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Refrigerating systems and heat pumps — Safety and environmental requirements —

Part 2: Design, construction, testing, marking and documentation

Systèmes frigorifiques et pompes à chaleur — Exigences de sécurité et d'environnement —

Partie 2: Conception, construction, essais, marquage et documentation

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 1, *Safety and environmental requirements for refrigerating systems*.

This second edition cancels and replaces the first edition (ISO 5149-2:2014), which has been technically revised. It also incorporates the Amendment ISO 5149-2:2014/Amd 1:2020.

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The main changes are as follows:

— alignment of the document with EN 378-2, with the future aim of merging the two documents;

— introduction of the hot surface ignition temperature (HSIT).

A list of all parts in the ISO 5149 series can be found on the ISO website.

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.

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Introduction

The purpose of this document is to encourage the safe design, construction, installation, operation and disposal of refrigerating systems.

The industry response to environmental issues has accelerated the introduction of alternative refrigerants. The entry of new refrigerants and blends onto the market and the introduction of new safety classifications prompted the revision of this document.

This document is directed to the safety of persons and property on or near the premises where refrigeration facilities are located. It includes specifications for fabricating a tight system.

This document is intended to minimize possible hazards to persons, property and the environment from refrigerating systems and refrigerants. These hazards are associated with the physical and chemical characteristics of refrigerants as well as the pressures and temperatures occurring in the refrigeration cycles (see Annex G).

Attention is drawn to hazards common to all compression systems, such as high temperature at discharge, liquid slugging, erroneous operation or reduction in mechanical strength caused by corrosion, erosion, thermal stress, fatigue stresses, liquid hammer or vibration.

Corrosion, however, should be given special consideration as conditions specific to refrigerating systems and heat pumps arise due to the alternate frosting and defrosting or the covering of equipment by insulation.

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Refrigerating systems and heat pumps — Safety and environmental requirements —

Part 2: Design, construction, testing, marking and documentation

1 Scope

This document specifies the design, construction and installation of refrigerating systems, including piping, components, materials and ancillary equipment directly associated with such systems, which are not covered in ISO 5149-1, ISO 5149-3, or ISO 5149-4. It also specifies requirements for testing, commissioning, marking and documentation. Requirements for secondary heat-transfer circuits are excluded except for any safety devices associated with the refrigerating system.

This document is applicable to new refrigerating systems, extensions or modifications of already existing systems, and for used systems, being transferred to and operated on another site.

This document is applicable to:

a) refrigerating systems, stationary or mobile, of all sizes, except vehicle air conditioning systems covered by a specific product standard;

NOTE Example of specific product standard is ISO 13043 and SAE J 639.

b) secondary cooling or heating systems;

c) the location of the refrigerating systems;

d) replaced parts and added components after the adoption of this document, if they are not identical in function and in capacity;

e) the conversion of a system for another refrigerant.

This document does not apply to goods in storage, with respect to spoilage or contamination.

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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 817, *Refrigerants — Designation and safety classification*

ISO 4126-1, *Safety devices for protection against excessive pressure — Part 1: Safety valves*

ISO 4126-2, *Safety devices for protection against excessive pressure — Part 2: Bursting disc safety devices*

ISO 5149-1, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Vocabulary*

ISO 5149-3:2026, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 3: Installation site, classification and selection criteria*

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ISO 5149-4, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 4: Operation, maintenance, repair and recovery*

ISO 7010, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13732-1, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces*

ISO 13732-3, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 3: Cold surfaces*

ISO 13971, *Refrigeration systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements and classification*

ISO 14903, *Refrigerating systems and heat pumps — Qualification of tightness of components and joints*

ISO 21922, *Refrigerating systems and heat pumps — Valves — Requirements, testing and marking*

ISO 24664, *Refrigerating systems and heat pumps — Pressure relief devices and their associated piping — Methods for calculation*

IEC 60079-29-1, *Explosive atmospheres — Part 29-1: Gas detectors — Performance requirements of detectors for flammable gases*

IEC 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60335-2-34, *Household and similar electrical appliances — Safety — Part 2-34: Particular requirements for motor-compressors*

IEC 60335-2-40, *Household and similar electrical appliances — Safety — Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers*

