

PUBLICLY AVAILABLE SPECIFICATION PRE-STANDARD

Security for industrial process measurement and control – Network and system security

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CONTENTS

FOREWORD.....	3
INTRODUCTION.....	4
1 Scope.....	5
2 Normative references	5
3 Terms, definitions, symbols, abbreviated terms and conventions	6
3.1 Terms and definitions	6
3.2 Symbols and abbreviated terms.....	12
4 Introduction and compliance	13
5 Principles and reference models.....	13
5.1 General	13
5.2 Threat-risk model	14
5.3 Security life cycle	16
5.4 Policy	17
5.5 Generic reference configurations.....	20
5.6 Protection models	23
6 ICS security policy – Overview	28
7 ICS security policy – Principles and assumptions	30
7.1 ICS security policy – Principles	30
7.2 ICS security policy – Assumptions and exclusions	31
7.3 ICS security policy – Organization and management.....	33
8 ICS security policy – Measures.....	37
8.1 Availability management.....	37
8.2 Integrity management.....	39
8.3 Logical access management	42
8.4 Physical access management.....	45
8.5 Partition management	46
8.6 External access management.....	47
Annex A Projected new edition of IEC 62443	51
Bibliography.....	53
Figure 1 – Threat-risk relationship	14
Figure 2 – Security life cycle	16
Figure 3 – Policy levels.....	18
Figure 4 – Industrial control system (ICS)	21
Figure 5 – GPH reference configuration: Generic ICS host with external devices	22
Figure 6 – Device protection: Hardening and access management.....	23
Figure 7 – Defense-in-depth through partitioning	25
Figure 8 – Example: ICS partitioning.....	26
Figure 9 – Generic external connectivity	27

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SECURITY FOR INDUSTRIAL PROCESS MEASUREMENT AND CONTROL – NETWORK AND SYSTEM SECURITY

FOREWORD

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A PAS is a technical specification not fulfilling the requirements for a standard but made available to the public.

IEC-PAS 62443-3 has been processed by IEC technical committee 65: Industrial-process measurement, control and automation.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
65/402/NP	65/412/RVN

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned will transform it into an International Standard.

This publication seeks the status of a basic security publication according to IEC Guide 104.

This PAS shall remain valid for an initial maximum period of three years starting from 2008-01. The validity may be extended for a single three-year period, following which it shall be revised to become another type of normative document or shall be withdrawn.

INTRODUCTION

The increasing degree of public networking of formerly isolated automation systems increases the exposure of such systems to attack. Standard IT security protection mechanisms have protection goals and strategies that may be inappropriate for automation systems. This PAS addresses the topic of securing access to and within industrial systems while assuring timely response which may be critical to plant operation.

For safety applications and applications in the pharmaceutical or other highly specialized industries, additional standards, guidelines, definitions and stipulations may apply, for example, IEC 61508, GAMP (ISPE), for GMP Compliance 21 CFR (FDA) and the Standard Operating Procedure of the European Medicines Agency (SOP/INSP/2003).

SECURITY FOR INDUSTRIAL PROCESS MEASUREMENT AND CONTROL – NETWORK AND SYSTEM SECURITY

1 Scope

This PAS establishes a framework for securing information and communication technology aspects of industrial process measurement and control systems including its networks and devices on those networks, during the operational phase of the plant's life cycle.

This PAS provides guidance on a plant's operational security requirements and is primarily intended for automation system owners/operators (responsible for ICS operation)

Furthermore, the operational requirements of this PAS may interest ICS stakeholders such as:

- a) automation system designers;
- b) manufacturers (vendors) of devices, subsystems, and systems;
- c) integrators of subsystems and systems.

The PAS allows for the following concerns:

- graceful migration/evolution of existing systems;
- meeting security objectives with existing COTS technologies and products;
- assurance of reliability/availability of the secured communications services;
- applicability to systems of any size and risk (scalability);
- coexistence of safety, legal and regulatory and automation functionality requirements with security requirements.

NOTE 1 Plants and systems may contain safety critical components and devices. Any safety-related security components may be subject to certification based on IEC 61508 and according to the SILs therein. This PAS does not guarantee that its specifications are all or in part appropriate or sufficient for the security of such safety critical components and devices.

