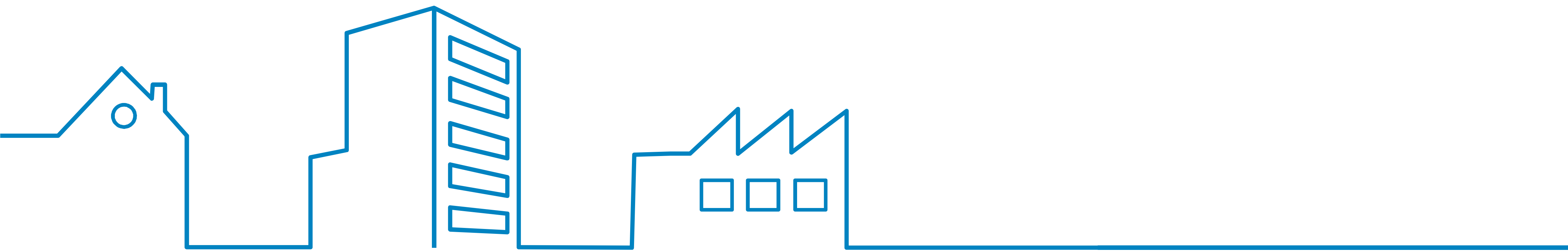
DAIKIN

Top secret
Secret
Internal use only
Public

Refrigerant concertation design guide for VRF systems (EN378). Legislation review, possible countermeasures and refrigerant detector’s requirements.

Renos Eleftheriadis

Mech Eng.



EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 378-1

November 2016

ICS 01.040.27; 27.080; 27.200

Supersedes EN 378-1:2008+A2:2012

English Version

Refrigerating systems and heat pumps - Safety and environmental requirements - Part 1: Basic requirements, definitions, classification and selection criteria

Systèmes frigorifiques et pompes à chaleur - Exigences de sécurité et d'environnement - Partie 1: Exigences de base, définitions, classification et critères de choix

Kälteanlagen und Wärmepumpen- Sicherheitstechnische und umweltrelevante Anforderungen - Teil 1: Grundlegende Anforderungen, Begriffe, Klassifikationen und Auswahlkriterien

This European Standard was approved by CEN on 3 September 2016.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania,

Table C.1 — Charge limit requirements for refrigerating systems based on toxicity

<table>
<tr><th rowspan="2">Toxicity class</th><th colspan="2" rowspan="2">Access category</th><th colspan="4">Location classification</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td rowspan="5">A</td><td colspan="2">a</td><td colspan="2">Toxicity limit × Room volume or see C.3</td><td rowspan="5">No charge restriction [a]</td><td rowspan="11">The charge requirements based on toxicity shall be assessed according to location I, II or III, depending on the location of the ventilated enclosure</td></tr>
<tr><td rowspan="2">b</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume or see C.3</td><td rowspan="4">No charge restriction [a]</td></tr>
<tr><td>Other</td><td>No charge restriction [a]</td></tr>
<tr><td rowspan="2">c</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume or see C.3</td></tr>
<tr><td>Other</td><td>No charge restriction [a]</td></tr>
<tr><td rowspan="6">B</td><td colspan="2">a</td><td colspan="2">For sealed sorption systems, toxicity limit × Room volume and not more than 2,5 kg,
all other systems, toxicity limit × Room volume</td><td rowspan="6">No charge restriction[a]</td></tr>
<tr><td rowspan="3">b</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume</td><td>Charge not more than 25 kg[a]</td></tr>
<tr><td>Density of personnel <1 person per 10 m²</td><td rowspan="2">Charge not more than 10 kg[a]</td><td>No charge restriction[a]</td></tr>
<tr><td>Other</td><td>Charge not more than 25 kg[a]</td></tr>
<tr><td rowspan="2">c</td><td>Density of personnel <1 person per 10 m²</td><td>Charge not more than 50 kg[a] and emergency exits are available</td><td>No charge restriction[a]</td></tr>
<tr><td>Other</td><td>Charge not more than 10 kg[a]</td><td>Charge not more than 25 kg[a]</td></tr>
<tr><td colspan="7">[a] For open air, EN 378-3:2016, 4.2 applies and, for machinery rooms, EN 378-3:2016, 4.3 applies.</td></tr>
</table>