IEC 60335-2-75, *Household and similar electrical appliances — Safety — Part 2-75: Particular requirements for commercial dispensing appliances and vending machines*

IEC 60335-2-89, *Household and similar electrical appliances — Safety — Part 2-89: Particular requirements for commercial refrigerating appliances and ice-makers with an incorporated or remote refrigerant unit or motor-compressor*

IEC 60335-2-118, *Household and similar electrical appliances — Safety — Part 2-118: Particular requirements for professional ice-cream makers*

IEC 60079-10-1:2020, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*

IEC 60730-2-6, *Automatic electrical controls — Part 2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements*

IEC 62990-1, *Workplace Atmospheres — Part 1: Gas detectors — Performance requirements of detectors for toxic gases*

IEC/TS 63542, *Refrigerant detection systems for flammable refrigerants*

3 Terms and definitions

For the purposes of this document, the definitions and abbreviations given in ISO 5149-1 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/

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4 General requirements

Refrigerating systems and components shall be designed and constructed with the intention to eliminate possible hazards to persons, property and the environment (see Annex G for potential hazards for refrigerating systems). Deliberate discharge of refrigerants shall only be permitted in a manner which is not harmful to persons, property and the environment.

Refrigerating appliances or systems constructed according to product standards such as IEC 60335-2-24 or IEC 60335-2-89 are presumed to be in conformity with this document.

IEC 60335-2-40 requires appliances to conform to the requirements of this document with regard to mechanical strength and pressure safety. In all other respects, appliances constructed according to IEC 60335-2-40 are presumed to be in conformity with this document.

NOTE Information for mechanical strength and pressure safety can be found in Clause 5 and Clause 6.

5 Requirements for components and piping

5.1 General

Components and piping shall conform to the related standards or requirements given in Table 1. Components not included in Table 1 shall conform to relevant national standards or codes. For components not listed in Table 1 and not covered by national standards or codes, the requirements of 5.2 to 5.5 shall apply.

Table 1 — Components and piping requirements

Components and piping	Requirements
Detector	5.2.2
Fired heat exchangers	5.2 to 5.5
Heat exchangers: — pipe coil without air (tube in tube) — multi-tubular (shell and tubes)	5.2 to 5.5
Plate heat exchangers	5.2 to 5.5
Headers and coils with air as secondary fluid	5.2 to 5.5
Receiver/accumulator/economizer	5.2 to 5.5
Oil separator	5.2 to 5.5
Drier	5.2 to 5.5
Filter	5.2 to 5.5
Muffler	5.2 to 5.5
Hermetic positive displacement compressor	IEC 60335-2-34 or IEC 60204–1
Semi-hermetic positive displacement compressor	IEC 60335-2-34 or IEC 60204–1
Open positive displacement compressor	5.2 to 5.5
Non-positive displacement compressor	IEC 60204–1
Pump	IEC 60204–1 combined with 5.4.3 and 5.5.1
Piping	5.2 to 5.5
Piping joints	5.2 to 5.5
Permanent joints	5.2 to 5.5
Non-permanent joints	5.2 to 5.5
Flexible piping	ISO 13971
Safety switching devices for limiting the pressure	5.2 to 5.5
Control pressure switch	5.2 to 5.5

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Table 1 *(continued)*

Components and piping	Requirements
Safety valve	ISO 4126-1 or ISO 24664 combined with 5.4.3
Bursting disc	ISO 4126-2 or ISO 24664 combined with 5.4.3
Valve	ISO 21922
Isolating valves	ISO 21922
Hand-operated valves	ISO 21922
Capped valves	ISO 21922
Liquid level indicators	ISO 21922
Gauges	5.2 to 5.5
Soldering materials	5.3.9
Brazing materials	5.3.10
Welding materials	5.3

If the component contains electrical components and if the component standard does not cover electrical safety, then the component shall fulfil the electrical requirements of IEC 60335-2-40, IEC 60335-2-34, IEC 60335-2-89 or IEC 60204–1, as relevant.

Piping and vessels manufactured in copper or carbon steel can suffer from stress corrosion cracking. Guidance on design is given in Annex F.

5.2 Specific requirements for particular components

5.2.1 Piping joints

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Joints shall be designed so that they are not damaged because of freezing of water on the outside. They shall be suitable for the pipe, the piping material and the pressure, temperature and fluid.