NOTE 2 This PAS does not include requirements for security assurance evaluation and testing.

NOTE 3 The measures provided by this PAS are rather process-based and general in nature than technically specific or prescriptive in terms of technical countermeasures and configurations.

NOTE 4 The procedures of this PAS are written with the plant owner/operator's mind set.

NOTE 5 This PAS does not cover the concept, design and implementation live cycle processes, i.e. requirements on control equipment manufacturer's future product development cycle.

NOTE 6 This PAS does not cover the integration of components and subsystems into a system.

NOTE 7 This PAS does not cover procurement for integration into an existing system, i.e. procurement requirements for owner/operators of a plant.

NOTE 8 This PAS will be extended into a 3-part International Standard to cover most of the restrictions expressed in the previous notes; for the planned scope of the extended standards, refer to Annex A.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 15408 (all parts), *Information technology – Security techniques – Evaluation criteria for IT security*

ISO/IEC 27002:2005, *Information technology – Security techniques – Code of practice for IT security management*

ISO/IEC Guide 73:2002, *Risk management – Vocabulary – Guidelines for use in standards*

3 Terms, definitions, symbols, abbreviated terms and conventions

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

access control

prevention of unauthorized use of a restricted resource, including its use in an unauthorized manner

[ISO/IEC 18028-2:2006, modified]

3.1.2

adversary

entity that attacks, or is a threat to, a system

[RFC 2828]

3.1.3

alert

instant indication that an information system and network may be under attack, or in danger because of accident, failure or people error

[ISO/IEC 18028-1:2006]

3.1.4

asset

anything that has value to the organization

[ISO/IEC 13335-1:2004]

3.1.5

assurance

performance of appropriate activities or processes to instil confidence that a deliverable meets its security objectives

[ISO/IEC/TR 15443-1]

3.1.6

attack

attempts to destroy, expose, alter, or disable an information system and/or information within it or otherwise reach the security policy

[ISO/IEC 18043]

3.1.7

attack surface

set of system resources exposed directly and indirectly to potential attack.

3.1.8

audit

formal inquiry, formal examination, or verification of facts against expectations, for compliance and conformity

[ISO/IEC 18028-1]

3.1.9

authenticate, authentication

provision of assurance of the claimed identity of an entity

[ISO/IEC 19792]

3.1.10

availability

property of being accessible and usable upon demand by an authorized entity

[ISO/IEC 7498-2]

3.1.11

commercial off-the shelf (COTS)

items which are manufactured and distributed commercially for multiple usages and/or customers; may be tailored for specific usage

NOTE COTS is in contrast to custom products designed entirely and uniquely for the specific application.

3.1.12

compromise

unauthorized use, disclosure, modification, or substitution, respectively, of data, programs or systems configuration, i.e., by and after intrusion.

3.1.13

confidentiality

property that information is not made available or disclosed to unauthorized individuals, entities, or processes

[ISO/IEC 13335-3]

3.1.14

credentials

means of proving that it is the one who claim to be, the abstract can be an IT account to access an information service or resource

[ISO/IEC 24760]

3.1.15

demilitarized zone (DMZ)

security host or small network (also known as a screened sub-net) inserted as a 'neutral zone' between networks

[ISO/IEC 18028-3]

NOTE It forms a security buffer zone (ISO/IEC 18028-3).

3.1.16

denial of service (attack)

attack against a system to deter its availability

[ISO/IEC 18028-4]

3.1.17

event

occurrence in a system that is relevant to the security of the system

[RFC 2828, modified]

3.1.18

exposed, exposure

evident state of being vulnerable and exposed to attack

3.1.19

external

outside of, or at the external border of the security perimeter of the ICN, i.e. relating to an external organizational or public network

3.1.20**external connectivity gateway (ECG)**

dedicated security gateway (SGW) at the external border of the security perimeter of the ICN, typically with additional functionality to meet specific requirements, i.e. for the connectivity of external devices

3.1.21**external network (EN)**

network external to the ICN and either part of the organization to which the ICN belongs, belonging to a third party or public, i.e., the Internet

3.1.22**forensic**

post-incident effort to explain an event in a formal and verifiable manner to attribute responsibilities in a consecutive and logical manner

3.1.23**gateway, security gateway (SGW)**

point of connection between networks, or from a network to subnetworks and external networks, intended to protect a network or subnetwork according to a specified security policy

[ISO/IEC 18028-3, modified]

NOTE A security gateway comprises more than only firewalls; the term includes routers and switches which provide the functionality of access control and optionally encryption (ISO/IEC 18028-3).