Table E.2 — Refrigerant designations of R400 blends

Refrigerant number	Composition [c] (weight %)	Composition tolerances (%)	Safety class	PED [l] fluid group	Practical limit [d] (kg/m³)	ATEL/ODL [g] (kg/m³)	LFL [h] (kg/m³)	Vapour density 25 °C, 101,3 kPa [a] (kg/m³)	Molecular mass [a]	Normal boiling point [a] (°C)	ODP [a e]	GWP [a f k] (100yr ITH)	GWP [a f m] (AR5) (100yr ITH)	Auto-ignition temperature (°C)
410A	R-32/125 (50/50)	+ 0,5 – 1,5/+ 1,5 – 0,5	A1	2	0,44 [i]	0,42 [i]	NF	2,97	72,6	– 51,6 to – 51,5	0	2 088	1 920	ND

Table C.1 — Charge limit requirements for refrigerating systems based on toxicity

<table>
<tr><th rowspan="2">Toxicity class</th><th colspan="2" rowspan="2">Access category</th><th colspan="4">Location classification</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td rowspan="5">A</td><td colspan="2">a</td><td colspan="2">Toxicity limit × Room volume or see C.3</td><td rowspan="5">No charge restriction [a]</td><td rowspan="5">The charge requirements based on toxicity shall be assessed according to location I, II or III.</td></tr>
<tr><td rowspan="2">b</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume or see C.3</td><td rowspan="4">No charge restriction [a]</td></tr>
<tr><td>Other</td><td>No charge restriction [a]</td></tr>
<tr><td rowspan="2">c</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume or see C.3</td></tr>
<tr><td>Other</td><td>No charge restriction [a]</td></tr>
</table>

Access Category

Table 4 — Access categories

Categories	General characteristics	Examples [a]
General access a	Rooms, parts of buildings, building where — sleeping facilities are provided — people are restricted in their movement — an uncontrolled number of people are present — any person has access without being personally acquainted with the necessary safety precautions	Hospitals, courts or prisons, theatres, supermarkets, schools, lecture halls, public transport termini, hotels, dwellings, restaurants
Supervised access b	Rooms, parts of buildings, buildings where only a limited number of people may be assembled, some being necessarily acquainted with the general safety precautions of the establishment	Business or professional offices, laboratories, places for general manufacturing and where people work
Authorized access c	Rooms, parts of buildings, buildings where only authorized persons have access, who are acquainted with general and special safety precautions of the establishment and where manufacturing, processing or storage of material or products take place	Manufacturing facilities, e.g. for chemicals, food, beverage, ice, ice-cream, refineries, cold stores, dairies, abattoirs, non-public areas in supermarkets

[a] The list of examples is not exhaustive.

Access category: examples

-a-

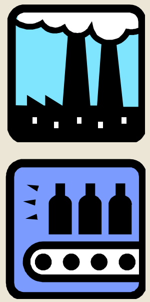
general access

-b-

supervised access

-c-

authorised access



Hospitals, courts or prisons, theatres, supermarkets, schools, lecture halls, public transport termini, hotels, dwellings, restaurants.

Business or professional offices, laboratories, places for general manufacturing and where people work.

Manufacturing facilities, e.g. for chemicals, food, beverage, ice, ice-cream, refineries, cold stores, dairies, abattoirs, non-public areas in supermarkets.

Table C.1 — Charge limit requirements for refrigerating systems based on toxicity

<table>
<tr><th rowspan="2">Toxicity class</th><th rowspan="2" colspan="2">Access category</th><th colspan="4">Location classification</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td rowspan="5">A</td><td colspan="2">a</td><td colspan="2">Toxicity limit × Room volume or see C.3</td><td rowspan="5">No charge restriction [a]</td><td rowspan="5">The charge requirements based on toxicity shall be assessed according to location I, II or III.</td></tr>
<tr><td rowspan="2">b</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume or see C.3</td><td rowspan="4">No charge restriction [a]</td></tr>
<tr><td>Other</td><td>No charge restriction [a]</td></tr>
<tr><td rowspan="2">c</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume or see C.3</td></tr>
<tr><td>Other</td><td>No charge restriction [a]</td></tr>
</table>

5.3 Location classification of refrigerating systems

There are four classes of location for refrigerating systems. The appropriate location shall be selected in accordance with this European Standard which takes account of possible hazards.

