

INTERNATIONAL STANDARD

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10374

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AMENDMENT 1
1995-12-15

Freight containers — Automatic identification

AMENDMENT 1

Conteneurs pour le transport de marchandises — Identification automatique

AMENDEMENT 1



Reference number
ISO 10374:1991/Amd.1:1995(E)

ISO 10374:1991/Amd.1:1995(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Amendment 1 to International Standard ISO 10374:1991 was prepared by Technical Committee ISO/TC 104, *Freight containers*, Subcommittee SC 4, *Identification and communication*.

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Freight containers — Automatic identification

AMENDMENT 1

Page ii

Replace the last paragraph with the following:

Annexes A and B form an integral part of this International Standard.

Page iii

In the second paragraph, first line, delete:

"..., which is an informative annex only,"...

Page 12

Change the status of annex B from informative to normative. The heading to annex B now reads as follows:

Annex B (normative)

AEI reflected energy system — Technical specifications

ICS 55.180.10

Descriptors: containers, freight containers, identification methods, information marks, tags (data processing), data blocks, data codes, data processing, data transmission, automatic systems, specifications.

Price based on 1 page

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**ISO
10374**

First edition
1991-10-01

Freight containers — Automatic Identification

*Conteneurs pour le transport de marchandises — Identification
automatique*



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ISO 10374:1991(E)

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International Standard ISO 10374 was prepared by Technical Committee ISO/TC 104, *Freight containers*, Sub-Committee SC 4, *Identification and communication*.

Annex A forms an integral part of this International Standard. Annex B is for information only.

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Introduction

This International Standard specifies a system for the automatic identification of freight containers and the electronic transfer of the identity of the container and permanent related information to third parties in a standard format. It is intended that the Automatic Equipment Identification (AEI) system will facilitate documentation, resource control, and communications (including electronic data processing systems). The visual container identification markings specified by ISO 6346 are not affected. Future additions to this International Standard will specify modulation, encoding and an open protocol.

Annex B, which is an informative annex only, describes the technical specification of a system that complies with the requirements of this International Standard. Parts of annex B are covered by patents held by

Amtech Corporation
17304 Preston Road E 100
Dallas, Texas 75252
USA

The patent-holder has stated that licences will be granted under reasonable terms and conditions.



Freight containers — Automatic identification

1 Scope

This International Standard establishes

- a) a container identification system which allows the transfer of information from a freight container to an automatic processing system by electronic means,
- b) a data coding system for container identification and permanent related information which resides within an electronic device called a tag installed on a freight container,
- c) a data coding system for the electronic transfer of both container identification and permanent related information from an electronic device installed on a freight container to automatic data processing systems,
- d) the description of the data to be included in the tag for transmission to the sensing equipment,
- e) performance criteria necessary to ensure consistent and reliable operation of the automatic equipment identification (AEI) system within the international transportation community,
- f) requirements for the physical location of the electronic device on freight containers, and
- g) security features to inhibit malicious or unintentional alteration of the information content of the electronic device when installed on a freight container.

It specifies all necessary user requirements in order to permit international use of the tag without modification or adjustment.

This International Standard applies to freight containers as defined in ISO 668 (see 3.1).

The use of AEI systems and the equipping of containers for automatic identification is not mandatory. The purpose of this International Standard is to optimize the efficiency of equipment control systems.

For this reason, any AEI system used for identifying containers shall conform to and be compatible with this International Standard.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 646:1983, *Information processing — ISO 7-bit coded character set for Information Interchange*.

ISO 668:1988, *Series 1 freight containers — Classification, dimensions and ratings*.

ISO 6346:1984, *Freight containers — Coding, identification and marking*.

IEC 68-2 (all parts), *Environmental testing — Part 2: Tests*.

Economic Commission for Europe, *Customs convention on the international transport of goods under cover of TIR carnets (TIR convention)*, and its amendments and corrigendum. 1975 to 1991.

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 freight container: An ISO freight container as specified in ISO 668.

3.2 "mandatory" and "optional": The terms "mandatory" and "optional" are employed in this International Standard to indicate the status of requirements from the ISO standpoint, and not to im-

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ply that a particular status does or does not result from intergovernmental agreement, legislation, etc.

3.3 physically and electronically secure: Capable of meeting the operational requirements specified in this International Standard (clause 4) after successfully completing the tests specified in A.1.

3.4 physically tamper-proof: Designed such that malicious disassembly and re-assembly, using commonly available tools, will be detected upon visual inspection.

3.5 electronically tamper-proof: Designed such that malicious modification of electronically stored information by subjection to electromagnetic signals from commonly available electronic devices is not possible.

3.6 range: Distance between the sensing equipment and the tag.

3.7 passing speed: Speed at which a tag passes the sensing equipment.

3.8 container movement status: Information which indicates the position, speed or direction of the container relative to the sensing equipment.

3.9 AEI system reliability: Ability of an AEI system to capture mandatory information from every tag, which is mounted, programmed and presented in accordance with this International Standard, and which enters its coverage area under environmental conditions as specified in A.3.

3.10 AEI system accuracy: For an AEI system for which it is assumed that the defined conditions for system reliability are met, the capability of the AEI system to detect any misinterpretation of mandatory information including bit errors.

