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Information technology — Automatic identification and data capture technology — AIDC application in industrial construction

Technologies de l'information — Technologie d'identification automatique et de capture de données — Application de l'AIDC pour la construction industrielle

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

Construction has a history that spans the entire human civilization. Traditional construction has lagged behind due to the interrelated issues of the rising costs, lengthy duration, massive pollution and the shortage of skilled construction labour. Industrial construction is a rapidly growing sector of construction, has the potential to be an effective solution for addressing these issues. See Annex A for more details. In the industrial construction business, mega structures including power plants, skyscrapers, warehouses, factories and other larger-than-life projects are designed, manufactured, installed and maintained by the industrialized methods. The methods include standardized design, factory production, assembly-style construction, integrated decoration and digital management. Industrial construction is an off-site, manufacturing-style construction method and system which covers all aspects of making a building, including

a) the process of making construction items such as prefabricated components, building parts, connectors or accessories from raw materials in plants,

b) the assembly, storage and shipment to the building site,

c) the assembly to specifications and building inspections,

d) maintenance,

e) potential demolition,

f) material recovery, and

g) disposal.

Automatic identification and data capture (AIDC) technology is the main technology for item and asset automatic identification and data capture since 1970s. In the past 50 years, AIDC and its global standardization have stimulated the digital transformation and informational management in the retail, healthcare and logistic industries globally.

The systematic study of AIDC technology application standards for industrialized construction will help to cope with industry challenges and promote the digital transformation and upgrading of the industry.

Information technology — Automatic identification and data capture technology — AIDC application in industrial construction

1 Scope

This document specifies the identification, data, information services, application guidance aspects and applicable requirements of automatic identification and data capture (AIDC) technology for different items and their hierarchy in industrial construction during their whole life cycle.

This document

— provides unique identification for items in industrial construction,

— specifies the semantics and data syntax to be used,

— specifies the data carriers to be used on items of various categories, substitutes and sizes,

— makes recommendations about the metadata of the items,

— specifies the application test method and parameters based on the large-scale test and scientific sampling rules,

— defines the information services protocol to be used as an interface between business applications and the AIDC system, and

— makes guidance for designers, workers, engineers, managers, end users and maintainers about the AIDC application in their daily work.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 6707-1, *Buildings and civil engineering works — Vocabulary — Part 1: General terms*

ISO 6707-2, *Buildings and civil engineering works — Vocabulary — Part 2: Contract and communication terms*

ISO 6707-3, *Buildings and civil engineering works — Vocabulary — Part 3: Sustainability terms*

ISO 6707-4, *Buildings and civil engineering works — Vocabulary — Part 4: Facility management terms*

ISO/IEC 15418, *Information technology — Automatic identification and data capture techniques — GS1 Application Identifiers and ASC MH10 Data Identifiers and maintenance*

ISO/IEC 15434, *Information technology — Automatic identification and data capture techniques — Syntax for high-capacity ADC media*

ISO/IEC 15459-1, *Information technology — Automatic identification and data capture techniques — Unique identification — Part 1: Individual transport units*

ISO/IEC 15459-2, *Information technology — Automatic identification and data capture techniques — Unique identification — Part 2: Registration procedures*

ISO/IEC 15459-3, *Information technology — Automatic identification and data capture techniques — Unique identification — Part 3: Common rules*

ISO/IEC 15459-4, *Information technology — Automatic identification and data capture techniques — Unique identification — Part 4: Individual products and product packages*

ISO/IEC 15459-5, *Information technology — Automatic identification and data capture techniques — Unique identification — Part 5: Individual returnable transport items (RTIs)*

ISO/IEC 15459-6, *Information technology — Automatic identification and data capture techniques — Unique identification — Part 6: Groupings*

ISO/IEC 15961-1, *Information technology — Data protocol for radio frequency identification (RFID) for item management — Part 1: Application interface*

ISO/IEC 15961-3, *Information technology — Data protocol for radio frequency identification (RFID) for item management — Part 3: RFID data constructs*

ISO/IEC 15961-4, *Information technology — Radio frequency identification (RFID) for item management: Data protocol — Part 4: Application interface commands for battery assist and sensor functionality*

ISO/IEC 15962:2022, *Information technology — Radio frequency identification (RFID) for item management — Data protocol: data encoding rules and logical memory functions*

ISO/IEC 15963-1, *Information technology — Radio frequency identification for item management — Part 1: Unique identification for RF tags numbering systems*

ISO/IEC 16022, *Information technology — Automatic identification and data capture techniques — Data Matrix bar code symbology specification*

ISO/IEC 18000-3:2010, *Information technology — Radio frequency identification for item management — Part 3: Parameters for air interface communications at 13,56 MHz*

ISO/IEC 18000-63, *Information technology — Radio frequency identification for item management — Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C*

ISO/IEC 18004, *Information technology — Automatic identification and data capture techniques — QR code bar code symbology specification*

ISO/IEC 18046-1, *Information technology — Radio frequency identification device performance test methods — Part 1: Test methods for system performance*

ISO/IEC 18046-2, *Information technology — Radio frequency identification device performance test methods — Part 2: Test methods for interrogator performance*

ISO/IEC 18046-3, *Information technology — Radio frequency identification device performance test methods — Part 3: Test methods for tag performance*

ISO/IEC 18046-4, *Information technology — Radio frequency identification device performance test methods — Part 4: Test methods for performance of RFID gates in libraries*

ISO/IEC 18046-5, *Information technology — Radio frequency identification device performance test methods — Part 5: Test methods for Environmental characteristics of RFID tag used in sporting goods*[1)]

ISO/IEC 19762, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*

ISO/IEC 19987, *Information technology — EPC Information Services (EPCIS)*

ISO/IEC 19988, *Information technology — GS1 Core Business Vocabulary (CBV)*

1) Under preparation. Stage at the time of publication: ISO/IEC FDIS 18046-5:2024.

ISO/IEC 20830, *Information technology — Automatic identification and data capture techniques — Han Xin Code bar code symbology specification*

ANSI MH10.8.2, *Data Identifiers*

GS1 General Specifications

GS1 EPC Tag Data Standard (TDS)

GS1 GLN Allocation Rules Standard

GS1 GTIN Allocation Rules Standard

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6707-1, ISO 6707-2, ISO 6707-3, ISO 6707-4, ISO/IEC 19762 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
industrial construction
off-site construction method that incorporates standardized digital design, industrialized manufacturing, *assembly* (3.15) construction, integrated decoration and digital management characteristics

3.2
prefabricated component
structural *component* (3.14) and other components that constitute a building structural system, which is prefabricated in a factory or on-site

3.3
building part
unit that is prefabricated or assembled in a factory or on-site to form a single building product, a composite product of the envelope system, facility and pipeline system, and internal decoration system of a building

3.4
modular unit
integrated factory prefabricated unit, which can be transferred as a whole, such as a complete room, a part of a large room, or integrated function units (e.g. bathrooms, elevators, kitchens and machine rooms)

3.5
integrated kitchen
kitchen that is assembled from factory-produced floors, ceilings, walls, cabinets, kitchen equipment and pipelines, and that is mainly assembled by non-wet construction

3.6
integrated bathroom
bathroom that includes a floor, ceiling, wall, sanitary ware equipment and pipelines produced by the factory and that is mainly assembled by non-wet construction

3.7
connector
unit that is used to connect functional building *components* (3.14) or parts

3.8
accessory
non-structural item that is installed on buildings or structures to improve functions

3.9
metadata
data or model that provide information about other data

3.10
master data
core information about the "who" and "what" in a business relationship

Note 1 to entry: The "who" can include the name, address and identification codes of the buyer and seller plus details of shipping, delivery and billing locations. The "what" shall include the product information such as product name, size, product model and unique identification number.

3.11
traceability
ability to trace all or part of the processes from procurement of *raw materials* (3.13) to production, consumption and disposal to clarify "when and where the product was produced by whom"

3.12
information service
set of system used for gathering, processing, storing and communicating information flow

3.13
material
raw material
substance or mixture of substances that is used to produce a product

Note 1 to entry: Materials are divided into primary materials, also known as primary raw materials, (sand, crushed stone, clay, etc.) and secondary materials, also known as secondary raw materials (concrete, building mixes, rolled metal, etc.).