The four classes of location are:

a) **Class IV - Ventilated enclosure**

If all refrigerant-containing parts are located in a ventilated enclosure then the requirements for a class IV location shall apply. The ventilated enclosure shall fulfil the requirements of EN 378-2 and EN 378-3.

b) **Class III – Machinery room or open air**

If all refrigerant-containing parts are located in a machinery room or open air then the requirements for a class III location shall apply. The machinery room shall fulfil the requirements of EN 378-3.

c) **Class II – Compressors in machinery room or open air**

If all compressors and pressure vessels are either located in a machinery room or in the open air then the requirements for a class II location shall apply unless the system complies with the requirements of class III. Coils and pipework including valves may be located in an occupied space.

d) **Class I – Mechanical equipment located within the occupied space**

If the refrigerating system or refrigerant-containing parts are located in the occupied space, then the system is considered to be of class I unless the system complies with the requirements of class II.

LOCATION classification – simplified examples

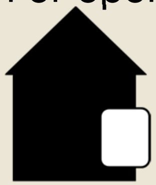
-I-

All refrigerant containing parts in the occupied space

Fridges, portables, Winecabinets,

-II-

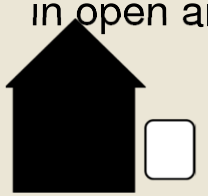
compressor, pressure vessel in machinery room or open air



Split airco, Split heat pumps, multisplits, condensing units

-III-

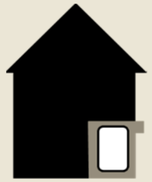
All Refrigerant containing parts in machinery room or in open air



Chillers, monobloc heat pumps

-IV-

ventilated enclosure



Special design products

Table C.1 — Charge limit requirements for refrigerating systems based on toxicity

<table>
<tr><th rowspan="2">Toxicity class</th><th rowspan="2" colspan="2">Access category</th><th colspan="4">Location classification</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td rowspan="5">A</td><td colspan="2">a</td><td colspan="2">Toxicity limit × Room volume or see C.3</td><td rowspan="5">No charge restriction [a]</td><td rowspan="5">The charge requirements based on toxicity shall be assessed according to location I, II or III.</td></tr>
<tr><td rowspan="2">b</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume or see C.3</td><td rowspan="4">No charge restriction [a]</td></tr>
<tr><td>Other</td><td>No charge restriction [a]</td></tr>
<tr><td rowspan="2">c</td><td>Upper floors without emergency exits or Below ground floor level</td><td>Toxicity limit × Room volume or see C.3</td></tr>
<tr><td>Other</td><td>No charge restriction [a]</td></tr>
</table>

Table E.2 — Refrigerant designations of R400 blends

Refrigerant number	Composition [c] (weight %)	Composition tolerances (%)	Safety class	PED [i] fluid group	Practical limit [d] (kg/m³)	ATEL/ODL [g] (kg/m³)	LFL [h] (kg/m³)	Vapour density 25 °C, 101,3 kPa [a] (kg/m³)	Molecular mass [a]	Normal boiling point [a] (°C)	ODP [a e]	GWP [a f k] (100yr ITH)	GWP [a f m] (AR5) (100yr ITH)	Auto-ignition temperature (°C)
410A	R-32/125 (50/50)	+ 0,5 – 1,5/+ 1,5 – 0,5	A1	2	0,44 [i]	0,42 [i]	NF	2,97	72,6	– 51,6 to – 51,5	0	2 088	1 920	ND

0,44 kg/m3

3.4.8
pressure vessel
any refrigerant-containing component of a refrigerating system other than:

- coils (including their headers) consisting of pipes with air as secondary fluid;
- piping and its valves, joints and fittings;
- control devices;
- pressure switches, gauges, liquid indicators;
- safety valves, fusible plugs, bursting discs;
- equipment comprising casings or machinery where the dimensioning, choice of material and manufacturing rules are based primarily on requirements for sufficient strength, rigidity and stability to meet the static and dynamic operational effects or other operational characteristics and for which pressure is not a significant design factor. Such equipment may include: pumps and compressors

  Note 1 to entry: The semi-hermetic and open type compressors used in refrigerating systems may be subject to the exclusion article 1.2.j of the Directive 2014/68/EU by referring to the working party group guidelines WPG 1/11, 1/12 and 2/34. The compressor manufacturer needs to decide on the basis of a case by case assessment, if the exclusion article 1.2.j of the Directive 2014/68/EU is applicable.

