



IEEE Standard for General Technical Requirements of Auxiliary Warehouse in a Smart Factory

IEEE Computer Society

Developed by the
Smart Manufacturing Standards Committee

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STANDARDS

IEEE Standard for General Technical Requirements of Auxiliary Warehouse in a Smart Factory

Developed by the

Smart Manufacturing Standards Committee
of the
IEEE Computer Society

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IEEE SA Standards Board

Abstract: Logistics operation processes in a smart factory, including the process composition such as warehousing, packaging, shipment, or transportation; implementation conditions; process quality evaluation; and process improvement are described in this standard. Methods for management organization, facility layout, equipment requirements, information systems, employee requirements, emergency management, and evaluation in a smart factory are defined in this standard.

Keywords: IEEE 3145™, operation process, smart factory, smart logistics

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Introduction

This introduction is not part of IEEE 3145-2024, IEEE Standard for General Technical Requirement of Auxiliary Warehouse in Smart Factory.

The efficient operation of smart factories and the effective control of production costs require the support of efficient auxiliary warehouses. Auxiliary warehouse is a special warehouse next to the production line or workshop/unit of the smart factory. The construction of auxiliary warehouses is important in supporting the mass customization of smart factories. This standard focuses on a single auxiliary warehouse in a smart factory and does not consider auxiliary warehouses outside of the smart factory and multiple auxiliary warehouses to keep the generalizability of this standard.

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IEEE Standard for General Technical Requirements of Auxiliary Warehouse in a Smart Factory

1. Overview

1.1 Scope

This standard defines general technical requirements of auxiliary warehouses in smart factories. The standard specifies technical requirements for facility, equipment, system, safety, and fault handling, as well as space layout and intelligent algorithm requirements.

1.2 Purpose

The purpose of this standard is to support the standardized design and construction of auxiliary warehouses in a smart factory setting with discrete manufacturing. Standardized auxiliary warehouses can play an important role in increasing the efficient operation of smart factories.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{6,7}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

⁶The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁷The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

1.4 Structure of this standard

First, from the perspective of spatial layout, this standard introduces the layout requirements of the auxiliary warehouse of the smart factory so that the warehouse can meet the warehousing operation of semi-finished products while being suitable for the operation of parts and components. Second, this standard introduces the technical requirements for auxiliary warehouses of smart factories in terms of technical requirements for facilities, equipment, intelligent algorithms, systems, safety, and fault handling. Finally, case studies are used to demonstrate the application of the standard in auxiliary warehouses of smart factories in industries such as communications and automobiles.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ISO/IEC 30163:2021, Internet of Things (IoT)—System requirements of IoT and sensor network technology-based integrated platform for chattel asset monitoring.⁸

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁹

smart factory: Through the application of artificial intelligence technology to product design, process, production, and other processes, the manufacturing factory can reflect perception, interconnection, collaboration, learning, cognition, decision-making, control, and execution capabilities, etc., in its key links or processes (IEEE Std 2934™-2022).

smart logistics: A logistics service model based on Internet of Things (IoT) that comprehensively uses smart technology and smart equipment to perceive, identify, and track the logistics service process to achieve real-time response, intelligent optimization, and efficient control (IEEE Std 2934-2022).

smart auxiliary warehouse: A warehouse set near the production lines and aims to provide efficient and smart replenishment, storage, and distribution services for production lines. It utilizes modern technologies, such as unmanned vehicles and artificial intelligence (AI) to supply raw materials seamlessly.

3.2 Acronyms and abbreviations

AGV	automated guided vehicle
AI	artificial intelligence
API	application programming interface
AS/RS	automated storage and retrieval system
ECS	equipment control system

⁸ISO publications are available from the International Organization for Standardization (<https://www.iso.org/>) and the American National Standards Institute (<https://www.ansi.org/>).

⁹*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org/>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

ERP	enterprise resource planning
DTU	data transfer unit
IoT	Internet of Things
PLC	programmable logic controller
RFID	radio frequency identification
RGV	rail-guided vehicle
TCP/IP	transmission control protocol/Internet protocol
UPS	uninterruptible power supply
VR	virtual reality
WCS/RCS	warehouse control system/ robot control system
WLAN	wireless local area network
WMS	warehouse management system

4. Principles for the construction of auxiliary warehouses

The need for intelligent technology for various functional areas, facilities, and equipment of the auxiliary warehouse shall be comprehensively considered to improve the operation efficiency of the auxiliary warehouse.

General standard technical specifications shall be adopted to assist the auxiliary warehouse operation process to help ensure the quality of the operation.

Intelligent technologies should be adopted to optimize the construction cost of auxiliary warehouses through cost-benefit trade-offs.

Auxiliary warehouse layout should be carried out in accordance with the objective law of material flow, and the setting of each area shall be beneficial for warehouse operations and easy to connect with the production line.

5. Space layout requirements

5.1 Requirements for functional area

The functional area shall include the main functional area and the auxiliary functional area. The main functional areas include the inbound area, storage area, picking area, outbound area, etc. The auxiliary functional areas mainly include the device charging area, the appliances' temporary storage area, and the office area.

The layout shall fully consider the principle of one-way material flow, the shape of the warehouse, and the position of the door (U-shape/I-shape/L-shape/W-shape). It should fully consider the smooth connection between the stock-out area and production.

The layout shall fully consider the influence of warehouse height and depth on automated storage and retrieval system (AS/RS) size, as well as the influence of space and doors on automated guided vehicle (AGV) passage.

The layout should fully consider the effect of upright column spacing.

The layout shall fully consider the impact on fire safety.