4 Operational requirements

4.1 Basic components of the AEI system

The AEI system shall consist of two basic components, i.e.

- a) an electronic device (tag) installed on the freight container, and
- b) electronic sensing equipment located apart from the freight container.

4.1.1 The tag shall be capable of

- a) maintaining the integrity of the freight container identification and permanent related information,

- b) encoding its information into a form suitable for conveyance to sensing equipment,
- c) being programmed in the field; however, the permanent data shall not be reprogrammable while the tag is fixed to the container,
- d) being physically and electronically secure and tamper-proof,
- e) being fixed to a container in accordance with the provisions of the TIR convention,
- f) being mounted between the typical vertical ribbing of the freight container side — it shall have dimensions as small as possible but not exceeding 30 cm x 6 cm x 2 cm,
- g) a minimum life of 10 years normal operational use and shall not require periodic maintenance,
- h) providing, through the sensing equipment, an indication of impending battery failure if it contains a battery,
- i) being read when it is
 - 1) operated in the environmental conditions specified in 4.6.1,
 - 2) within range (see table 1),
 - 3) moving in relation to the sensing equipment at an acceptable speed (see table 1),
 - 4) sufficiently separated from adjacent similar tags to allow discrimination (see table 1), and
 - 5) suitably oriented (see 4.6.2), and
- j) international operation, without the necessity of licensing tags individually.

4.1.2 The sensing equipment shall be capable of

- a) reading information contained in the tag when it is properly presented, and
- b) decoding the information contained in the tag into a form suitable for transmission to automatic data processing systems.

4.2 Information content of the tag

The information contained in the tag is in one or more of the following categories:

- mandatory, permanent (non-changeable) information;
- optional, permanent (non-changeable) information;

- optional, non-permanent (changeable) information.

Optional information contained in a tag shall not adversely affect the operation of systems requiring only the mandatory information contained in the tag.

4.3 Tag requirements — Basic information

The tag shall provide, as a minimum, the basic information about the container so that reference to other tables or databases is unnecessary. The following tag basic information is mandatory and permanent:

- a) tag type;
- b) equipment identifier;
- c) owner code, in accordance with ISO 6346;
- d) serial number, in accordance with ISO 6346;
- e) check digit, in accordance with ISO 6346;
- f) length (in centimetres);
- g) height (in centimetres);
- h) width (in centimetres);
- i) container type code, in accordance with ISO 6346;
- j) maximum gross mass (in hundreds of kilograms);
- k) tare mass (in hundreds of kilograms).

4.4 Sensing equipment requirements

4.4.1 The sensing equipment shall be capable of providing the information conveyed by the tag, as presented in 4.3, to the automated processing system.

4.4.2 The sensing equipment shall be of a technology adaptable to accommodate fixed or mobile installations, or portable applications.

4.4.3 The sensing equipment and connected real-time electronic data processing (EDP) system shall be capable of adding to the tag data the following operational information:

- a) sensing equipment unit identification;
- b) date and time;
- c) freight container movement status.

4.5 Safety and regulatory considerations

The system when installed or operated in a particular country shall comply with national and local governmental safety and radio frequency (r.f.) regulations, and any other governmental rules and regulations which may apply, including those relating to human radiation exposure levels.

Automatic identification equipment systems will be used internationally in areas in which both occupational and non-occupational exposure limits apply for human exposure to radiated energy. In areas readily accessible to the general public, emission levels of radiated energy from electronic automatic identification equipment shall comply with standards for non-occupational exposure and shall not exceed the specified limits for non-occupational exposure depending on the country of use.

4.6 Performance specifications for the AEI system

4.6.1 Environmental conditions

AEI equipment is typically subject to the harsh environments of the marine, rail and road transportation industries. Sand and dust, salt spray, grease, snow, ice and grime can be expected to coat the tag and sensing equipment. Physical shock and vibration are commonly encountered as a result of handling and transport operations.

Substantial temperature variations are common in worldwide container operations, as well as prolonged exposure to sunlight, including ultraviolet rays. The tag shall operate satisfactorily at tag surface temperatures between -50°C and $+80^{\circ}\text{C}$ and shall maintain the integrity of stored data at temperatures from -70°C to $+85^{\circ}\text{C}$. The tag shall survive and maintain the integrity of stored data under (as a minimum) the severest of the environmental conditions covered by the test methods specified in A.1.

The system shall be capable of full operation in the electromagnetic environment typically found at transportation facilities. The tag shall survive and maintain the integrity of stored data in a maximum peak field strength of 50 V/m for 60 s, as may be encountered from any r.f. source such as a shipborne radar under normal operation or other such devices [see A.1, item j)].

4.6.2 "Proper presentation" of the tag

The orientation requirements for "proper presentation" of the tag to the sensing equipment are illustrated in figure 1, which shows four tags labelled A, B, C and D.