Note 2 to entry: This definition is aligned to directive 2014/68 EU.

3.7.9
practical limit
concentration used for simplified calculation to determine the maximum acceptable amount of refrigerant in an occupied space

Note 1 to entry: RCL is determined by toxicity and flammability tests, but practical limit is derived from RCL or historically established charge limit.

3.7.10
refrigerant concentration limit
RCL
maximum refrigerant concentration, in air, in accordance with and specified in C.3 of this European Standard and established to reduce the risks of acute toxicity, asphyxiation, and flammability hazards

Note 1 to entry: It is used to determine the maximum charge size for that refrigerant in a specific application.

3.7.11
quantity limit with additional ventilation
QLAV
charge density of refrigerant that when exceeded creates an instantaneous dangerous situation, if the total charge leaked within the occupied space

Note 1 to entry: See C.3 for the use of Quantity Limit with Additional Ventilation (QLAV) to manage risk for systems in occupied spaces where the level of ventilation is sufficient to disperse the leaked refrigerant within 15 min.

3.7.12
quantity limit with minimum ventilation
QLMV
charge density of refrigerant that would result in a concentration equal to the RCL in a room of non-air tight construction with a moderately severe refrigerant leak

Note 1 to entry: See C.3 for the use of Quantity Limit with Minimum Ventilation (QLMV) to manage risk for systems in occupied spaces not below ground level where the level of ventilation is not sufficient to disperse the leaked refrigerant within 15 min. The calculation is based on an opening of 0,003 2 m^2 and a leak rate of 2,78 g/s.