The layout shall prioritize the requirements of the intelligent warehouse and of the main functional areas, make full use of the area and space of the warehouse, and improve its utilization rate.

Functional areas shall be adjusted according to the different scenarios of the auxiliary warehouse.

The layout shall fully consider the characteristics of the stored materials and make corresponding regulations on the cleanliness of the auxiliary warehouse.

The layout of the auxiliary warehouse shall fully consider accessibility and scalability.

If the above principles conflict, priority shall be given to help ensure the efficient operation of the main functional area.

5.2 Requirements for inbound area

The inbound area shall set the appropriate number and size of platforms according to the storage demand. The direction of entering the warehouse shall be determined according to the vehicle movement of the entire factory.

In the inbound area, the turning and vehicle parking requirements shall be met. The influence of the platform height, the slope of the boarding bridge, and other factors on the vehicle's unloading shall also be considered.

The inbound area shall meet the requirements for temporary storage and turnover of materials, and a canopy should be built in the inbound area.

The inbound area should be close to the storage areas.

If the materials need to be inspected, the inbound area should meet the requirements of material inspection.

The inbound area should be equipped with Internet of Things (IoT) devices that meet the functions, such as vehicle queuing calls, automatic inventory of goods, automatic receipt, automatic handover, etc.

5.3 Requirements for storage area

The storage area shall consider the material classification to determine different storage modes.

The size of the storage area shall be dynamically determined according to the business volume, frequency of use, use, and storage mode, taking into account material physical volume, storage capacity, temperature and humidity, anti-static, and other storage and order characteristics.

Small and medium-sized materials should be stored in AS/RS. High-frequency outbound materials should adopt a goods-to-person automated storage solution.

When large-scale materials are stacked on the ground, they should be isolated and managed automatically through IoT devices.

The storage area shall consider the isolation area of defective products and dangerous goods. Dangerous goods (such as batteries) shall be stored in a separate area according to the requirements of the dangerous goods level.

Bonded materials and non-bonded materials shall be stored in distinct compartments.

5.4 Requirements for picking area

The picking area shall consider the type, size, frequency of use and usage of materials, and other characteristics to set the appropriate picking mode, such as pick-to-light, goods-to-person picking, machine vision picking, etc.

The picking area shall be based on the space span of the material picking operation, available space resources, picking efficiency requirements and implementation costs, etc., to select the appropriate picking equipment, such as truss picking equipment and manipulator picking equipment.

The picking area should consider the flow line of the material and connect the storage area and the outbound area. If materials need to be packaged and labeled, the picking area needs to be equipped with appropriate equipment.

When personnel are required to work in the picking area, the configuration of human-computer interaction facilities and equipment should be considered to facilitate manual picking and improve working efficiency.

The picking area shall support single-SKU picking and multi-SKU mixing of materials according to order.

An abnormal material area should be set up in the picking area to facilitate the processing of defective and faulty materials.

5.5 Requirements for outbound area

The placement of the outbound area shall consider the layout of the production line, ensuring that it facilitates swift delivery to the production line.

Before the materials are delivered to the production line, the outbound area shall fully consider the production takt time to help ensure efficient outbound operations and optimal performance of stackers and other related equipment.

During the delivery of the materials to the production line, the outbound area shall consider the material demand and characteristics of the production line to carry out flexible delivery.

After the materials are delivered to the production line, if the materials need to be returned to the warehouse, there shall be a corresponding inbound function in the outbound area.

The outbound area should be equipped with IoT devices that meet the functions of outbound automatic calls, handover, etc.

The outbound area shall have the picking function for materials if necessary.

If there are multiple outbound areas, the logistics routes of every outbound area shall be independent and non-intersecting.

The outbound area shall be based on ergonomics to realize reasonable setting of equipment and personnel.

5.6 Requirements for device charging area

The device charging area shall meet the fire protection requirements and set up an independent device charging area.

The device charging area shall be as close as possible to the device from the main functional areas.

The size of the device charging area shall be designed according to the number of devices with charging needs in the warehouse.

The device charging area shall refer to the local architectural design requirements, and the charging equipment shall be placed against the outer wall.

5.7 Requirements for appliances' temporary storage area

The fragmented space of the warehouse shall be fully utilized to realize the centralized temporary storage of appliances.

The appliances' temporary storage area shall be close to the main functional areas for appliances to facilitate the recycling of appliances.

Scanning devices such as radio frequency identification (RFID) or barcodes should be provided to automatically recycle appliances.

The appliances' temporary storage area shall consider the appliance cleaning and have the corresponding cleaning function.

5.8 Requirements for office area

The office area shall be set based on the fragmented space of the warehouse.

The office area shall consider the principle of relevance to monitor the use of equipment, inventory circulation, and serve the business in the inbound and outbound areas.

5.9 Requirements for other areas

When the auxiliary warehouse has a multi-storied structure, space for transportation facilities such as elevators, freight elevators, and traditional elevators should be reserved according to the architectural form of the auxiliary warehouse, and the specific location and quantity should be designed according to the material flow direction and flow rate.

The central control system area shall be reserved for the auxiliary warehouse, and its specific location shall be designed in combination with the overall layout of the auxiliary warehouse to help ensure safe and efficient operation.

6. Facility technical requirements

6.1 Ground requirements

6.1.1 Requirements for load

The load on the ground of the auxiliary warehouse shall be comprehensively considered according to factors such as equipment, container, product load, ground flatness, ground settlement, etc.

Concentrated loads should be applied to places where the ground of the auxiliary warehouse bears heavy loads, such as pre-embedding or civil foundations for manipulators, gantry, and other equipment.