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- a) A tag shall be regarded as "properly presented", in terms of its orientation, even if it has an angular displacement such as illustrated for tag A in figure 1 (i.e. it is rotated about an axis perpendicular to the face of the tag by an amount not exceeding 20° to either side of the vertical) in addition to the angular displacement θ , as specified in table 1 for each type of combined system requirement.
- b) The requirements governing the angles marked ϕ_x and ϕ_y in figure 1 (the angles between the axis of the sensing equipment and the lines joining the "effective" centre of the sensing equipment with the centres of the tags) will vary according to the circumstances under which the reading is required, e.g. at gate houses, between the legs of a quay crane, etc. and the design of sensing equipment. Hence although the tag is required to perform satisfactorily if the interrogating signal reaches it from any direction within a cone of 2θ included angle (as illustrated for tag D in figure 1), the "window" within which a tag must be presented to a particular sensing equipment will vary with the design of the sensing equipment.

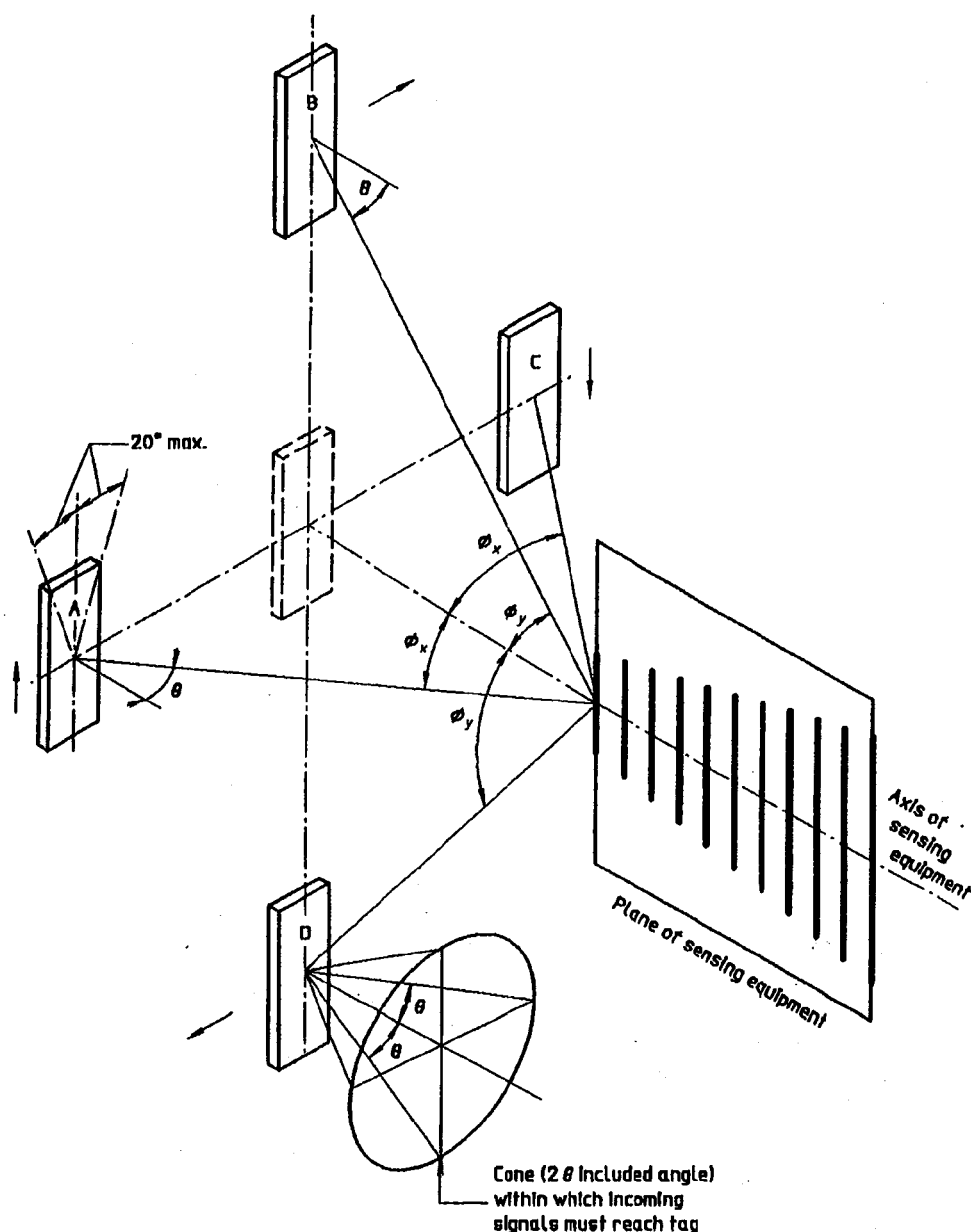


Figure 1 — Tag presentation requirements

4.6.3 Combined system requirements

The AEI system shall be capable of reading a tag on containers in accordance with all the combined requirements given in table 1 (see also figure 2).

Table 1 — Combined system requirements

| Passing speed km/h | Range ¹⁾ m | Discrimination ²⁾ m | Presentation angle θ degrees |
|--|--------------------------|-----------------------------------|--|
| 130 | 1 to 13 | 10 | 20 |
| 80 | 1 to 13 | 5 | 30 |
| 30 | 1 to 10 | 1,2 | 70 |
| 0 | 0,1 to 2 | 1,5 | 90 |
| 1) Tests shall be conducted at the minimum and maximum values of each range. | | | |
| 2) Discrimination: distance between two tags. | | | |

4.6.4 AEI system reliability and accuracy

Tags which are positioned, programmed and presented to the sensing equipment in accordance with the provisions of this International Standard shall have a minimum AEI system reliability of 99,99 %, i.e. no more than one no-read event in 10 000

readings, and an AEI system accuracy of 99,999 9 %, i.e. one undetected incorrect reading in 1 000 000 readings.