Definitions

3.2.3

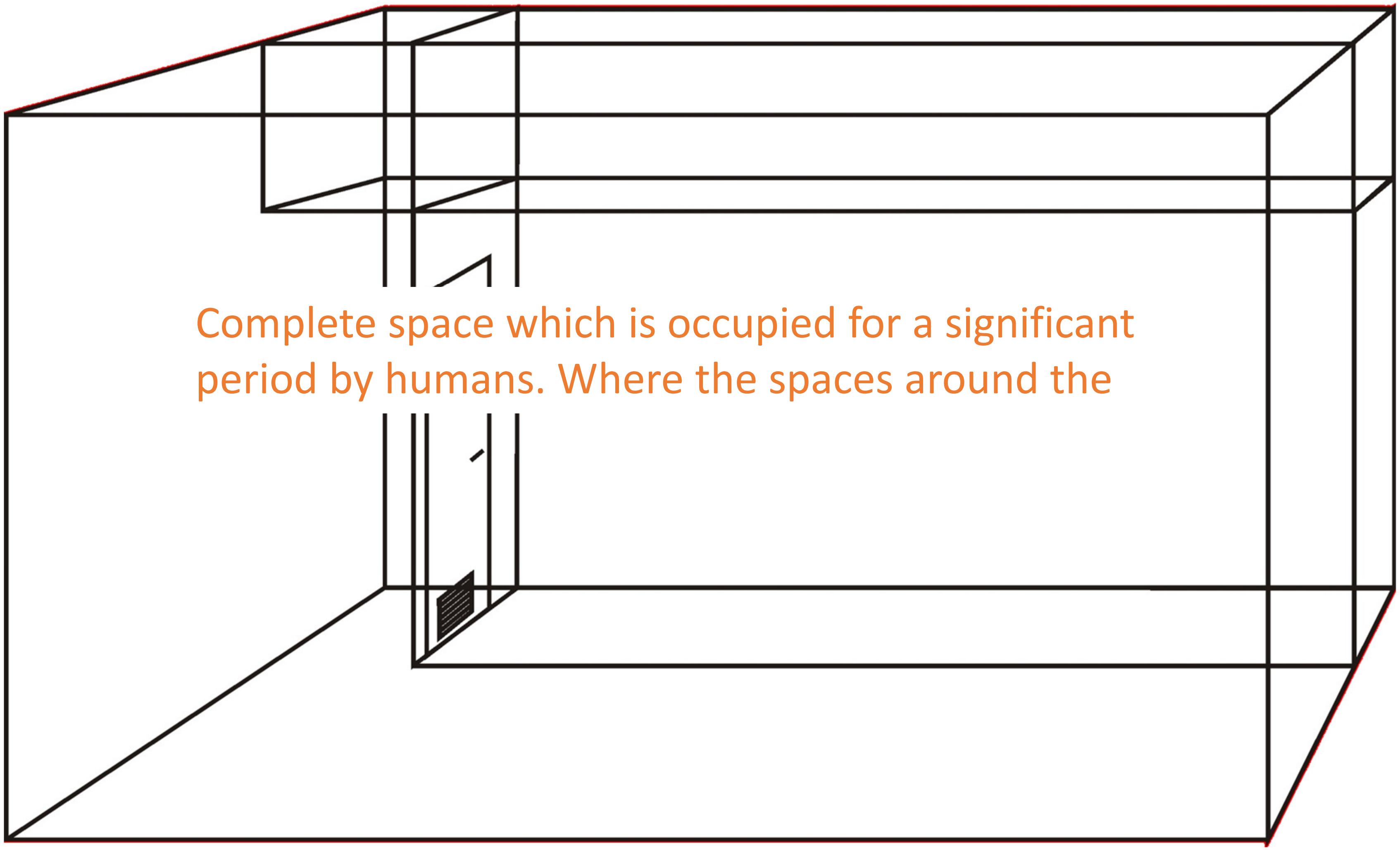
occupied space

space in a building which is bounded by walls, floors and ceilings and which is occupied by persons for a significant period

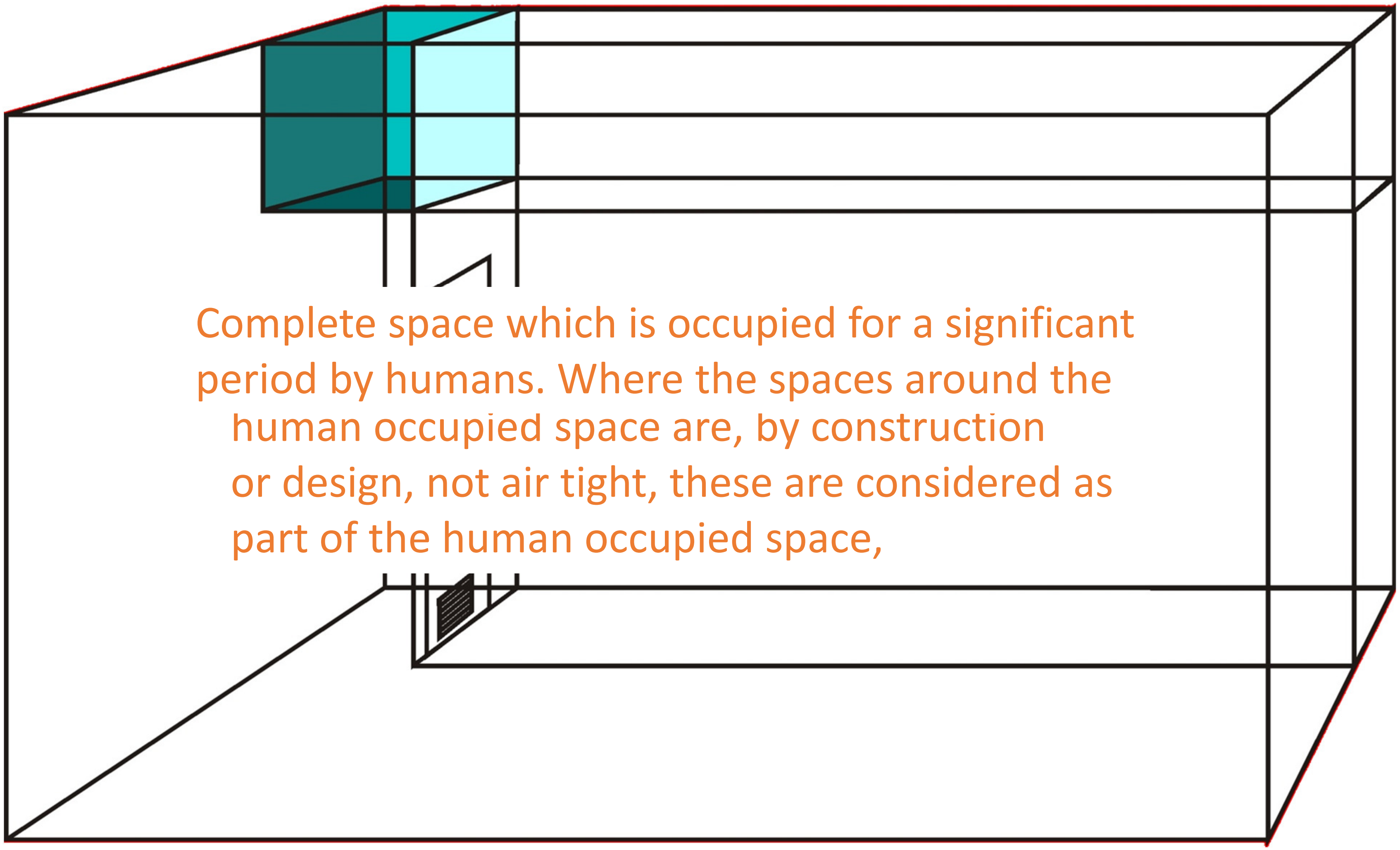
Note 1 to entry: Where the spaces around the apparent occupied space are, by construction or design, not air tight with respect to the occupied space, these may be considered as part of the occupied space. above; e.g. false ceilings voids, crawl ways, ducts, movable partitions and doors with transfer grilles or undercut doors.