3.14
component
constituent part of equipment that cannot be physically divided into smaller parts without losing its character

3.15
assembly
set of one or more sub-assemblies or *components* (3.14) constituting a single end-use product

4 Abbreviated terms

AFI application family identifier

AI application identifier

BIM building information modelling

DI data identifier

PC protocol control

HVAC heating, ventilation and air conditioning

5 Methodology

5.1 Industrial construction and AIDC

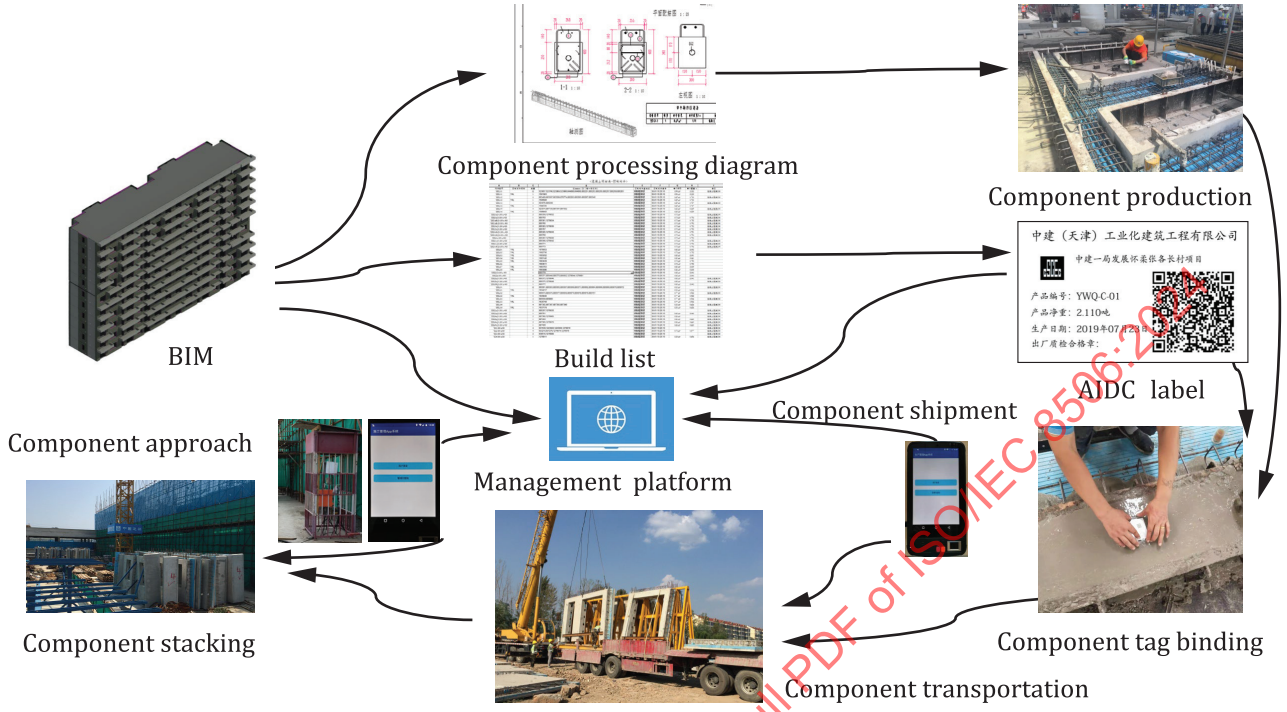


Figure 1 — AIDC and industrial construction

The evolution of industrial construction is requiring efficient supply chain management and transparency, and automatic data collecting and sharing can effectively improve its productivity. AIDC technology is one of the keys to help achieve these measures. The AIDC enhanced industrial construction process, illustrated in Figure 1, starts from planning and BIM project design stage. Right from the early stages of a building's design, architects and engineers can identify the products and parts that meet their specifications, including their environmental and operational cost attributes, and track their delivery on-site the detailed design models of the components or parts which would be the main compositions of the building would be sent to the prefabricated components plants. At the end of the production process, the items, illustrated in Annex A, are AIDC-labelled, and hence, they can be identified during the storage, transportation, assembly and maintenance, and the master data about the items and the process can be recorded. The identification tag would be utilized during the whole life cycle of the components and the construction projects.

5.2 Items in industrial construction

5.2.1 General

Since 1970s, AIDC technology is the main technology used to automatically identify and capture data for items and assets. In the past 50 years, AIDC and its global standardization have stimulated digital transformation and informational management in the retail, healthcare and logistic industries throughout the world.

As items in industrial construction are very different from items in grocery stores and hospitals, data, management approach and life cycle requirement are distinctive to the category of items.

5.2.2 Items categories

5.2.2.1 Items without off-the-shelf identifications

This category "items without off-the-shelf identifications" includes the prefabricated components, parts, connectors, and the roofing, windows and doors, items in the HVAC and firefighting items etc. Physical items can also be classified as industrial construction items, such as building unit, apparatuses, assets or parts of the building or infrastructure. The characteristic to identify physical items is that they are the objects of information management for industrial construction and unique identification is required. For this category, the methodology and identification framework rules defined in 5.3 and Clause 6 shall apply, and the detailed identification solutions will be standardized in future documents.

5.2.2.2 Items with off-the-shelf identifications

The category "items with off-the-shelf identifications" includes items are mainly the products that already have globally accepted ISO standardised AIDC data carriers and that are uniquely identified according to ISO/IEC 15459-1, ISO/IEC 15459-4, ISO/IEC 15459-5 and ISO/IEC 15459-6. For example, the lights which already have GS1 barcodes. The identifications shall be maintained, recorded and referenced by information management systems of industrial construction during the life time of the items as the identification is agreed between business partners, and detailed information about the characteristics of the item such as brand name, net weight/content and package measurements, is available for partners. One item shall not carry more than one unique identifier. All users of GS1 identification keys and supporting data attributes shall comply with the conformance specifications and rules provided in GS1 General Specifications, which include the allocation and management rules for each GS1 identification key.

NOTE GS1 identification keys and GS1 application identifier data and GS1 data carriers are defined in GS1 General Specifications.

5.2.3 Hierarchy, relationship and life cycle

Hierarchy are the key characters for the identification and data record of components, connectors and building parts, etc. The hierarchy in this document means the composition relationships among different level of items. The hierarchy for the items in industrial construction are defined by detail-designed BIM model of different building, prefabricated components, building parts, modular units and accessories in the certain construction project. For example, a building part is made of two specific components connected by five specific connectors. See Figure 2 for a reference.

The relationship of the items in industrial construction are defined by detail-designed BIM model of different building, prefabricated components, building parts, modular units and accessories in the certain construction project. As for the components, connectors and building parts, the connection and installation order of the items are the key characters for its identification and data record.

Life cycle for the identification are mainly defined by the stakeholders of the construction which can be the contractor, subcontractor, owner, maintainer, end-users or other entities defined by regulations or orders of certain territory. The identification shall be valid during the defined life cycle.

5.3 Methodology of identification in industrial construction

5.3.1 Methodology overview

The hierarchy, relations and life cycle of entities in industrial construction is illustrated in Figure 2.