4.6.5 Tag positioning

The tag shall not protrude beyond the envelope of the freight container and shall have provisions for permanent mounting that will not render the structural or environmental integrity of the freight container below the service requirements.

Only a single tag shall be required to identify each freight container. The tag shall be located on the exterior surface of the right sidewall as seen from the door end of the container, approximately 0,3 m from the edge with the blind end, in the case of containers of length 12,2 m (40 ft) or less (recessed between the first and second sidewall corrugations, if applicable) or approximately 0,3 m to the rear of the lifting position, in the case of containers of length greater than 12,2 m (40 ft), but, in any case, not more than 5,94 m from the transverse centre-line of the container (see figures 3 and 4). The letter *h* indicates the overall container height.

In the case of non-box, smooth-skin and thermal containers, the tag may be located in proximity to the lower corner fittings as an alternative to the preferred location described above.

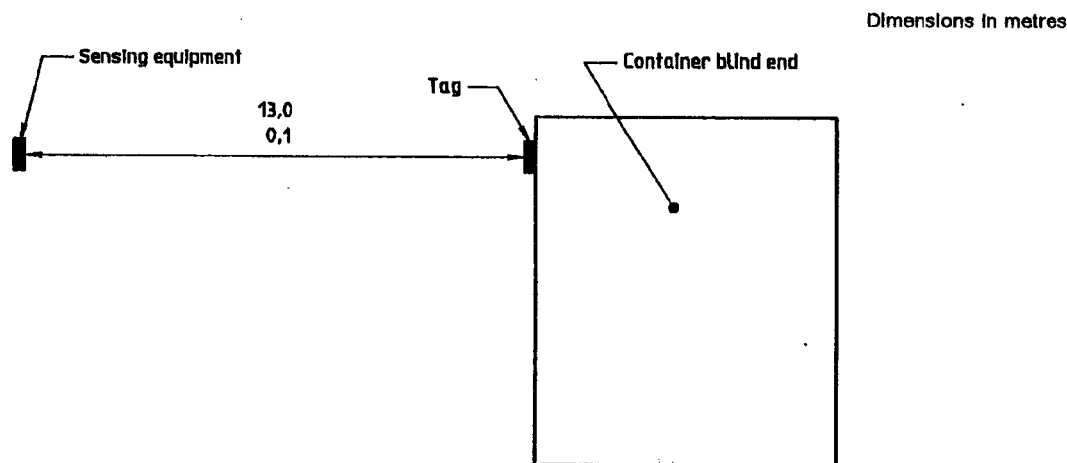


Figure 2 — Read range

Dimensions in metres

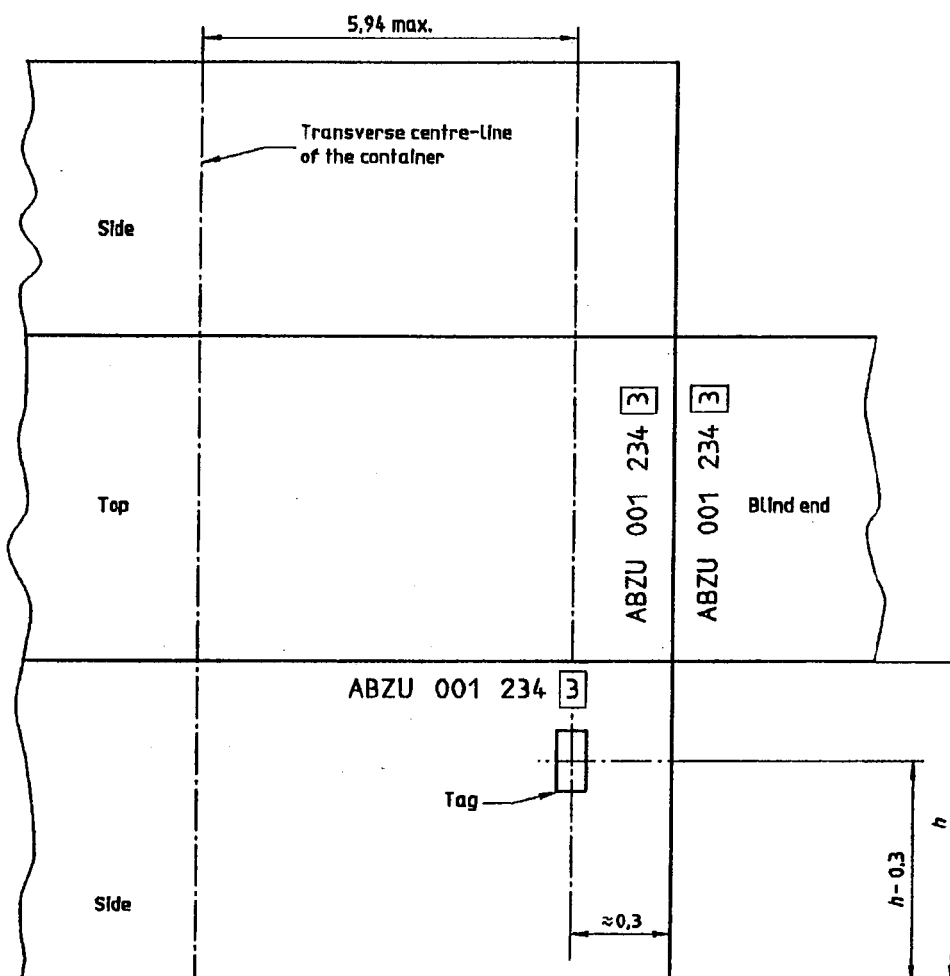


Figure 3 — Tag location for containers of length 12,2 m (40 ft) or less

Dimensions in metres