3.1.24**harden, hardening**

removing unnecessary functionality to reduce physical, logical and/or organizational vulnerabilities

3.1.25**human-machine-interface (HMI)**

equipment function designed to present information output to, and to accept information input from the operator to make a human, as operator, integral part of a process

3.1.26**incident**

security event, or a combination of multiple security events, that constitutes a security

3.1.27**industrial control network (ICN)**

network connecting ICS equipment; different ICNs may coexist within one plant and may be connected to remote equipment and resources outside the plant

3.1.28**industrial control system (ICS)**

system consisting of computing and industrial control hosts, devices and equipment, that are integrated together to control an industrial production, transmission, or distribution process

NOTE In the context of this PAS, the term ICS stands for automation systems in general, including supervisory control and data acquisition (SCADA).

3.1.29**insider, inside, internal**

(entity) inside the security perimeter; insider is an entity authorized to access system resources

NOTE An insider attack refers to use of system resources in an unauthorized manner.

3.1.30**integrity**

safeguarding the accuracy and completeness of information and processing methods

[ISO/IEC 21827]

NOTE Integrity may apply specifically to data (data integrity) or to the integrity of the operational ICS as system integrity.

3.1.31

intranet

computer network, especially one based on public network technology, that an organization uses for its own internal, and usually private, purposes and that is closed to outsiders

3.1.32

intrusion

incident in which an unauthorized entity, i.e. an attacker, gains or evidently attempts to gain, access to restricted system resources

[RFC 2828, modified]

3.1.33

intrusion detection

security service that monitors and analyses system events for the purpose of finding, and providing real-time or near real-time warning of, attempts to access system resources in an unauthorized manner

[RFC 2828]

3.1.34

(cryptographic or physical) key

device, media or plaintext associated with authentication or cryptographic methods or access control privileges.

3.1.35

log, logging

gathering of data on information security events for the purpose of review and analysis, and ongoing monitoring

[ISO/IEC 18028-1]

3.1.36

malware

malicious software, such as a virus or a trojan, designed specifically to damage or disrupt a system

[ISO/IEC 18028-1]

3.1.37

(counter-) measure

action, device, procedure, or technique that reduces a threat, a vulnerability, or an incident by eliminating or preventing it, by minimizing the harm it can cause, or by discovering and reporting it so that corrective action can be taken

[RFC 2828]

3.1.38

message

ordered series of octets (or bits) intended to convey information

[ISO/IEC 2382, modified]

3.1.39

monitor

observe real-time actions and events to provide evidence about what was observed

[ISO/IEC 13888-1, modified]

3.1.40**non-repudiation**

property of an action that permits repeated subsequent proof that the action was performed by, or originated from, a given actor

[RFC 2828, modified]

3.1.41**owner/operator**

business enterprise responsible for operating an ICS or SCADA system

3.1.42**partition, partitioning**

delimited physical or logical zone to allow or deny access to resources, subject to access rules and control mechanisms

[CCOPP v0.5, modified]

NOTE A partition has a clear border with other partitions. The security policy of a partition is typically enforced by a combination of mechanisms both at the partition edge and within the partition. Partitions can be hierarchical.

3.1.43**perimeter**

boundary of a network partition or zone, typically protected by mechanisms according to security policy or specified access control rules.

3.1.44**physical access gate (PAG)**

physical access point to control the authorization of, for example, personnel and equipment when entering or leaving the security perimeter of the plant and/or a physical ICS partition

3.1.45**plaintext**

human or machine readable and intelligible data, i.e. data input prior to transformation by encryption, or data output by decryption

[RFC 2828, modified]

3.1.46**plant**

facilities, typically with a physically protected perimeter, hosting the physical process, the ICS and its ICN

3.1.47**privilege**

right or permission expressly granted to a single or specified group of user(s) or device(s) to perform specified actions, in specified roles and associated to established identity

3.1.48**proxy (server)**

computer process that relays a protocol between client and server computer systems, by appearing to the client to be the server and appearing to the server to be the client

[RFC 2828, modified]

3.1.49**real-time**

referring to the response time of computing devices as being so short that it seems to be immediate and without delay

3.1.50

redundancy

duplication of security critical components of a system with the intention of increasing availability of the system

NOTE While redundancy increases the availability, for example, of a communication channel, its side-effect generally is an increase in vulnerability.