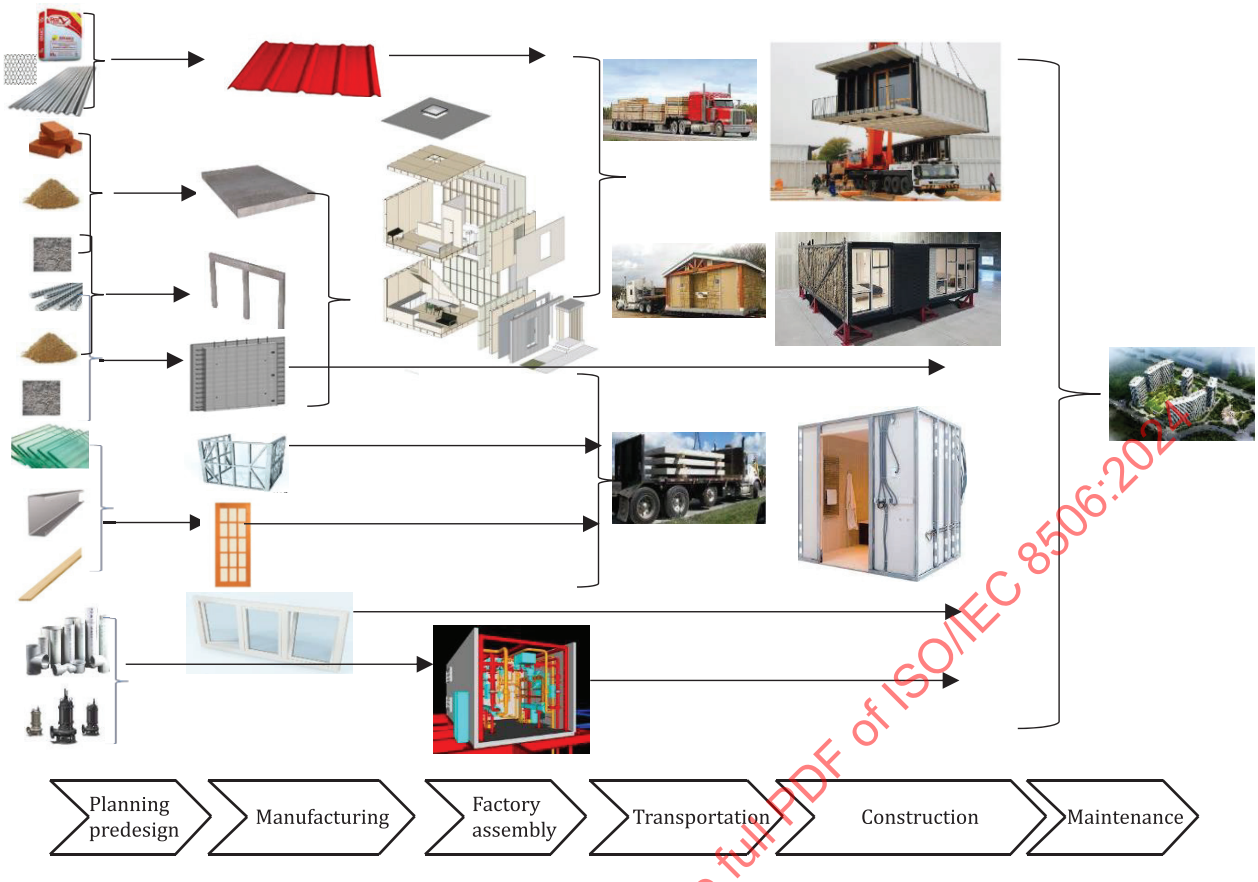


Figure 2 — Hierarchy, relationship and life cycle of industrial construction entities

The items in industrial construction is illustrated as building materials, building parts, modular units, components, connectors and the identification methodology includes the configuration of the what, who, when, where and how issues about entities in the whole construction process – see Figure 3.

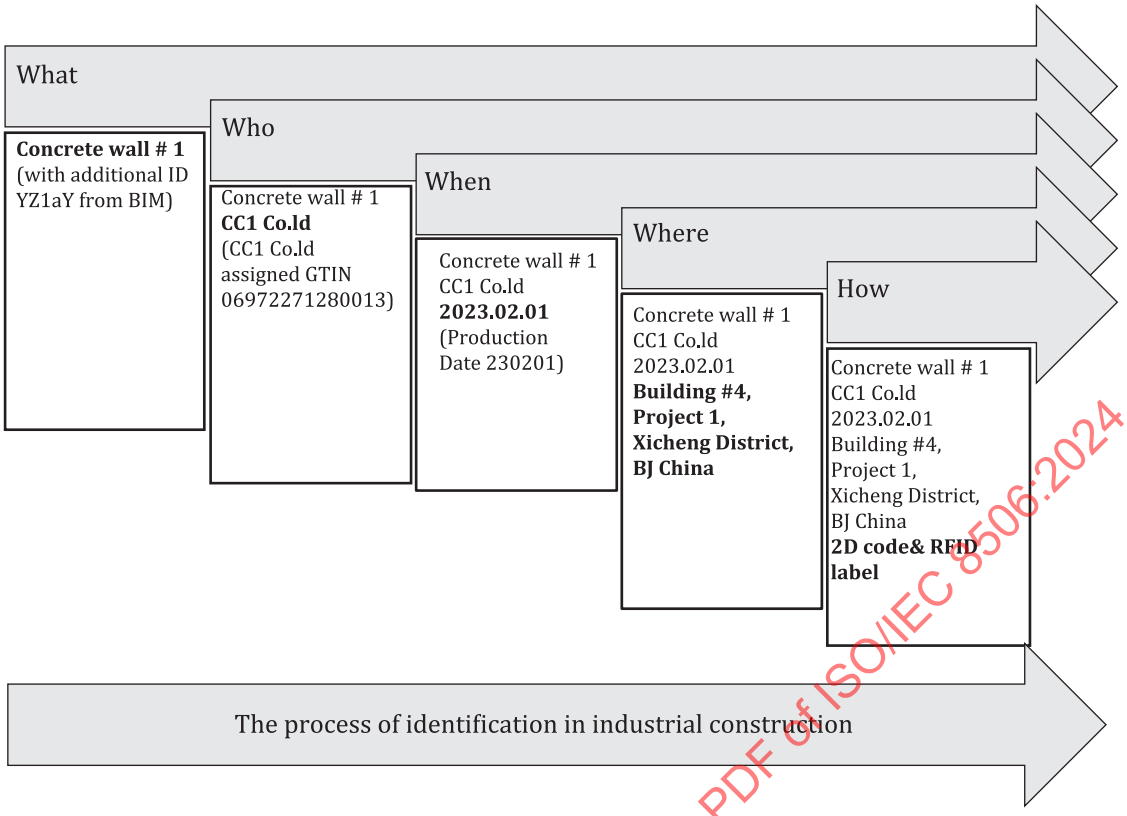


Figure 3 — Identification methodology for industrial construction

5.3.2 What: Item to be identified

5.3.2.1 Physical entities in construction

The physical entities in construction, such as the building materials, components, building parts, connectors, accessories and their groupings during the manufacturing and logistic process shall be identified.

a) The building materials includes a large variety of cement, sand, steel, glass, timber, bamboo, tiles, bricks, wires and tunnels as illustrated in Figure 2. The identification of building materials shall be defined in accordance with the physical materials, the package and the amount of the materials. The predefined unit or certain amount of building materials shall be bound with an AIDC data carrier of corresponding unique identification on the packages or its surface.

b) The components which includes the walls, pillars, girders, plates etc., that are manufactured in plants, shall be numbered in accordance with the unique identification rules in Clause 6 and can be individually identified. The connectors and the accessories such as sleeves or doors shall be identified individually or on their packages. The components, connectors or accessories shall be labelled with an AIDC data carrier of corresponding unique identification.

c) The building parts, such as stairs, integrated kitchens, integrated bathrooms, bridge segments which would be formed or assembled by components, connectors and/or construction materials in plants or in the construction site, shall also be numbered and identified individually. The building parts shall be labelled with an AIDC data carrier of corresponding unique identification.

d) The modular units, such as the modular units in the structural system, the external-envelope system, the facility and pipeline system, and the internal decoration system of a construction or infrastructure which are formed by factory-produced components, construction material, HVAC devices, pumps, etc., are all objects that shall be identified. The modular units shall be labelled with an AIDC data carrier of corresponding unique identification.

5.3.2.2 Physical assets

The assets in a building or infrastructure, such as facilities, devices and the accessories such as windows or doors, shall also be identified. Physical assets are the physical entities or their derivatives in the construction process in most cases after the construction or the infrastructure is delivered and treated as physical assets. A physical entity can be a product at one stage of its life cycle and an asset at another. The use of a product identifier shall be tied to business processes associated with products such as ordering, stock keeping and invoicing. The use of an asset identifier shall be tied to business processes associated with asset management such as capitalized assets, depreciation, maintenance, repair and operations.