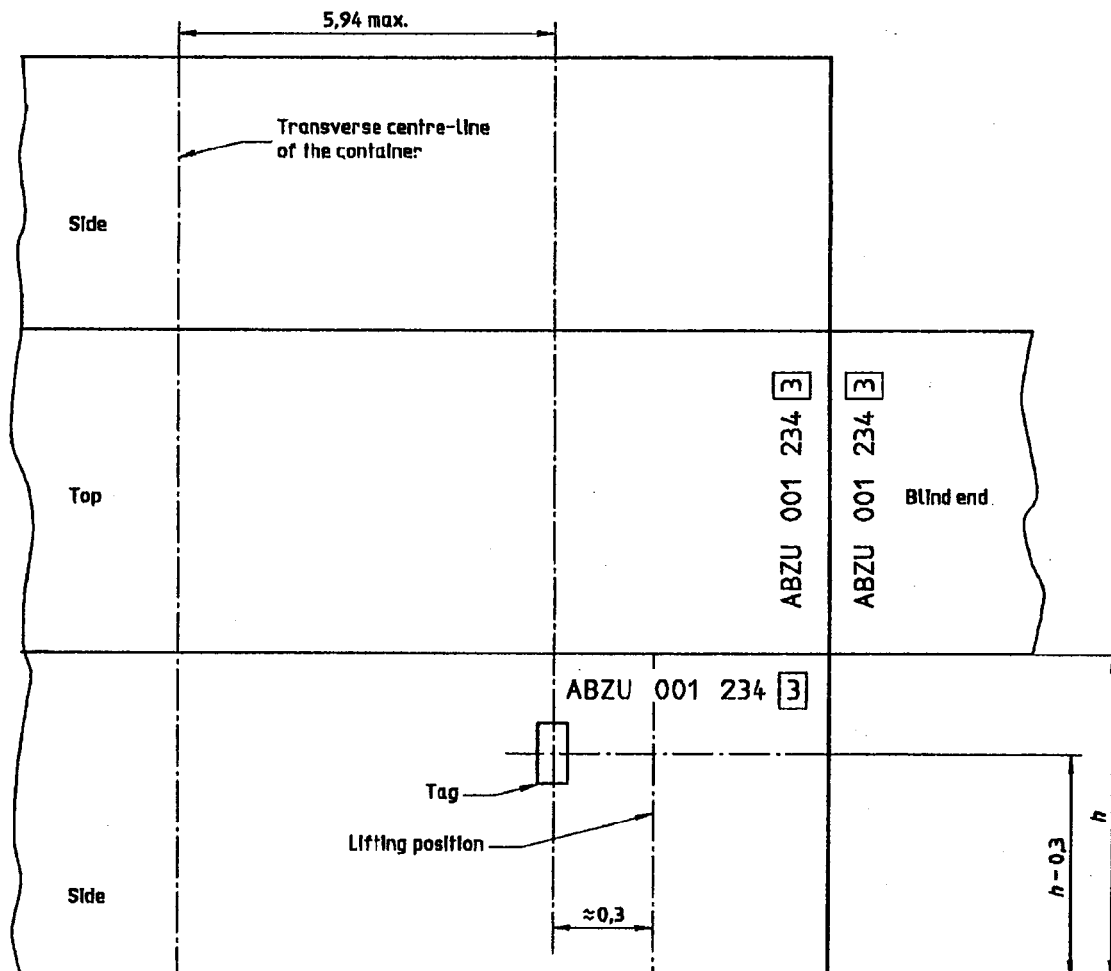


Figure 4 — Tag location for containers of length greater than 12,2 m (40 ft)

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5 Tag data content and format

The tag shall be able to store at least the permanent and mandatory data in accordance with the specifications of table 2.

6 Tag frequency of operation and sensitivity

The tag shall respond to an interrogating signal within the bands 850 MHz to 950 MHz and 2 400 MHz to 2 500 MHz. The tag shall not significantly respond to r.f. signals in frequency bands other than those specified in this International Standard.

The tag sensitivity shall be tested in accordance with A.4.

For r.f. radiation, it is recommended, notwithstanding nationally specified limits, that the design and application of equipment be such that human exposure levels are as low as reasonably achievable, taking economic and social conditions into account

as set forth in the ALARA principle (r.f. emissions should be As Low As Reasonably Attainable) endorsed by the World Health Organization.

7 Interface

The sensing equipment shall present data to the automated processing system in accordance with the International Reference Version (IRV), as specified in ISO 646, using a standard computer serial interface and an RS 232C or RS 485 port.