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Coated (e.g. galvanized) pipes shall not be welded unless all coating has been completely removed from the joint area. Welded joints shall be suitably protected.

5.2.2 Fixed refrigerant detection systems

5.2.2.1 General

The detector for the detection of refrigerant gases shall be a pre-set (indicating or alarm only) refrigerant detector/sensor or a proportional (transmitter or measuring) refrigerant detector. The refrigerant detection system shall be accurate at the pre-set alarm point and reliable according to the relevant standards, as specified below.

The detection system shall conform to one of the following standards, where applicable:

— For detection systems where sensors are incorporated in the control of the refrigerating system, IEC 60335-2-40 and IEC TS 63542 shall apply, where relevant.

— For detection systems separately installed at the installation site, such as a machinery room or other location, IEC 60079-29-1 and IEC 62990-1 shall apply, where relevant.

An appropriate maintenance period shall be established for each type of detector used. The t_{90} response time of the detector, including the optional delay time specified by the system manufacturer, shall be 30 s or less.

The detector shall be suitable for foreseeable variations in power supply voltage experienced at the installation site and shall be triggered at the set value within the tolerances defined in the listed standards, where specified.

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Where vibration requirements are specified, they shall apply to the detection system and not to the entire refrigerating system.

5.2.2.2 Refrigerant detection system output and general performance

A refrigerant detector shall give at least one output signal at a pre-set alarm point set by the manufacturer of the detector. The pre-set alarm point shall not be adjustable on site. It should also have a separate output for the fault signal.

The refrigerant detection system shall maintain the same performance between 0 °C and 30 °C. For applications outside this temperature range, the detector shall be specified for safe operation at the temperature for the specific application.

The pre-set alarm point for the refrigerant detection system shall be set at no more than 25 % of the lower flammability limit (LFL) or 50 % of the acute toxicity exposure limit/oxygen deprivation limit (ATEL/ODL). The pre-set alarm value for the oxygen detector shall be 19,5 % by volume.

The value shall be selected to ensure that the output signal is triggered at or below the alarm threshold value under all expected mains power voltage conditions.

The accuracy of the alarm threshold level and the long-term drift shall be recorded in the instruction manual specified in 6.4.3.3 in order to demonstrate that the alarm threshold level is within the limit specified and will be assured throughout the lifetime of the detector.

The refrigerant sensors or the parts containing the refrigerant sensors shall be marked or tagged with:

— year of manufacturing and where relevant, date of expiration;

— reference number or other means for identifying the refrigerant sensor.

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5.2.2.3 Information on resistance to contaminants and high concentrations

The effect of contaminants or high concentrations of refrigerant gas on the accuracy, alarm threshold level and the performance of the sensor as stated by the detector manufacturer, and minimum requirements for maintenance, calibration and replacement shall be included in the instruction manual.

5.3 Materials

5.3.1 Cast iron and malleable iron

Cast iron and malleable iron shall only be used when suitable for the particular application, in accordance with the requirements of this document.

NOTE 1 Since some grades of cast iron are brittle, their application is dependent on temperature, stress and design considerations.

NOTE 2 Malleable iron has two general classifications with several different grades in each. These can have very different mechanical properties.

5.3.2 Steel, cast steel, carbon steel and low-alloy steel

Steel, cast steel, carbon steel and low-alloy steel can be used for all parts carrying refrigerant and also for heat-transfer medium circuits. Where there is a combination of low temperatures and high pressure or where corrosion risks or thermal stresses are present, steel with adequate impact strength shall be used, paying regard to thickness, the lowest operating temperature and its welding properties.

NOTE Guidance on stress corrosion cracking in carbon steel vessels is given in Clause F.3.

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5.3.3 High-alloy steel

High-alloy steel can be required where there is a combination of low temperatures and high pressure or where corrosion risks or thermal stresses are present. The impact strength shall be adequate for the particular duty and the material suitable for welding, if required.

5.3.4 Stainless steel

When using stainless steel, the grade of stainless steel shall be compatible with the process fluids and possible atmospheric impurities, e.g. sodium chloride (NaCl) and sulphuric acid (H_2SO_4).

5.3.5 Copper and copper alloys

Copper in contact with refrigerants shall be oxygen-free or de-oxidized.