The typical assets are the items which are functional content or fraction of a building or infrastructure which shall be managed and maintained by owners. The assets include devices, modular units and/or accessories such as doors and windows. The physical assets shall be labelled by owners of them with an AIDC data carrier of corresponding unique identification, which shall be read and recorded during their life cycle.

5.3.2.3 Location

The location or position of a building or infrastructure or relative location in a building or infrastructure shall be identified with unique identification. The unique identification of location shall be recorded in the industrial construction process or maintenance process etc. with their GLNs or other location references. The use of GS1 Global Location Number (GLN) shall comply with GS1 GLN Allocation Rules Standard. The other location identification shall be led by location reference ANSI MH10.8.2 Data (L-999L) of identifiers. The unique identification of location can be labelled on the physical surface of the location and can be read, verified and recorded during the construction or assets management process.

5.3.3 Who: Partner responsible for identifying items

The brand owners of some identified items such as construction material supplier or connector and accessories supplier shall be the responsible party for the identification of their own items. The other responsible partners who shall add tags on items like components, building parts and/or modular unit can be contractors, sub-contractors or owners of construction projects etc. They shall be the owner of one of the company identification number (CIN) issued by an issuing agency in the frameworks of ISO/IEC 15459-2 and ISO/IEC 15459-3. The rules of the chosen issuing agency shall be applied. This is, for example, the item number allocation rules, code specifications and other application details.

5.3.4 When: Duration of the identification and the AIDC

The identification shall begin as soon as the item is manufactured and shall last for the intended management requirements timeline. For example, the identifier for the specific quantity of wall paintings.

The identification shall be either utilized or recorded, or both as the completion of the manufacturing or construction, and the AIDC shall be available during the intended timeline in the intended or casual construction or maintenance environment.

5.3.5 Where: Place of identification

The position identification conforms with ISO/IEC 6523-1 and the relevant information of the items and the process can be collected and ascertained, recorded, shared, exchanged and re-examined between stakeholders of the industrial construction. The actual position of the tagging, writing and reading events shall be subject to the agreement or contract between partners.

5.3.6 How: Identification, data and information services solutions

The identification, which shall follow the rules in Clause 6, related data of identification and business evens, and information services solutions shall be clarified for different items in industrial construction business. The actual identification data carrier solution shall be subject to the requirement or contract of partners to meet the requirement of the construction project.

6 Unique identification framework

6.1 General rules

6.1.1 General

Unique identification means to issue a unique data string which “represents” an item that can be encoded in the AIDC data carrier and attached to the item. The unique identification links the relevant data record with the item in the object information management systems. However, the item mentioned can be in a different form of granularity and shall be issued by appropriate partners on the consideration of the balance between cost and management requirements. The unique data string shall comply with ISO/IEC 15459-3, and shall be determined by an issuing agency code (IAC) unique enterprise identifier (CIN) assigned by issuing agencies.

6.1.2 Standard name level or model level

As for the physical items defined in 5.3.2.1 and 5.3.2.2 such like prefabricated components, the highest identification granular level shall be the item with the same name in the same type of items in the plant. The characteristic for this identification granularity is that the things under this item shall have the same model name, detailed design model in BIM, cost and materials (e.g. one kind of prefabricated components designed by a manufacture with the defined shape, dimensions and manufacture parameters).

6.1.3 Batch or lot level

The lower granular for physical items defined in 5.3.2.1 and 5.3.2.2 can be the components with the same batch or lot number which differs from the other with production details, or can be required by partner or regulations to identify at this level. For example, the batch of the said prefabricated components in 6.1.2 with the batch number A0522.

6.1.4 Serial level (unique identifier item)

The most granular level shall be the unique identifier item (UII) for each of serial items which bound to the specific time, place or other detailed production information or required by partners or regulations to identify at this level (e.g. a single component of the said prefabricated component in 6.1.3). The batch or lot number can be referenced by the UII.

The UII shall contain the IAC, unique enterprise identifier (CIN) assigned by the issuing agency, and the serial number for each single item. The UII can also contain additional AIDC data. See ISO/IEC 15459-3 for more details.

6.2 Principles of unique identification

6.2.1 Uniqueness principle

The uniqueness principle includes the following concepts.

a) The sole purpose of the unique identification is to uniquely identify the item, not to carry information about the item.

b) Differences in the basic characteristics for certain granularity items shall result in a different unique identification and each single item on the serial granularity level shall be assigned a unique serial number. All users of GS1 identification keys and supporting data attributes shall comply with rules provided in GS1 General Specifications, which include the allocation and management rules for each GS1 identification key.

NOTE GS1 identification keys and GS1 application identifier data are defined in GS1 General Specifications.

c) Each single physical item on the serial granularity level shall be assigned a serial number.

d) In general, the party which is responsible for the quality and management of the items shall be responsible for the uniqueness of the unique identification for items. The allocation of GS1 unique identification shall follow the rules in GS1 General Specifications and related documents such as GS1 GTIN Allocation Rules Standard and GS1 GLN Allocation Rules Standard.

e) Related data, other than the unique identification, linked to the items shall be recorded, maintained, stored and transferred by the issuer.

6.2.2 Stability principle

The stability principle includes the following concepts.

a) Once the unique identification number is assigned, it shall remain unchanged if the basic characteristics of the item have not changed.

b) The unique identification shall be valid during the existence of the referenced item.

NOTE Valid means that the unique identification number and the linked data in issuer can be retrieved from the issuer by other parties.

c) The unique identification number shall not be reassigned to another item.

d) Data, other than the UII, that is linked to the items shall be recorded, maintained, stored and transferred by the issuer.

6.3 Unique identification and its data carrier

The unique identification shall consider the differences among building materials, prefabricated components, building parts, connectors, modular unit, assets and positions. The unique identification shall be as given in the following standards.

a) The unique identification shall comply with ISO/IEC 15459-1, ISO/IEC 15459-4, ISO/IEC 15459-5 and ISO/IEC 15459-6.

b) The syntax of unique identification in 2D barcode data carrier shall conform to ISO/IEC 15418, ISO/IEC 15434 and/or rules in the ISO/IEC standardized data carrier symbology standards such as ISO/IEC 16022, ISO/IEC 18004 and ISO/IEC 20830. When choosing a 2D barcode as a data carrier, the data carrier identifier defined in ISO/IEC 15424 can prefix the unique identification message before transmission.

c) The syntax for RFID tags shall comply with ISO/IEC 15961-1, ISO/IEC 15961-3, ISO/IEC 15961-4, ISO/IEC 15962 and ISO/IEC 15963-1. The RFID tag which carries GS1 data shall also comply with GS1 EPC Tag Data Standard (TDS). The RFID tag and devices shall comply with air interface standards such as ISO/IEC 18000-63 or ISO/IEC 18000-3:2010, Mode 3. When choosing RFID as a data carrier, encoding rules described in Annex B shall be used. Examples of identifiers are provided in Annex C.

7 Application test

The application test shall be conducted at typical application environment. These tests shall include a series of performance tests and mechanical tests of the tags and readers under extreme temperature, with different tagging and labelling methods, and after some mechanical processes such as scratch, pressure and corroding. The performance test shall be based on ISO/IEC 18046-1, ISO/IEC 18046-2, ISO/IEC 18046-3, ISO/IEC 18046-4 and ISO/IEC 18046-5. The test methods and performance requirements for factories, transportation and on-site construction scenarios will be standardized in another standard.

8 Metadata

Metadata are the basic information units of prefabricated components, connectors, component parts and accessories. They are the property data set or data model to describe the information recorded from the real

physical objects and can be standardized separately. For each kind of entity, the metadata set can include the classification of objects according to IEC 81346-1, IEC 81346-2, ISO 81346-10, ISO 81346-12, and the data set to describe the real entities such as the manufacture's name, weight, three-dimensional measurement and/or other characters.

