concentration) or inferred from the effects of the release (e.g., thermal radiation from a fire).

Detection may include combustible gas, toxic gas, smoke, flame, acoustic emission, or rapid heat rise in areas adjacent to the process itself and in critical areas, such as occupied buildings or buildings with unrated electrical equipment. Detector coverage and associated detection capability varies substantially depending on the hazard scenario.

Actions taken by the FGS may be manually or automatically initiated and may affect a wide variety of systems, such as audible and visual alarm indications, water deluge, fire suppressant initiation, chemical deluge activation, manipulation of heating, ventilation, and air conditioning (HVAC) system equipment, process isolation, or process de-pressurization. Similar to detection capability, mitigation effectiveness is highly scenario-dependent.

Use of performance-based design is not currently the norm for FGS within the process industries. FGS have traditionally been designed and implemented according to various good engineering practices, such as NFPA 72 (ref 2.2), and EN 54 (ref 2.3). These prescriptive practices do not require evaluation of the risk reduction capability of the FGS as measured by its safety integrity and probability of failure on demand (PFD). Some users in specific applications, such as life safety systems, electronics manufacturing and off-shore facilities, have started applying performance-based design and management concepts, similar to those presented in either ANSI/ISA-84.00.01-2004 or IEC 61511, to FGS functions. For example, these users assess loss-of-containment scenarios during the hazards and risk analysis where an FGS can reduce the scenario risk. The identified FGS are then designed and managed to achieve the allocated risk reduction.

A performance-based approach is difficult to apply to FGS due to three factors:

1) Traditional techniques are suited for hazards related to process deviations from normal operation, which can easily be identified using a hazards and risk analysis. These process hazards have known initiating causes and consequences, allowing the Safety Instrumented Function (SIF) to be specifically designed to detect the event and to respond by achieving or maintaining a safe state of the process. FGS are generally implemented to reduce the risk from losing containment, such as leaks from equipment seals, flanges, and piping. These hazards may be difficult to define and analyze without using advanced risk analysis techniques, such as gas dispersion modeling or fire modeling associated with a given scenario.

2) FGS do not prevent a hazardous situation, but rather minimize the effects of an event that has already occurred. FGS typically reduce the magnitude and severity of the consequence instead of eliminating it. Typical hazards and risk analysis assumes that the identified safety function eliminates the consequence. Consequently, it is important to understand and evaluate the hazard scenario resulting from FGS operation to ensure that the residual risk is acceptable.

3) Even properly designed and managed FGS can provide poor risk reduction in the operating environment due to inadequate detector coverage and mitigation effectiveness. An analysis by Health and Safety Executive (HSE) of eight years of hydrocarbon release data (ref 2.4) showed

that regardless of the type of FGS design, the effective detection rate was about 60%. The detection of many releases was significantly delayed, leading to higher consequences than expected. Even if very high integrity can be achieved by the hardware design and testing (e.g., low average probability of failure on demand), sufficient reduction in risk will not occur unless the detector coverage is also very high. For FGS functions, detector coverage should be analyzed with the same quantitative rigor as the verification of the average probability of failure on demand for the hardware design.

FGS ineffectiveness is also related to the inability of the mitigation elements (e.g., fire water system, ventilation system) to perform their functions with high probability of success. Mitigation may include stopping the process, diverting the hazardous material, applying fire water with the appropriate flow and spray characteristics, or simply activating alarms notifying personnel to shelter-in-place or evacuate to designated safe areas. Initiating an FGS's action does not necessarily mean that the consequence can be fully mitigated. As in the case of detector coverage, mitigation effectiveness is dependent on many situational or scenario-specific factors.

As a result of these factors, it is difficult to develop a sound technical justification for allocating risk reduction to FGS functions in a simplified risk assessment process, such as layer of protection analysis (LOPA) (ref 2.5). The identification of FGS functions and allocation of risk reduction to them requires detailed release scenario development and residual risk considerations that are beyond simplified risk-assessment tools. Further, FGS performance verification requires evaluation of the detector coverage and mitigation effectiveness, as well as hardware and software design.

This ISA technical report describes the analysis that should be undertaken and the effectiveness criteria that should be specified when an FGS is implemented. The report follows a safety lifecycle similar to that of either ANSI/ISA-84.00.01-2004 or IEC 61511 to discuss the development of detector-coverage criteria applicable to each FGS function and to support a series of application examples (Annex A) that illustrate the techniques used to develop and verify the detector coverage.

1 Scope

1.1 This technical report is informative and does not contain any mandatory requirements.

1.2 This technical report is intended to be used in conjunction with other good engineering practices applicable to FGS installations. It is not intended to stand alone or be a replacement for application-specific practices.

1.3 This technical report acknowledges but does not address mitigative effectiveness associated with notification appliances and personnel response requirements.

1.4 This technical report is intended to:

- Be used by those with a thorough understanding of ANSI/ISA-84.00.01-2004.
- Clarify the additional information that should be considered when developing a performance-based FGS design. This includes development of a safety lifecycle model for FGS design and management.
- Clarify how to define FGS functions within typical FGS designs where automatic action is taken as a result of detection of a fire or gas event.
- Provide example scenario assessments to demonstrate the application of performance-based concepts to the analysis and design of FGS.

2 References

2.1 ANSI/ISA-84.00.01-2004 (IEC 61511 Mod), *Functional Safety: Safety Instrumented Systems for the Process Industry Sector,* Parts 1, 2 & 3, International Society of Automation, Research Triangle Park, NC, 2004.

2.2 NFPA 72, National Fire Alarm Code, National Fire Protection Association, 2007.

2.3 EN 54-2: 1997 Fire Detection and Fire Alarm Systems Part 2: Control and Indicating Equipment.

2.4 HSE Offshore Fire and Explosion Strategy – Issue 1; http://www.hse.gov.uk/offshore/strategy/fgdetect.htm.

2.5 CCPS/AIChE, Layer of Protection Analysis: Simplified Process Risk Assessment, First Edition, New York, 2001.

2.6 CCPS/AIChE, Guidelines for Chemical Process Quantitative Risk Analysis, Second Edition, New York, 2000.

2.7 ANSI/ISA-TR84.00.02, *Safety Instrumented Systems (SIS) – Safety Integrity Level (SIL) Evaluation Techniques*, International Society of Automation, Research Triangle Park, NC, 2002.

2.8 IEC 61511 *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*, Parts 1, 2 & 3.

3 Abbreviations and Acronyms

1ooN – One out of N Voting