Copper and alloys with a high percentage of copper shall not be used for parts carrying ammonia unless their compatibility has been previously established.

NOTE Guidance on stress corrosion cracking in copper pipes is given in Clause F.2.

5.3.6 Aluminium and aluminium alloys

Aluminium and aluminium alloys may be used in any part of the refrigerant circuit provided that their strength is adequate and it is compatible with the refrigerants and the lubricants being used.

Aluminium used for gaskets for use with ammonia shall be of at least 99,5 % purity. Aluminium alloys containing more than 2 % magnesium shall not be used with halogenated refrigerants unless their compatibility has been previously established.

Aluminium and its alloys shall not be used in contact with methyl chloride (CH_3Cl).

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5.3.7 Magnesium and magnesium alloys

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Magnesium and magnesium alloys shall not be used unless their compatibility with refrigerants has been previously established.

5.3.8 Zinc and zinc alloys

Zinc shall not be used in continuous contact with the refrigerants ammonia and methyl chloride (CH_3Cl).

External zinc coating of components is permissible.

Electro-zinc plating of components is permissible.

5.3.9 Soldering alloys

Soldering alloys shall not be used for refrigerant containment purposes.

5.3.10 Brazing alloys

Brazing alloys shall not be used unless their compatibility with refrigerants and lubricants has been established.

5.3.11 Tin and lead-tin alloys

Tin and lead-tin alloys can be corroded by halogenated refrigerants and shall not be used unless their compatibility has been previously established.

Copper-free lead antimony or lead-tin alloys may be used for valve seats.

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5.3.12 Gasket and packing materials

Gasket and packing materials for sealing joints and for sealing stuffing boxes on valves shall be resistant to the refrigerants, oil and lubricants used and shall be suitable for the expected range of pressures and temperatures.

5.3.13 Glass

Glass may be used in refrigerant circuits and for terminal insulators, indicators and sight glasses, but it shall be resistant to the pressures, temperatures and chemical actions which can occur.

5.3.14 Asbestos

Asbestos shall not be used.

5.3.15 Plastics and elastomers

When plastics or elastomers are used, they shall be:

— suitable for the mechanical, electrical, thermal, chemical and long-term creep stresses to which they are subjected;

— compatible with refrigerant or refrigerant-oil mixtures with which they are in contact.

5.4 Testing

5.4.1 General

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All components, except type-approved components including piping consisting of type-tested components, shall undergo the following tests:

a) strength-pressure test (see 5.4.2);

b) tightness test (see 5.4.3);

c) functional test (see 6.3.1).

The results of these tests shall be recorded. Tests according to the relevant component standard are considered to satisfy these testing requirements. When agreed by the manufacturer of the refrigerating system assembly, some or all tests may be executed on the refrigerating system assembly (see 6.3).

5.4.2 Strength-pressure test

5.4.2.1 Individual strength-pressure test

Each component shall be strength-pressure-tested individually at a minimum of 1,43 × P_S (where P_S is the maximum allowable pressure). The individual strength-pressure test shall be carried out as a hydrostatic pressure test by means of water (under the condition that the refrigeration circuit shall not be contaminated when the test is complete) or some other liquid, except where a component cannot be pressure-tested with liquid for technical reasons. In that case, the component shall be tested by means of air or some other non-hazardous gas. Adequate precautions shall be taken to prevent danger to people and to minimize risk to property.

As an alternative, the components can be type-approved by testing at 3 × P_S or by testing according to the fatigue test as described in 5.4.2.2.

If the maximum continuous operating temperature exceeds 125 °C for copper or aluminium, or 200 °C for steel, then the type-approved strength test pressure shall be increased according to the ratio of allowable stress at the test temperature and that at the maximum continuous operating temperature based on a known pressure vessel code or a published national or international standard. For example, if the material

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of the component has an allowable stress of 35 N/mm^2 at test temperature and 27 N/mm^2 at maximum continuous operating temperature, then the type-approved test shall be conducted at 3,9 times (3 × 35/27) of maximum allowable pressure.

5.4.2.2 Fatigue test

As an alternative to the pressure test as mentioned in 5.4.2.1, the components shall be subjected to a strength-pressure test at 2 × P_S provided they conform to the fatigue test as described in this subclause.