9 Information service

An information service framework with reference to ISO/IEC 19987 and ISO/IEC 19988 provides the data interface and business interoperation interface between the AIDC systems and the application systems, and defines the application program interfaces (APIs) of services for partners and consumers to access. It also shall define the service registration strategy and resolve strategy.

10 Application guide

10.1 General

The application guidelines shall provide practical guidance for all staff of stakeholders in the industry chain such as designers, manufacturers, constructors, construction engineers, owners and maintainers regarding the application of AIDC technology in their daily work. They are the best business practices standards to promote the effective collaboration of all parties in the industry chain to implement applications in different scenarios.

10.2 Guidance for the designer

The designer formulates different data templates based on different design software (BIM/CAD) which are in turn based on the overall requirements and basic principles of AIDC application. The designer also submits relevant key design information to the manufacturer accordingly.

10.3 Guidance for the manufacturer

The manufacturer connects the key information of the designer and ensures that the factory's products can be correctly and efficiently identified to promote lean production and industrialized construction. This is the key importance of AIDC technology which connects virtual construction and physical construction.

10.4 Guidance for the constructor

Based on the management considerations of the whole life cycle of the construction project, the constructor takes the lead and all parties participate, put forward the overall requirements and basic principles of AIDC application, and jointly promote its achievement.

10.5 Guidance for the construction engineer

Guidance for construction engineer guides construction engineers to flexibly apply AIDC technology to promote construction efficiency and project quality traceability.

10.6 Guidance for the owners and maintainer

Guidance for owners and maintainers guides owners and maintainers to uses AIDC technology to promote daily inspections, troubleshooting and preventive maintenance.

10.7 Guidance for the consumers and the public

Guidance for consumers and the public guides the public to apply AIDC technology to improve the convenience of living.

Annex A
(informative)

Background information about industrial construction

A.1 Process of industrial construction

A.1.1 Planning stage

Construction projects are not single activities. In order for construction projects to be executed in a cost-efficient manner, effective planning is required. At this stage, the physical and financial framework for the construction or infrastructure is complete.

A.1.2 Pre-design or conceptual design stage

Pre-design is the phase of analysis that occurs after some form of funding is available. During the pre-design phase, studies are done to analyse space requirement issues, the constraints and opportunities of the proposed site, and the cost versus the budget. The amount of funding available in the pre-design phase varies and is a critical factor in determining which studies take precedence. Funds can be available to develop a detailed project or only to investigate certain technical issues in order to determine the scope, budget or project schedule.

A.1.3 Detailed design stage

Detailed design is sometimes referred to as 'developed design' or 'definition'. It is the process of taking on and developing the approved concept design. By the end of the detailed design process, the design can be dimensionally correct and co-ordinated, describing all the main components of the building and how they fit together. However, technical aspects of the design can require further development. At this stage, the proper prefabricated components, connectors and parts are designed or chosen as part of the construct.

However, some technical aspects of the design can require further development; design by components specialists, is yet to be done.

A.1.4 Manufacturing stage

At the manufacturing stage, the whole models of the precast components, assemblies or parts are determined and go directly into an automated production line for fabrication. Production lines can include industrial robots, overhead gantries, conveyors or other automated equipment that complete the translation of materials to building components and assemblies. The components, parts or connectors are needed for product identification at this stage.

A.1.5 Transportation stage

The prefabricated component transportation and storage are critically important operations, especially for the projects located in the downtown, where space available for prefabricated components storage is limited. The transportation plan of prefabricated components determines whether there would be sufficient components and space on-site, respectively, for construction and for storage. The storage layout affects the time of hoisting, relocation times and then the construction efficiency. Here, the word “relocation” refers to the operation of removing the above components in a stack of prefabricated components in order to access the desired component to be installed according to the construction sequence of prefabricated components.

A.1.6 Assembly or installation stage

At the assembly or installation stage, elements manufactured off-site are assembled and installed in a construction site environment. The works includes

— carrying out dimensional checks of the slab and mark up positions, e.g. starter bars and rails according to specifications and drawings,

— erect components such as panels, large format block work, staircases, columns, flooring, lintels and pods according to specifications and drawings,

— installing propping and other temporary works such as edge protection as per specifications and drawings,

— carrying out structural connections using items such as, rebar, strand, grout and specialist fixings as per specifications and drawings, and

— carrying out finishing works and installation of the ancillary items such as window formers, cavity trays and insulation products.

A.1.7 Maintenance or repair and recycling stage

Maintenance is the process of ensuring that buildings and other assets retain a good appearance and operate at optimum efficiency. Inadequate maintenance can result in decay, degradation and reduced performance, and can affect heath and threaten the safety of users, occupants and others in the vicinity. At this stage, the identification of the items of the construct shall be recorded and maintained for either repair or recycling, or both.

A.2 Item examples to be identified

A.2.1 General

The physical entities, such as the components, parts, connectors, accessories and their groupings during the logistic process, and the functional parts after the assembly, can be identified.

The components include, for example, walls, pillars, girders, plates which can be individually identified. The connectors and the accessories can be sleeves or doors which have packages. The parts, such as stairs or kitchens would be formed in plants or in the construction field, and shall also be identified properly.

A.2.2 Beams and girders

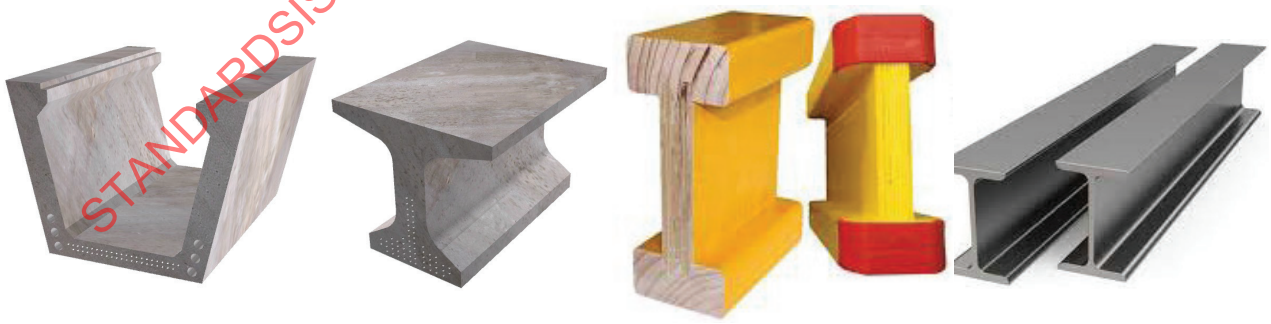


Figure A.1 — Examples of beams and girders in industrial construction

Beams or girders are horizontal components that provides support to other components, see Figure A.1. For example, precast hollow-core, solid slab flooring or roofs. They can be pre-stressed or conventionally reinforced. This depends on the span lengths and loads. These structural pieces are typically rectangular, L-shaped or inverted tee-shaped, and can be, for example, concreate, steel or timber.

A.2.3 Columns

Prefabricated columns are vertical load-bearing components with haunches or corbels used to transfer horizontal loads to the foundations. Columns can be fabricated in various shapes, sizes and colours. See Figure A.2.

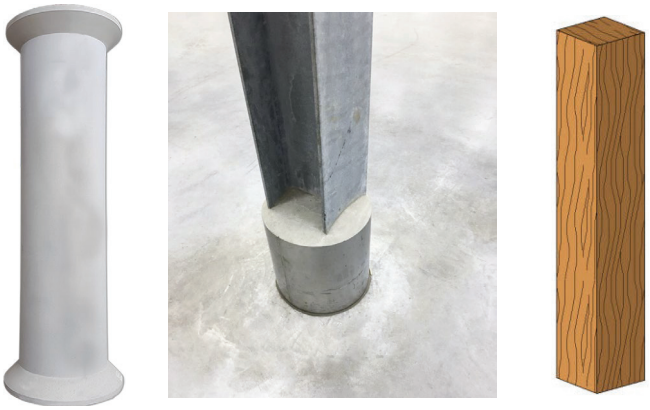


Figure A.2 — Columns in industrial construction

A.2.4 Slabs

Slabs are offered in a variety of sizes and are flexible for us in a multitude of flooring and foundation applications, see Figure A.3.