human occupied space (chapter 3.2.2)

human occupied space (chapter 3.2.2)

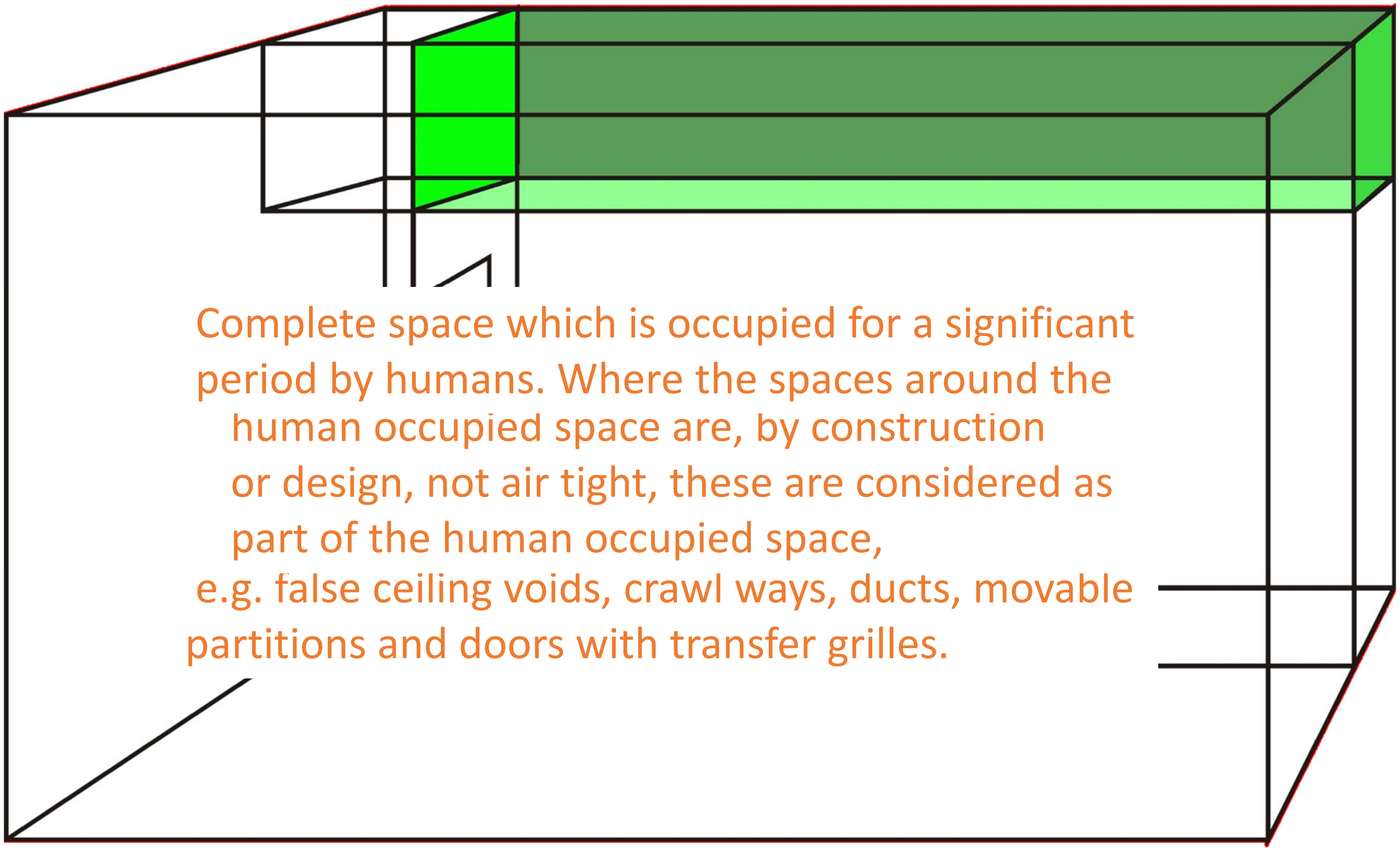


human occupied space (chapter 3.2.2)



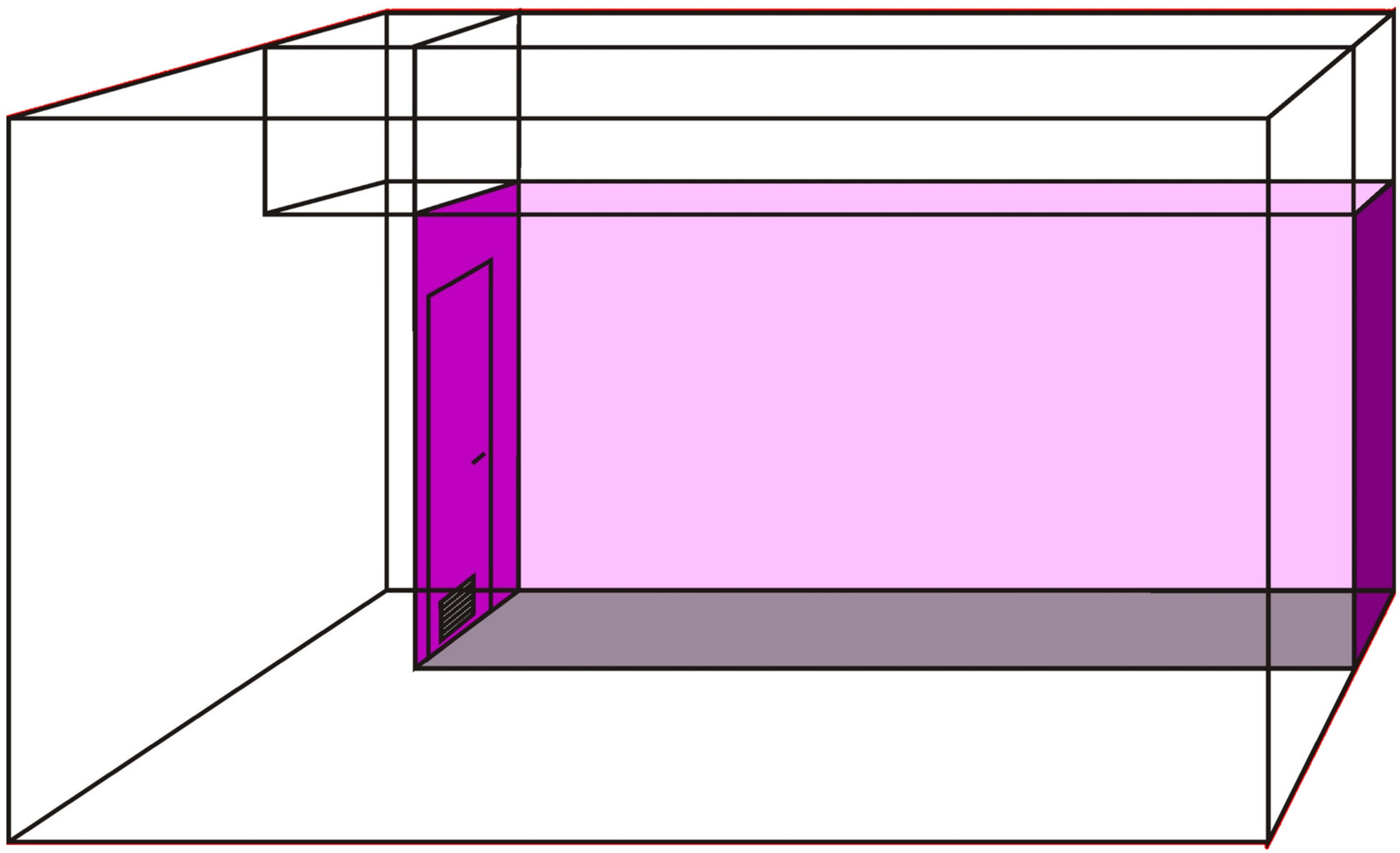
Complete space which is occupied for a significant period by humans. Where the spaces around the human occupied space are, by construction or design, not air tight, these are considered as part of the human occupied space,