NOTE 1 For more information, see CCITT V.24:1984, *List of definitions for interchange circuits between data terminal equipment and data circuit-terminating equipment*.

8 AEI system testing and requirements

8.1 The AEI basic components shall be submitted to type tests as defined in annex A.

8.2 When properly installed, the system shall meet the reliability and accuracy requirements specified in this International Standard.

Table 2 — Value limits

| Data | Value | | Unit representation |
|------------------------------|---------|---------|-----------------------|
| | minimum | maximum | |
| Tag type ¹⁾ | 0 | 3 | Type code |
| Equipment identifier | 1 | 32 | Type code |
| Owner code ²⁾ | AAAA | ZZZZ | Alphabetical |
| Serial number ²⁾ | 000000 | 999999 | Numerical |
| Check digit ²⁾ | 0 | 9 | Numerical |
| Length | 1 | 2000 | Centimetres |
| Height | 1 | 500 | Centimetres |
| Width | 200 | 300 | Centimetres |
| Container type ²⁾ | 0 | 127 | Type code |
| Maximum gross mass | 19 | 500 | Hundreds of kilograms |
| Tare mass | 0 | 99 | Hundreds of kilograms |

1)

0 — Less than basic information (such a tag is not in accordance with this International Standard)

1 — Basic information

2 — More than basic information

3 — Spare

2) In accordance with ISO 6346.

Annex A (normative)

Testing

A.1 Testing of tag under various environmental conditions

The tag shall function correctly during and after each of the following tests.

- | | |
|--------------------------------|--|
| a) Low temperature | — IEC 68-2 (Mil. Std. 810D Method 502.2); minimum temperature of $-50\text{ }^{\circ}\text{C}$. |
| b) High temperature | — IEC 68-2 (Mil. Std. 810D Method 501.2, Procedure II); cycled between $+70\text{ }^{\circ}\text{C}$ and $+38\text{ }^{\circ}\text{C}$, temperatures specified in 4.6.1. |
| c) Mechanical shock | — IEC 68-2 (Mil. Std. 810D Method 615.3, Procedure I); 30g for 11 ms, half-sine pulse. |
| d) Random vibration | — IEC 68-2 (Mil. Std. 810D Method 520.0, Procedure II); 2 h duration, axis up to 3g at $-50\text{ }^{\circ}\text{C}$, ambient, and $+70\text{ }^{\circ}\text{C}$ ambient. |
| e) Humidity | — IEC 68-2 (Mil. Std. 810D Method 507.2); 95 % non-condensing. |
| f) Rain | — IEC 68-2 (Mil. Std. 810D Method 506.1, Procedure II). |
| g) Salt fog | — IEC 68-2 (Mil. Std. 810D Method 509.2, Procedure I). |
| h) Drop shock | — IEC 68-2 (Mil. Std. 810D Method 516.3, Procedure II); height 3,3 m, impact surface 5 cm plywood backed with concrete. |
| i) Sand and dust | — IEC 68-2 (Mil. Std. 810D, Method 510.2). |
| j) Electromagnetic environment | — The tag shall survive and maintain the integrity of stored data in a maximum peak field strength of 50 V/m for 60 s. |

A.2 Testing of sensing equipment

The testing of sensing equipment shall be agreed between the user and the supplier.

A.3 Testing of the complete system

Testing of the combined system requirements shall be carried out to prove the ability of the system to function properly under normal operating conditions at locations where the system is intended to operate.

Normal operating conditions include the following:

- temperature: between $-50\text{ }^{\circ}\text{C}$ and $+70\text{ }^{\circ}\text{C}$;
- humidity: up to 100 %, condensing;
- random vibration: frequencies as specified in IEC 68-2 (Mil. Std. 810D Method 520.0, Procedure II) at amplitudes up to 0,29g.

A.4 Tag signal strength

When a "properly presented" tag is excited by an effective isotropic radiated power (EIRP) of 1 W at 10 m reference range, it shall respond within the modulated return signal strength, exclusive of carrier and as measured at a 10 m range, specified in table A.1.

Table A.1 — Tag signal strength

| R.m.s. signal frequency MHz | R.m.s. signal strength | |
|--------------------------------|-------------------------|-------------------------|
| | min. $\mu\text{V/m}$ | max. $\mu\text{V/m}$ |
| 888 to 889 | 1 400 | 4 100 |
| 902 to 928 | 1 400 | 4 100 |
| 2 400 to 2 500 | 310 | 900 |

The tag's return signal strength shall be reduced by no more than 3 dB when the tag is rotated by $\pm 10^\circ$ in the plane coincident to the sensing equipment polarization, which shall be vertical for freight container tags, and by $\pm 20^\circ$ in the plane perpendicular to the sensing equipment polarization (see figure A.1).

The tag shall have a minimum sensitivity such that an interrogating signal of 150 mV/m will allow proper tag operation.