3.1.51

residual risk

risk that remains after countermeasures have been applied

[RFC 2828]

3.1.52

risk

combination of the probability of an event and its consequence where probability is the extent to which an event is likely to occur

[ISO/IEC Guide 73:2002]

NOTE Consequence is the harm to assets.

3.1.53

secure, security

a product, system, or service is considered to be secure to the extent that its users can rely that it functions (or will function) in the intended way. This is usually considered in the context of an assessment of actual or perceived threats

[ISO/IEC/TR 15443-1]

3.1.54

security centre

trusted resource for monitoring, patching, updating, handling signature and alert information relative to the security maintenance of the ICN; an external security centre is located outside the ICN security perimeter

3.1.55

(information) security management system (ISMS)

that part of the overall management system, based on a business risk approach, to establish, implement, operate, monitor, review, maintain and improve organizational security

[ISO/IEC 27001, modified]

3.1.56

security measure

(security) measure against possible breach of security of a protected system

3.1.57

security policy

set of rules and practices that specify or regulate how a system or organization provides security services to protect sensitive and critical system resources

[RFC 2828]

3.1.58

security relevance/relevant

item, i.e. action or event, that could result in a breach of security

3.1.59**security violation**

act or event that disobeys or otherwise breaches security policy

[RFC 2828]

3.1.60**strength of function**

quality of a security function expressing the minimum efforts assumed necessary to defeat its expected security behaviour by directly attacking its underlying security mechanisms

[ISO/IEC 15408-1, modified]

3.1.61**trust, trusted**

expectation that a partition, host or device will behave in a predictable manner for a specific purpose under specified operating condition and subject to explicit security policy

3.1.62**threat**

potential for violation of security, which exists when there is a circumstance, capability, action, or event that could breach security and cause harm

[RFC 2828]

3.1.63**user**

person, organization entity, or automated process that accesses a system, whether authorized to do so or not

[RFC 2828]

3.2 Symbols and abbreviated terms

COTS	Commercial off-the-shelf
DMZ	Demilitarized zone
ECG	External connectivity gateway
EN	External network
GPH	General purpose host
HMI	Human-machine-interface
ICS	Industrial control system
IDS	Intrusion detection system
ISMS	(Information) security management system
O/S	Operating system
PAG	Physical access gate
ICN	Industrial control network
PSM	Portable storage medium
SED	Stand-alone external device
SGW	Security gateway

4 Introduction and compliance

Use of IT security methods and standards have become common place in the office environment in the form of the ubiquitous code of practice for information security management (ISO/IEC 27002, previously known as ISO/IEC 17799), for operational security, and the evaluation criteria for IT security (ISO/IEC 15408), for product development.

Now the internet and wireless networks have arrived on the shop floor. Security problems in automation systems are increasingly making headlines in the specialized press; but commonly acknowledged practice and related standards are lagging, and this despite the higher stakes involved in automation systems, with possible physical production losses and impact on health, human life and environment.

As has previously occurred in the operational security in the office environment, this PAS is an initial effort to provide guidance for the operational security of automation systems.

However, the methods and standards from the office environment cannot be easily applied to automation systems. A study of EWICS [15]¹ has shown that the widely used ISO/IEC 27002 would have to be extended considerably to be applicable to industrial control systems. While 189 items have been judged applicable to very applicable, 85 % or 45 % have been found to require additional guidance.

This PAS contains good practice identified by practitioners based on their practical experience but developed independently of ISO/IEC 27002.

NOTE While it may be desirable to harmonize the structure and vocabulary of this PAS with ISO/IEC 27002, this has not been done at this time.

This PAS is intended to fill the presently existing void while further efforts are planned to enhance the guidance in a future edition of IEC 62443 as outlined in Annex A.