Three test samples shall be filled with fluid and shall be connected to a pressure-driving source. The pressure shall be raised and lowered between the upper and lower cyclic values at a rate specified by the manufacturer for a total number of 250 000 cycles. The entire specified pressure excursion shall occur during each cycle.

For safety purposes, it is recommended to use a non-compressible fluid:

— For the first cycle, the maximum P_S for the low-pressure side components or the maximum P_S for the high-pressure side components shall be applied.

— For the test cycles, the upper-pressure value shall not be less than 0,7 × P_S and the lower-pressure value shall not be greater than 0,2 × P_S. The upper-pressure value shall be 0,9 × P_S for water heat exchangers in the refrigerating system.

— For the final test cycle, the test pressure shall be increased to 1,4 × P_S (twice 0,7 × P_S). The pressure shall be 1,8 × P_S (two times of 0,9 × P_S) for water heat exchangers in the refrigerating system.

The strength-pressure test at 2 × P_S shall be performed on three samples, other than the samples used for the fatigue test. If the maximum continuous operating temperature exceeds 125 °C for copper or aluminium, or 200 °C for steel, the fatigue test shall be conducted at least 10 °C above the maximum operating temperature.

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5.4.2.3 Acceptance criteria

In the case of individual strength test at minimum 1,43 × P_S, permanent deformation shall not result from these tests.

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In the case of type approval, it is deemed that the components are designed to withstand a pressure not less than three times the component's maximum allowable pressure without rupture (or not less than two times the component's maximum allowable pressure without rupture after the fatigue test). Confirmation shall be provided by testing.

The component shall not rupture, burst or leak after completion of the fatigue test.

5.4.3 Tightness test

The tightness test shall be performed according to the type approval procedure as specified in ISO 14903.

Components not covered by the scope of ISO 14903 shall be tested with detection equipment with a sensitivity of 3 g/year of refrigerant or better, under a pressure of at least 0,25 × P_S. The acceptance criterion is that no leak shall be detected.

The manufacturer of the refrigerating assembly may agree with the component manufacturer to execute some or all component tightness tests on the refrigerating system assembly (see 6.3.3).

The tightness test shall be conducted only after the component has passed a strength-pressure test or has been verified by a type test.

For environmental and safety reasons, nitrogen, helium and carbon dioxide are preferred test media. Tracers may be added to the test gases. Mixtures of air and other gases should be avoided as certain mixtures can be dangerous. Air may be used if the hazard of ignition is eliminated and the safety of the workers is ensured. Oxygen shall not be used for tightness tests.

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After testing, care shall be taken to ensure that the test medium is relieved safely.

5.5 Marking and documentation

5.5.1 Marking

Components shall be marked with the following items, unless the component standard is published and requires more specific marking items:

a) the name or logo of the manufacturer;

b) the type designation;

c) the serial number or batch number, if one exists;

d) the year of manufacture, for components of nominal size greater than DN 25;

e) the design pressure or maximum allowable pressure;

f) the applicable refrigerant (where appropriate);

g) the capacity of the main function (where appropriate).

When agreed by the manufacturer of the refrigerating system assembly, components assembled in a factory are not required to be marked by the component manufacturer. It is not necessary to mark small components on which such markings are impractical, but the attached documentation shall indicate the information specified from a) to g).

5.5.2 Documentation

Sample Document

The documentation shall include the following information:

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a) the results of tests;

b) the material test certificates;

c) the inspection certificates.

Material test certificates shall be provided by the manufacturer as required by the purchaser to enable the purchaser to ensure that the material used conforms with the required specification and that it is traceable from the final test through production up to receipt, preferably at the time of delivery and not later than the time of commissioning. Any required inspection certificate shall be prepared on behalf of and signed by the competent person who carried out the inspection, test or checking.

Documentation shall include the following specifications:

— the maximum allowable pressure;

— the maximum allowable temperature;

— the applicable refrigerant;

— the applicable oil.

Generic components which can be used for all types of refrigerant may be labelled with a more general indication of the refrigerant, for example “suitable for halocarbons”, “suitable for all refrigerants listed in ISO 817”, or as appropriate.

5.5.3 Fusible plugs

The nominal melting temperature of the fusible material shall be stamped on the non-fusible portion of the plug.

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