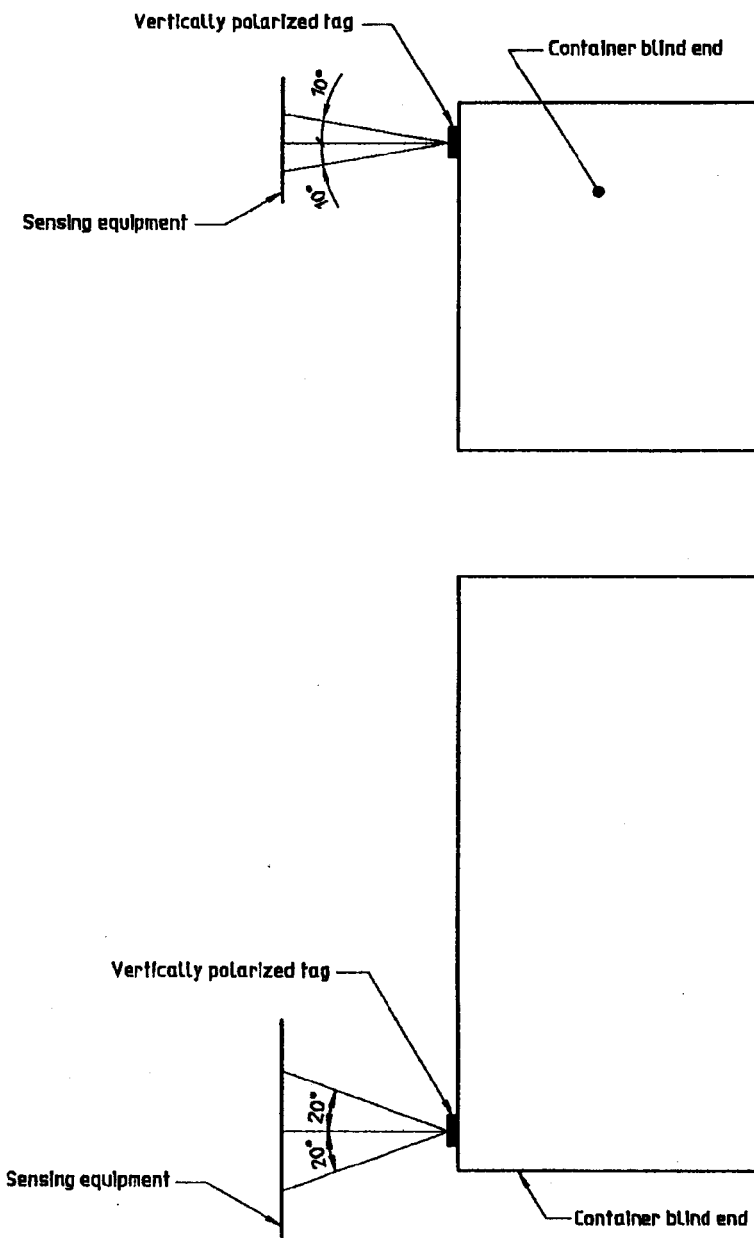


Figure A.1 — Illustration of the deviations of the tag position applicable when testing the return signal strength

Annex B (informative)

AEI reflected energy system — Technical specifications

B.1 General

This annex describes a reflected energy system in which sensing equipment decodes radio waves reflected by an identification tag mounted on a freight container. The reflected radio waves indicate the alphanumeric identification code of the container as well as its related permanent information.

This annex describes a tag which contains the basic information specified in 4.2 and 4.3 and which may be programmed in the field only by physical contact to a programming unit.

The information in this annex is in conformity with and supplemental to requirements elsewhere in this International Standard.

B.2 Tag characteristics and specifications

B.2.1 The tag shall not itself originate or generate radio frequencies. The tag shall be capable of being read by sensing equipment which operates at any selected frequency within the two frequency ranges of 850 MHz to 950 MHz and 2 400 MHz to 2 500 MHz.

B.2.2 The attachment method shall be at the choice of the user, but fasteners shall be in accordance with the provisions of the TIR convention.

B.2.3 The tag shall be operational within 4 ms after excitation by an interrogating signal from the sensing equipment.

B.3 Tag to sensing equipment communication

B.3.1 The encoding of user data bits shall include the 8 sub-bits for each user bit. A sub-bit shall be coded by the tag and decoded by the sensing equipment with a modified FSK (frequency-shift keying) code using two harmonically related frequencies, one (40 kHz) being the exact double of the other (20 kHz) with a frequency tolerance of

$\pm 10\%$. A "0" bit shall consist of one 20 kHz square wave cycle followed by two 40 kHz square wave cycles. A "1" bit shall consist of two 40 kHz square wave cycles followed by a 20 kHz square wave cycle. All transitions shall be phase continuous. As depicted in figure B.1, the tag shall produce a waveform which shall have a nominal 1 μ s rise and fall time and a duty cycle for the 20 kHz and 40 kHz square wave cycles of 50 %.

B.3.2 The data sequence of communication bits for freight container identification and related permanent information shall be as shown in table B.1.

B.3.3 The tag electronics shall cause the data to scroll repeatedly without pause from bit "cell" 127 of one frame (a frame consisting of all 128 bits) to bit "cell" 0 of the succeeding frame.

The security code specified in B.3.2 and indicated in table B.2 may be used to provide a degree of tamper protection and shall consist of the special characters shown.