Compliance to the policy of this PAS is a local matter. It may be stated in reference to all provisions of the ICS policy or to part of it or to a customized version of it.

Certain measures of the policy may not be applied because they are not applicable at a given time for a given configuration in a given security context. The policy allows for this modularity and customization.

Also, depending on the specific ICS, it may be deemed necessary or desirable, for example, from a risk/cost trade-off perspective, not to implement certain measures as prescribed by the policy. By the nature of security, this may only be done temporarily in application of ICS policy using its exception management provision.

5 Principles and reference models

5.1 General

This PAS describes good practice in terms of technical and organizational security measures for the protection of the ICS and its industrial control network (ICN), including generally existing ICN subnetworks.

This clause explains the underlying reference models.

¹ Figures in square brackets refer to the bibliography.

The users of this PAS should customize these models for their specific application, in order to apply the provisions of the security policy to their specific requirements.

The advice of this PAS may need to be complemented by other models and related policy, i.e. threat-risk assessment, general security policy, and ISMS.

5.2 Threat-risk model

5.2.1 Overview

A general security related threat-risk model is shown in Figure 1. From the figure can be read:

- threats are using vulnerabilities of the ICS;
- without counter-measures they may represent intolerable risk (to the assets);
- generally counter-measures are required to minimize risk (to the assets).

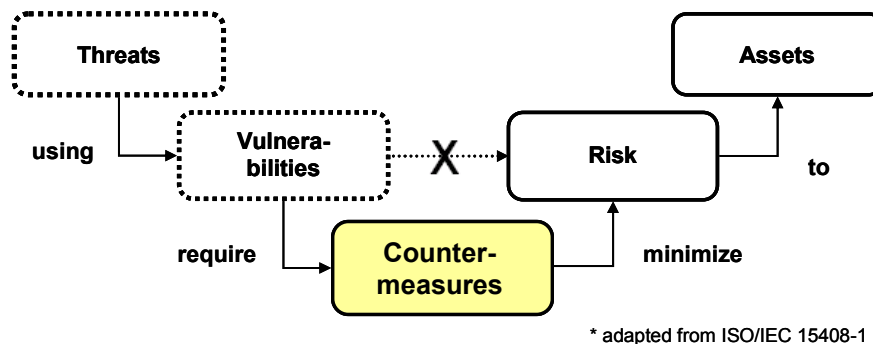


Figure 1 – Threat-risk relationship

Counter-measures are widely available, as general processes, detailed procedures and sometimes in detail specifications.

This PAS will provide counter-measures as processes, and this in the form of a proposed policy.

5.2.2 Threats

Threats are possible security-related unwanted events causing damage, i.e. monetary loss. Events that have some likelihood to occur in an ICS are:

- attacks by vandals and terrorists;
- ICS failure following a security event;
- denial of service attacks;
- breach of confidentiality, for example, disclosure of production information;
- breach of the law;
- undesirable event through acts of God, for example, extreme weather conditions like a storm or tornado.

Other events could be added that may be specific to a particular organization.

Typically, occurrence of such events would be reported to management, the speed of reporting, related action and the level of management involved being a function of their severity.

Such an event, also known as security incident, may be thought of as a newspaper headline.

5.2.3 Risk

Risk is defined in ISO/IEC Guide 73 as a "combination of the probability of an event and its consequence", as the damage, or consequence of a security incident. The occurrence of an incident may give rise to one or more consequences and may also trigger other events.

Damage that may be suffered in an ICS includes

- loss of revenue;
- unanticipated costs;
- inability to carry out some or all of a business;
- loss of the monetary value of buildings and contents;
- safety incident;
- fines due to violation of legal requirements such as emission control;
- consequences due to violation of regulatory requirements such as GAMP 0;
- customer dissatisfaction;
- adverse press coverage;
- court action against an employee or the business itself.

It is a fact that protection efforts require monetary efforts for technologic, physical and organizational measures. Therefore, the consequence of an adverse security event generally needs to be expressed in monetary terms.

The risk to the assets of the ICS requires to capture the value of the assets and their unsecured exposure to attack. This is usually very difficult and subjective, for example, when considering as a consequence a loss in the reputation of an organization.