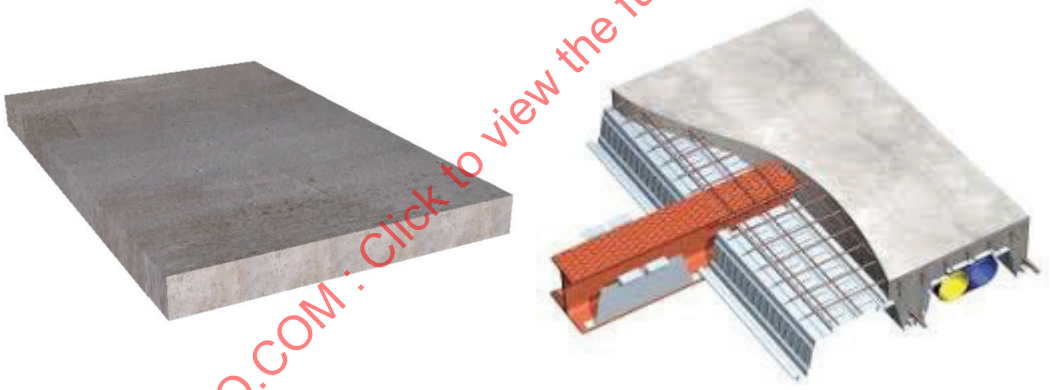


Figure A.3 — Slabs in industrial construction

A.2.5 Foundations

Prefabricated foundations are designed to accelerate the production and only require minimal excavation and soil compaction prior to placement. This saves both time and money when compared to traditional cast-in-place foundations. See Figure A.4.

Figure A.4 — Foundations in industrial construction

A.2.6 Walls or panels

Prefabricated walls or panels are used in many interior, exterior, and load bearing or non-load bearing building applications. They provide a professional finished look as well as increased thermal properties. The walls or panels are produced in a wide range of materials and sizes to meet a variety of application needs. See Figure A.5.

Figure A.5 — Walls and panels in industrial construction

A.2.7 Building parts

Parts such as stairs, kitchen or water closet can be produced and transported as a whole. Some parts (functional parts) also can be assembled at the construction site with components. Figure A.6 illustrates some examples of parts.

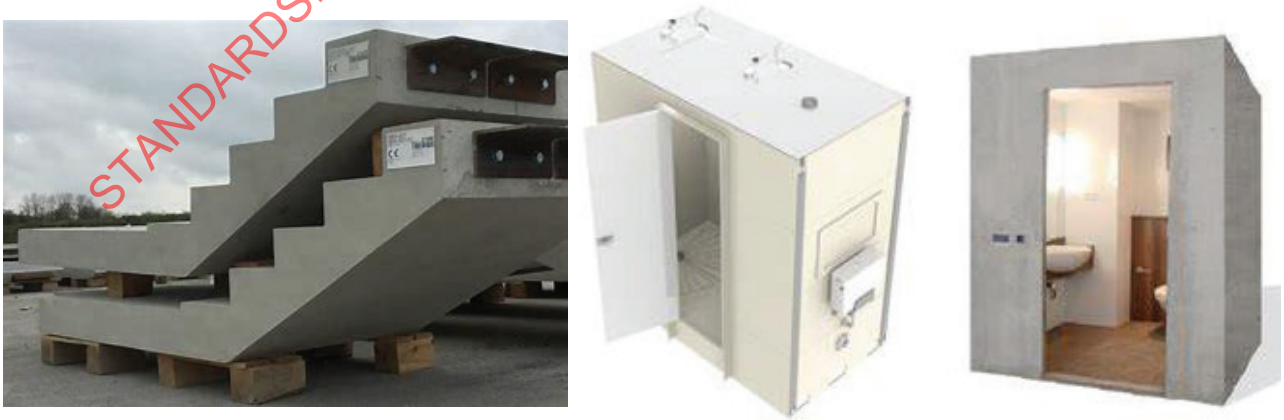


Figure A.6 — Parts in industrial construction

A.2.8 Structural system

Figure A.7 — Example of a structural system

Structural system is a whole that is assembled by structural components through reliable connection to withstand or transmit load effects. Common structural building parts can be composed of concrete components, steel structural components, wood structural components and bamboo structural components. Taking prefabricated concrete buildings as an example, the typical precast concrete components of the structural building part include precast walls or panels, precast columns, precast beams, concrete composite slabs and precast stairs. See Figure A.7.

A.2.9 Envelope system

The envelope system is composed of building exterior walls, roofs, exterior doors and windows and other parts, and is used to divide the entire parts and components of the indoor and outdoor environment of the building. Taking the prefabricated concrete building as an example, the typical components and parts of the envelope system include facade panels, bay windows, external doors and windows and roof envelope systems. See Figure A.8.

Figure A.8 — Example of an envelope system

A.2.10 Internal decoration system

The internal decoration system is composed of floor, wall, lightweight partition, ceiling, interior doors and windows, kitchen and bathroom, etc., to meet the overall requirements of the building space. Taking prefabricated concrete buildings as an example, the typical components and parts of the internal decoration system include assembled internal partition walls, assembled floors, assembled ceilings, interior doors and windows, integrated kitchens, and integrated bathrooms. See Figure A.9.

Figure A.9 — Example of an internal decoration system

A.2.11 Facility and pipeline system

The facility and pipeline system is composed of water supply and drainage, heating, ventilation and air conditioning, electrical and intelligent, gas and other equipment and pipelines to meet the overall function of the building. Taking prefabricated concrete buildings as an example, the typical components and parts of the facility and pipeline systems include assembled machine rooms, pipeline wells and modular fresh air system. See Figure A.10.

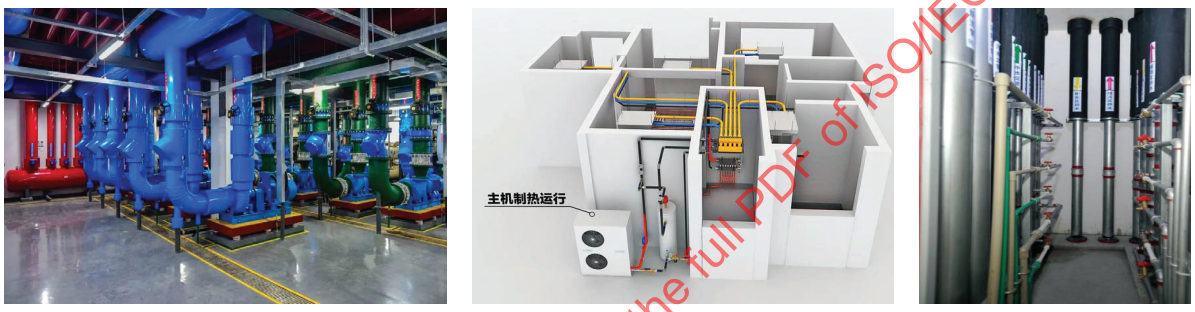


Figure A.10 — Example of a facility and pipeline system

A.2.12 Precast utility tunnel

A precast utility tunnel is cast and formed in sections in the factory, and the on-site assembly process is used to construct an entire integrated utility tunnel. See Figure A.11.

Figure A.11 — Example of a precast utility tunnel

A.2.13 Prefabricated bridge

A prefabricated bridge is a bridge that is composed of prefabricated components or parts connected and combined in various reliable ways. See Figure A.12.

Figure A.12 — Example of a prefabricated bridge

A.2.14 Precast drainage pipe

A precast drainage pipe is a drainage pipe that is prefabricated at the factory. See Figure A.13.