B.3.4 The tag shall use the coded freight container identification and related permanent information to amplitude-modulate the incoming continuous wave r.f. carrier signal from the sensing equipment. The resulting modified FSK signal (carrier and sidebands) shall be reflected by the tag, received by the sensing equipment for decoding, and after decoding made available to automatic data processing systems. The modulation polarity shall be of no consequence.

B.4 Sensing equipment

The sensing equipment shall transmit a continuous wave carrier signal at a user frequency within either the 850 MHz to 950 MHz band or the 2 400 MHz to 2 500 MHz band as may be allowed under national and local regulations. The sensing equipment effective isotropic radiated power (EIRP) and the sensing equipment receiver sensitivity shall be adjustable to read properly tags responding as required in A.4 at the minimum range required by the user.

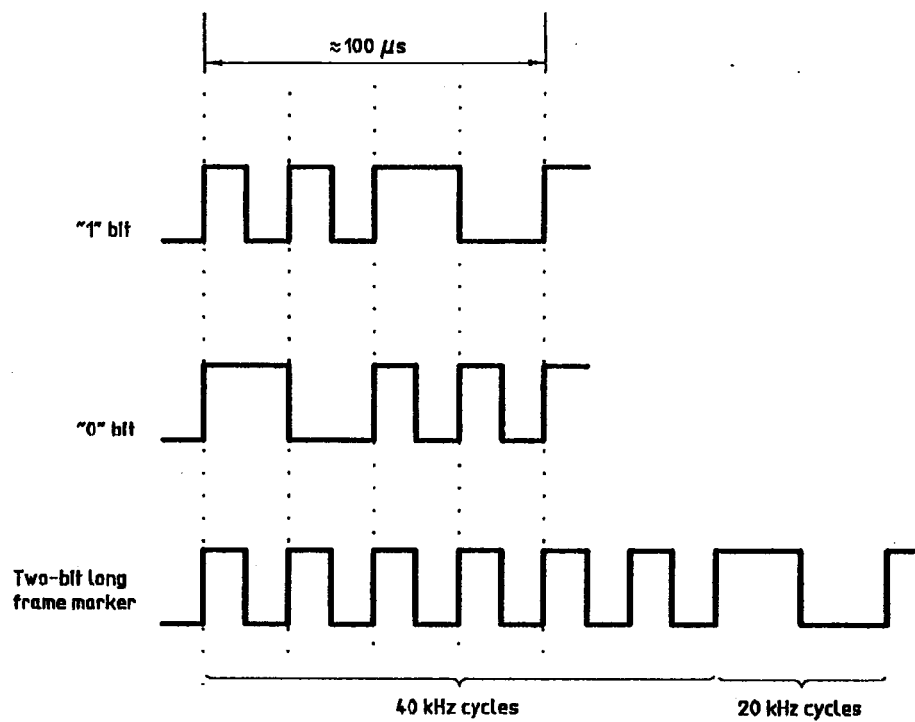


Figure B.1 — Frequency-shift keying (FSK) encoding

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Table B.1 — Tag data sequence

| Data | Bits required | Tag data sequence |
|------------------------------------|---------------|-------------------|
| Equipment Identifier ¹⁾ | 5 | 0 to 4 |
| Tag type ²⁾ | 2 | 5, 6 |
| Owner code | 19 | 7 to 25 |
| Serial number | 20 | 26 to 45 |
| Check digit | 4 | 46 to 49 |
| Length | 10 | 50 to 59 |
| First check sum ³⁾ | 2 | 60, 61 |
| Framing bits ⁴⁾ | 2 | 62, 63 |
| Length (continued) | 1 | 64 |
| Height | 9 | 65 to 73 |
| Width | 7 | 74 to 80 |
| Container type code | 7 | 81 to 87 |
| Maximum gross mass | 9 | 88 to 96 |
| Tare mass | 7 | 97 to 103 |
| Spare | 2 | 104, 105 |
| Security | 12 | 106 to 117 |
| Data format code ⁵⁾ | 6 | 118 to 123 |
| Second check sum ³⁾ | 2 | 124, 125 |
| Frame marker ⁶⁾ | 2 | 126, 127 |

1) Bit code set to "01010".

2) Bit code set to "01".

3) Check sums shall be calculated by adding the total number of bits in the preceding data field (bits 0 to 59 for the first sum and bits 62 to 123 for the second sum) and truncating the binary result to two bits, with the most significant bit first and the least significant bit last.

4) 62 and 63 both equal "1".

5) Bit code set to "110011".

6) The "end-of-frame" marker shall consist of six 40 kHz cycles followed by one 20 kHz cycle.

Table B.2 — Security data character bit codes

| Character | Code | Character | Code | Character | Code |
|-----------|------|-----------|------|---------------|------|
| ! | 1 |) | 9 | ? | 31 |
| " | 2 | + | 11 | @ | 32 |
| # | 3 | , | 12 | { | 59 |
| \$ | 4 | : | 26 | \ | 60 |
| % | 5 | ; | 27 | } | 61 |
| & | 6 | < | 28 | ^ | 62 |
| ' | 7 | = | 29 | _ (underline) | 63 |
| (| 8 | > | 30 | | |

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UDC 621.869.88:681.5.015:681.3:621.39

Descriptors: containers, freight containers, information marks, lags (data processing), data blocks, data codes, data processing, data transmission, automatic systems, specifications.

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