5.2.4 Threat-risk assessment

Threat-risk assessment (TRA) leads to the evaluation of risk and its correspondent assets-at-risk, threats and vulnerabilities. TRA is a prerequisite to the selection and detailed specification of protection measures.

TRA, in particular with respect to electronic attack on computer systems connected to unsecured or untrusted networks, are at this time not amenable to mathematical-statistical analysis, i.e., malicious human attacks are purposeful and do not have the statistical property of random failure events. Thus extrapolating from historical data (as generally possible with random failures) cannot predict the future probability of human attack. For this reason, the likelihood of security-related occurrences may elude a purely statistical approach forever.

While there are many TRA models available, none has been widely accepted. Quantitative methods are misleading. Generally, security risk is assessed by in-house experts or consultants, followed by evaluation against the ICS owner/operator's risk criteria.

Because of the foregoing, this PAS does not propose TRA methods.

5.2.5 Risk treatment, acceptance and communication

After their assessment, risks generally will be found unacceptable without risk treatment.

Risks are treated using such measures as those proposed by this PAS, other measures that may be indicated as prerequisites in this PAS, and still others that are not mentioned in this PAS and that may be judged necessary by the owner/operator of the ICS, a regulator or the legislator.

Security measures should be

- effective, efficient, and strong enough to withstand identified threats;
- predictable with respect to the effort for establishing them;
- easy to install and to use;
- free of retroactive impact on the existing manufacturing process;
- ideally maintenance-free.

Most of the requirements of this PAS will allow for options differing by the amount of invested effort and obtained level of protection, to suit acceptable risk. Strength of measures should be balanced such that achieved protection by one measure may not be weakened by lack of protection of another measure.

Measures have to be reasonably complete, that is not leaving security holes. In concert, measures should mutually independent and preferably supportive of each other. Special care shall be given to assure that measures do not impede each other.

Measures are costs. Therefore, chosen measures need to be balanced to yield a cost-effective solution. If an organization cannot afford the cost, this may require an optimization process, including change to ICS configuration, limitation of communications and complementary organizational measures.

Finally, risk has to be accepted by the stakeholders and communicated to those involved prior to the implementation of measures and at every major change.

NOTE The foregoing, and this PAS, do not cover formal establishment of trust which requires security evaluation using acknowledged criteria and methodology, for example, ISO/IEC 15408 and/or ISO/IEC 27001.

5.3 Security life cycle

The provisions of this PAS are based on a security life cycle model, shown in Figure 2.

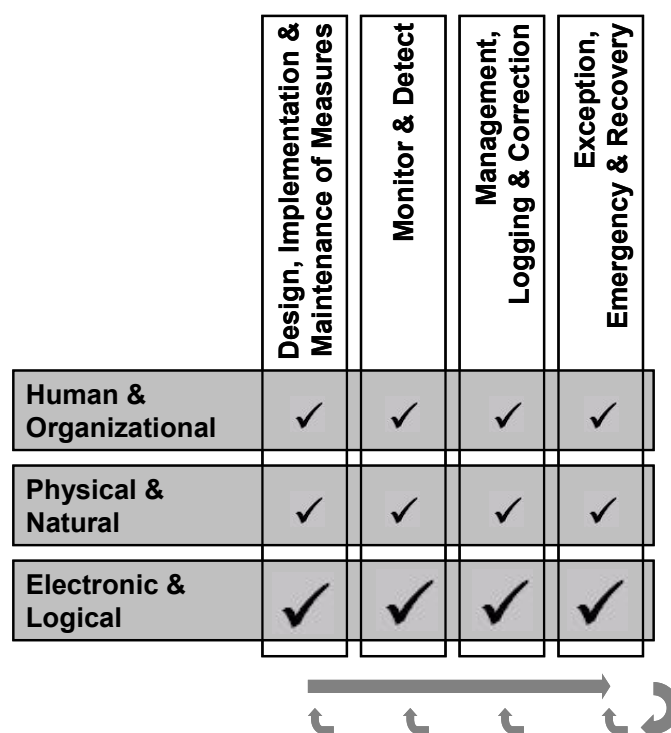


Figure 2 – Security life-cycle