Figure A.13 — Example of a precast drainage pipe

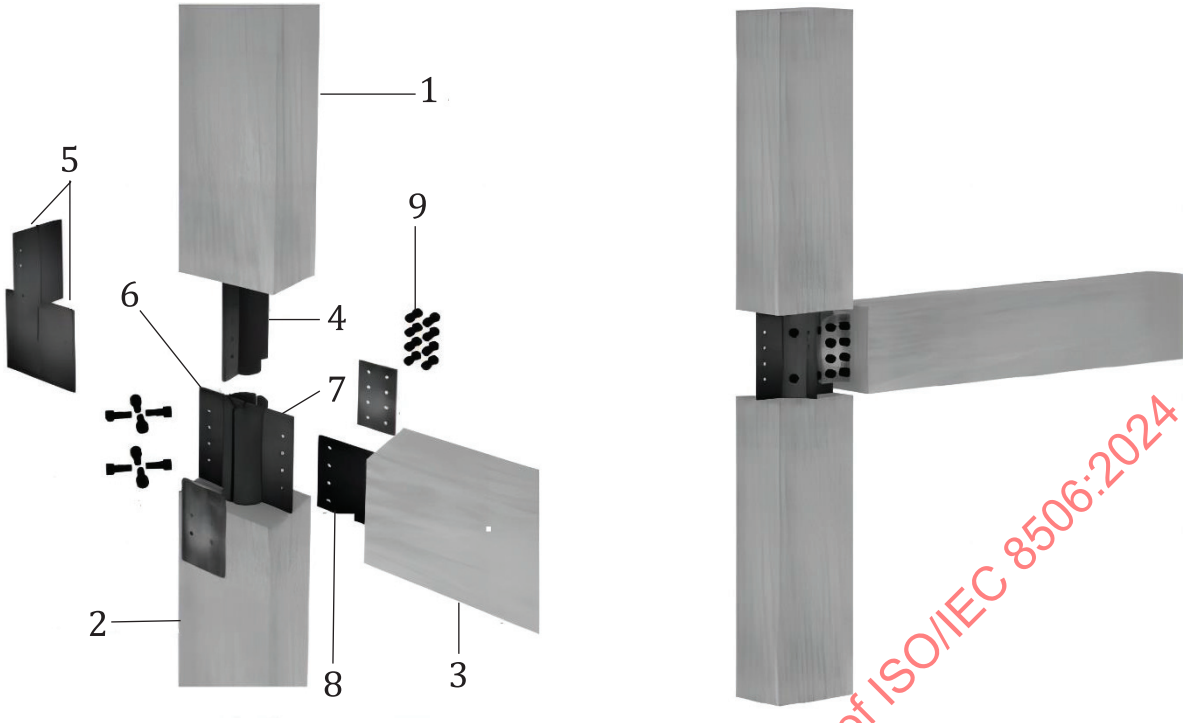
A.2.15 Reinforced concrete segment

The segment is precast in the factory with steel bars and concrete as the main raw materials, mainly used for subway construction. See Figure A.14.

Figure A.14 — Example of reinforced concrete segment

A.2.16 Connectors

The connectors include, for example, the sleeves, to link the prefabricated components or parts together, see Figure A.15.



a) Before connection **b) After connection**

Key

1 upper column (prefabricated component)
2 lower column (prefabricated component)
3 beam (prefabricated component)
4 bottom tube (connector)
5 gusset plate (connector)
6 top tube (connector)
7 packing plate (connector)
8 protruding plate (connector)
9 steel bolt (connector)

Figure A.15 — Connectors in industrial construction

A.2.17 Accessories

The accessories include windows, doors, devices, pipes and building materials, etc.

Annex B
(normative)

RFID encoding

B.1 General

This document recommends three possible forms of encoding for ISO/IEC 18000-63 and ISO/IEC 18000-3:2010, Mode 3 RF tags:

— a GS1 SGTIN-96, SGTIN-198, SGTIN+, and DSGTIN+, GIAI-96, GIAI-202 and GIAI+ compliant form for the UII in Memory Bank “01”:

  — the segmentation of ISO/IEC 18000-63 and ISO/IEC 18000-3:2010, Mode 3 tags is illustrated in Figure B.1;

  — SGTIN and GIAI encoding is detailed in GS1 EPC Tag Data Standard (TDS);

— a structure employing ISO/IEC 15962:2022, Format 13 (relative OID) in MB “11”;

— a simplified structure, encoding an entire ISO/IEC 15434 message as a unit, employing a “no directory”, encoded in either six-bit or UTF-8, as defined in ISO/IEC 15962 and as described in the remainder of this annex in MB “11”.

B.2 Tag structure

Each of these encoding forms can be unambiguously discerned by the content of bits 0x17 through 0x1F of a Memory Bank “01”, as illustrated in Figure B.2 and bits 0x00 through 0x1F of a Memory Bank “11”.

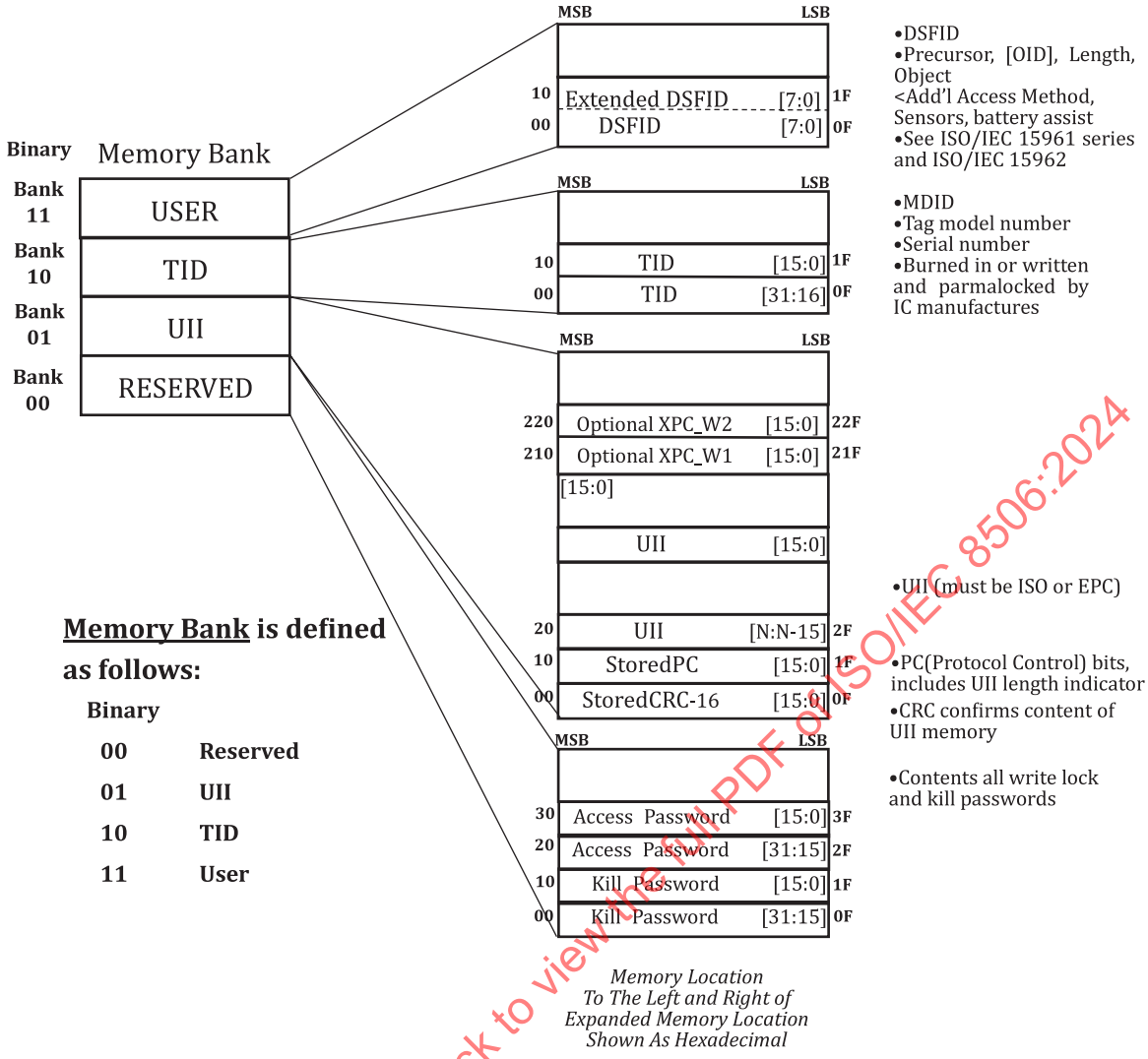


Figure B.1 — ISO/IEC 18000-63 and ISO/IEC 18000-3:2010, Mode 3 logical memory structure

The <Reserved> values in Figure B.1 shall not to be used without a re-issuance of this document that reflects the defined values and functionality. An example would be a decision of the GS1 community to use this encoding and petitioning for the encoding of an ECI. Additionally, the presence of one or more of these characters can signal a different behaviour on the part of the decoder. While these <Reserved> values are not used in this iteration of this document, they shall not be used for any other purpose than defined by this document.

