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**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

GB/T 45111-2024

**Quality control guidelines for layer of protection analysis
(LOPA), safety integrity levels (SIL) determination and
verification**

保护层分析(LOPA)、安全完整性等级(SIL)定级和验证质量控制导则

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Foreword

This document is in accordance with the provisions of GB/T 1.1-2020 "Guidelines for standardization work Part

1. Structure and drafting rules for standardization documents" Drafting. Please note that some of the contents of this document may involve patents. The issuing organization of this document does not assume the responsibility for identifying patents. This document was proposed by the China Machinery Industry Federation. This document is under the jurisdiction of the National Industrial Process Measurement, Control and Automation Standardization Technical Committee (SAC/TC124). This document was drafted by: Mechanical Industry Instrumentation Comprehensive Technical and Economic Research Institute, China National Petroleum Corporation Safety and Environmental Protection Technology Research Institute Co., Ltd. Company, Guoneng (Lianjiang) Port Power Co., Ltd., Shanghai Gas Engineering Design and Research Co., Ltd., China Electric Power Engineering Consulting Group North China Electric Power Design Institute of Design Co., Ltd., MSA (China) Safety Equipment Co., Ltd., SUPCON Technology Co., Ltd., Liaoning Metso Testing Technology Co., Ltd. Co., Ltd., Shanghai Gelue Software Technology Co., Ltd. The main drafters of this document are: Liu Yao, Shuai Bing, Xu Deteng, Shi Xueling, Huang Buyu, Dong Xiujian, Zhu Minglu, Wei Zhenqiang, Tang Bin, Lv Feng, Chen Xiaohua, Fan Yongfeng, Shi Suijing, Yu Wenguang, Zhu Xuying, Li Qiujuan, Li Wang, Wang Juhong, Sun Yong, Sun Yongkang, Yan Xiaosheng, Sun Shu, Zhou Wei, Zhang Zuoben, Xie Yalian, Yu Shiheng, Ma Tieliang, Li Yuming, Ma Yunli, Qian Fuqun, Yang Minwen, Zhang Xue, Wang Xiaopeng, Cao Xinyi, Zhou Li, Nie Zhongwen, Ma Xinxin, Zhao Yan, Sun Wenyong, Shi Wei,

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With the widespread application of GB/T 20438 (all parts) and GB/T 21109 (all parts), the concept of functional safety has been effectively popularized. In the oil, gas, chemical, power and other industries, functional safety studies how to ensure the safety of the safety instrument system (SIS). The reliability of SIS in executing safety instrumented functions (SIF) is expressed by safety integrity. Performance capability is characterized by the Safety Integrity Level (SIL). The purpose of the hazard and risk analysis mentioned in this document is to comprehensively identify potential hazards and operational problems in the system, generally in the form of qualitative analysis. Analysis can be carried out after the basic process flow design is completed. Common analysis methods include. Hazard and Operability Analysis (HAZOP), Fault Tree Analysis (FTA), Checklists, Failure Mode and Effects Analysis (FMEA). In engineering practice, further semi-qualified analysis is generally required for high-risk points and important control points identified in hazard and risk analysis. Layer of protection analysis (LOPA) is a commonly used semi-quantitative risk analysis method. During the work, the risk reduction capacity will be allocated to the protection layers that have been set or should be set according to the risk scenario. If SIF is involved, it is necessary to confirm the SIF. Determine the corresponding SIL requirements, this process is called SIL classification. The purpose of SIL verification is to verify the hardware safety integrity and system safety integrity through quantitative calculation and, when necessary, qualitative analysis. In order to confirm that the SIF configuration meets the SIL requirements of the SIL classification, common SIL verification methods include. reliability block diagram method, fault tree method, Markov method, etc. SIL verification is usually carried out after the SIS design is completed to ensure that the SIS configuration meets the safety requirements. During the operation and maintenance phase, regular functional safety assessments (including hazard and risk analysis, SIL classification, SIL verification, etc.) are required to ensure that Confirm that the SIFs executed by the SIS can maintain the corresponding SIL capabilities. Through the formulation of this document, a review basis is provided for various industries to carry out LOPA work, SIL classification and verification work, and to guide enterprises to The LOPA work, SIL classification and verification process achieves quality control and improves the level of operational risk management. Layer of Protection Analysis (LOPA), Safety Integrity SIL rating and verification quality control guidelines

1 Scope

GB/T 45111-2024 is the Chinese quality control guideline for layer of protection analysis, for safety integrity level determination and for SIL verification. Functional safety standards say what a safety instrumented function must achieve; they say very little about whether the

analysis that set the target was done competently, and in practice a LOPA study or a SIL calculation can be produced quickly, look complete, and be worthless. This document addresses precisely that gap. It first fixes the relationship between LOPA, SIL determination and SIL verification, then divides each of the three into quality control nodes, and then for each sets the control elements, the personnel, the data, the process and content, and the documentation, together with detailed control requirements for each element and the review requirements that close it out. The process and content requirements for LOPA run to ten pages and cover the initiating event classification and typical frequencies, the protection layer model, the identification of independent protection layers and the SIL tables of GB/T 21109.1-2022; those for SIL verification cover the hardware fault tolerance requirements, the maximum allowable SIL for type A and type B components and the parameters permitted in the verification calculation. Six annexes give worked record sheets, reports and review sheets. It applies to the quality control of LOPA, SIL determination and SIL verification.

This document defines the relationship between layer of protection analysis (LOPA) and safety integrity level (SIL) classification and SIL verification, and specifies Quality control elements, quality control requirements and quality control review requirements for LOPA work, SIL rating and SIL verification.

Note. In this document, SIL rating refers specifically to SIL rating work carried out using the LOPA method. This document applies to quality control for LOPA, SIL classification and verification.

2 Normative references

The contents of the following documents constitute the essential clauses of this document through normative references in this document. For referenced documents without a date, only the version corresponding to that date applies to this document; for referenced documents without a date, the latest version (including all amendments) applies to This document.

GB/T 20438 (all parts) Functional safety of electrical/electronic/programmable electronic safety-related systems

GB/T 20438.1-2017 Functional safety of electrical/electronic/programmable electronic safety-related systems Part

3 Terms and definitions

The following terms and definitions apply to this document.

3.1 Scenario An event or sequence of events that may lead to undesirable consequences.
[Source: GB/T 32857-2016, 3.1.9]