Tag memory shall be logically separated into four distinct banks, each of which can comprise one or more memory words. A logical memory map is given in Figure B.1. See ISO/IEC 18000-63 for details. A general description of the memory banks is as follows.

— Reserved memory (MB00) shall contain the kill and access passwords.

— UII memory (MB01) shall contain a CRC-16, protocol control (PC) bits and a code, i.e. a UII, which identifies the object to which the tag is or will be attached. See Figure B.2.

— TID memory (MB10) shall contain an 8-bit ISO/IEC 15963-1 allocation class. TID memory shall contain

  — sufficient identifying information for an interrogator to uniquely identify either the custom commands or optional features, or both, that a tag supports, and, to be compliant to this document, and

— a unique serial number.

— User memory (MB11) allows user-specific data storage. The storage format described in ISO/IEC 15961-3 and ISO/IEC 15962 defines the memory organization.

B.3 Protocol control bits

The PC bits contain physical-layer information that a tag backscatters with its UII during an “inventory” operation. There are 16 PC bits, stored in UII memory. See Figure B.2.

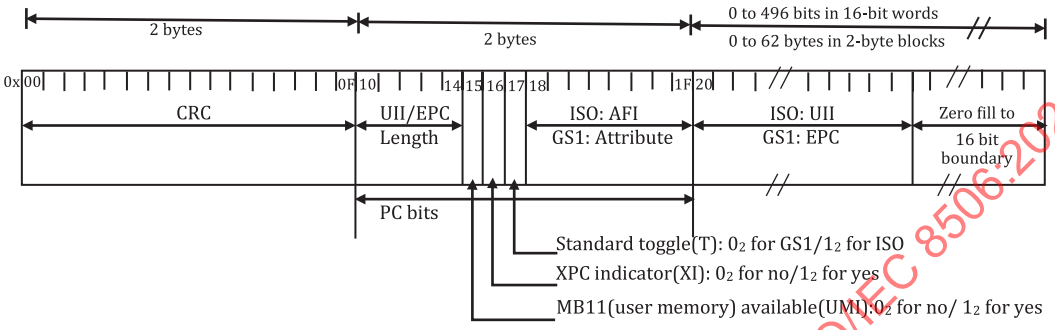


Figure B.2 — ISO/IEC 18000-63 and ISO/IEC 18000-3:2010, Mode 3 structure of Memory Bank 01

B.4 Encoding a Memory Bank 01 unique item identifier

Bit 0x17 of MB01 is the switch between ISO formats and EPC formats. When Bit 0x17 is set to a “0”, the UII encoding is as per GS1 EPC Tag Data Standard (TDS). When Bit 0x17 is set to a “1”, the UII encoding is as per ISO/IEC 15459-1, ISO/IEC 15459-4, ISO/IEC 15459-5, ISO/IEC 15459-6, preceded by an ISO/IEC 15961 application family identifier (AFI).

When using GS1 format, the encoding of a MB01 shall be done as per Figure B.3.

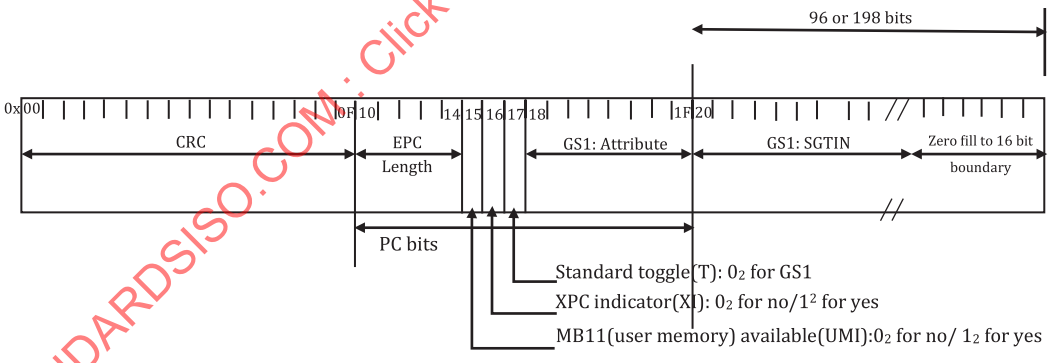


Figure B.3 — Encoding a MB01 using GS1 format

When using the ISO format, the encoding of a MB01 shall be done as per Figure B.4.

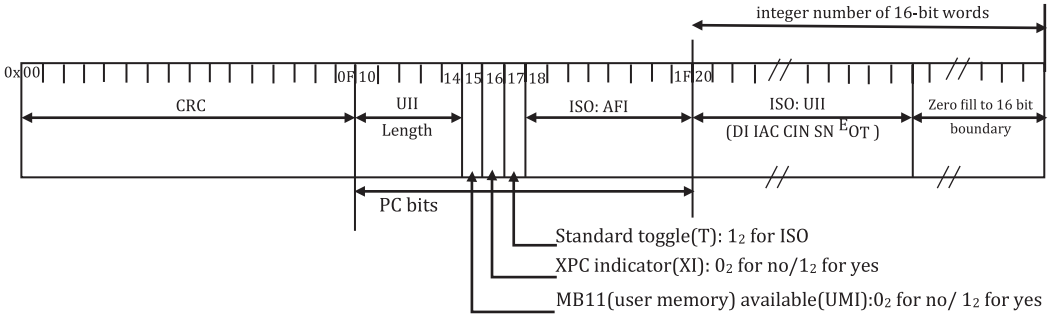


Figure B.4 — Encoding of a MB01 using ISO format

For ISO format RFID purposes, the AFI would be added to the data structure:

— AFI = 0xA1

— DI = 25S

— IAC = UN (DUNS)

— CIN = 043325711

— SN = MH8031200000000001

A complete data structure, using the information defined above, is 0xA125SUN043325711MH8031200000000001. It is represented by the six-bit encoding in Table B.1 in MB01 and is shown in Table B.2.

Table B.1 — Six-bit encoding

Space	100000	**0**	110000	**@**	000000	**P**	010000
E_{O_T}	100001	**1**	110001	**A**	000001	**Q**	010001
Reserved	100010	**2**	110010	**B**	000010	**R**	010010
F_S	100011	**3**	110011	**C**	000011	**S**	010011
U_S	100100	**4**	110100	**D**	000100	**T**	010100
Reserved	100101	**5**	110101	**E**	000101	**U**	010101
Reserved	100110	**6**	110110	**F**	000110	**V**	010110
Reserved	100111	**7**	110111	**G**	000111	**W**	010111
(	101000	**8**	111000	**H**	001000	**X**	011000
)	101001	**9**	111001	**I**	001001	**Y**	011001
*	101010	**:**	111010	**J**	001010	**Z**	011010
+	101011	**;**	111011	**K**	001011	**[**	011011
,	101100	**<**	111100	**L**	001100	\	011100
-	101101	**=**	111101	**M**	001101	**]**	011101
.	101110	**>**	111110	**N**	001110	**G_S**	011110
/	101111	**?**	111111	**O**	001111	**R_S**	011111

NOTE Table B.1 is six-bit encoding created through the simple removal of the two high-order bits from the 7-bit character set of ISO/IEC 646, save the shaded values. The shaded values are re-assigned, as provided, to minimize the bit count when using the ISO/IEC 15434 envelope.