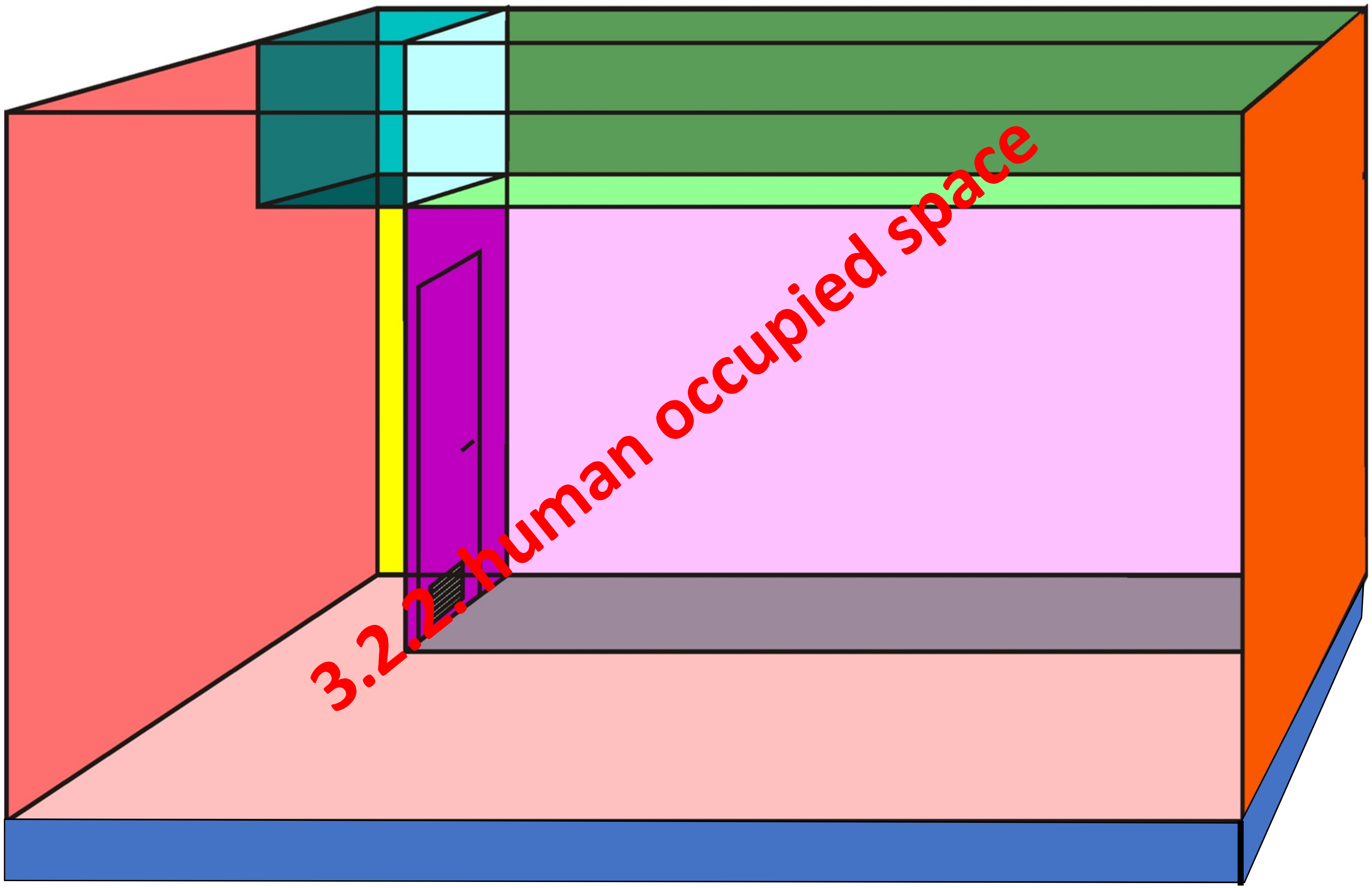
human occupied space (chapter 3.2.2)



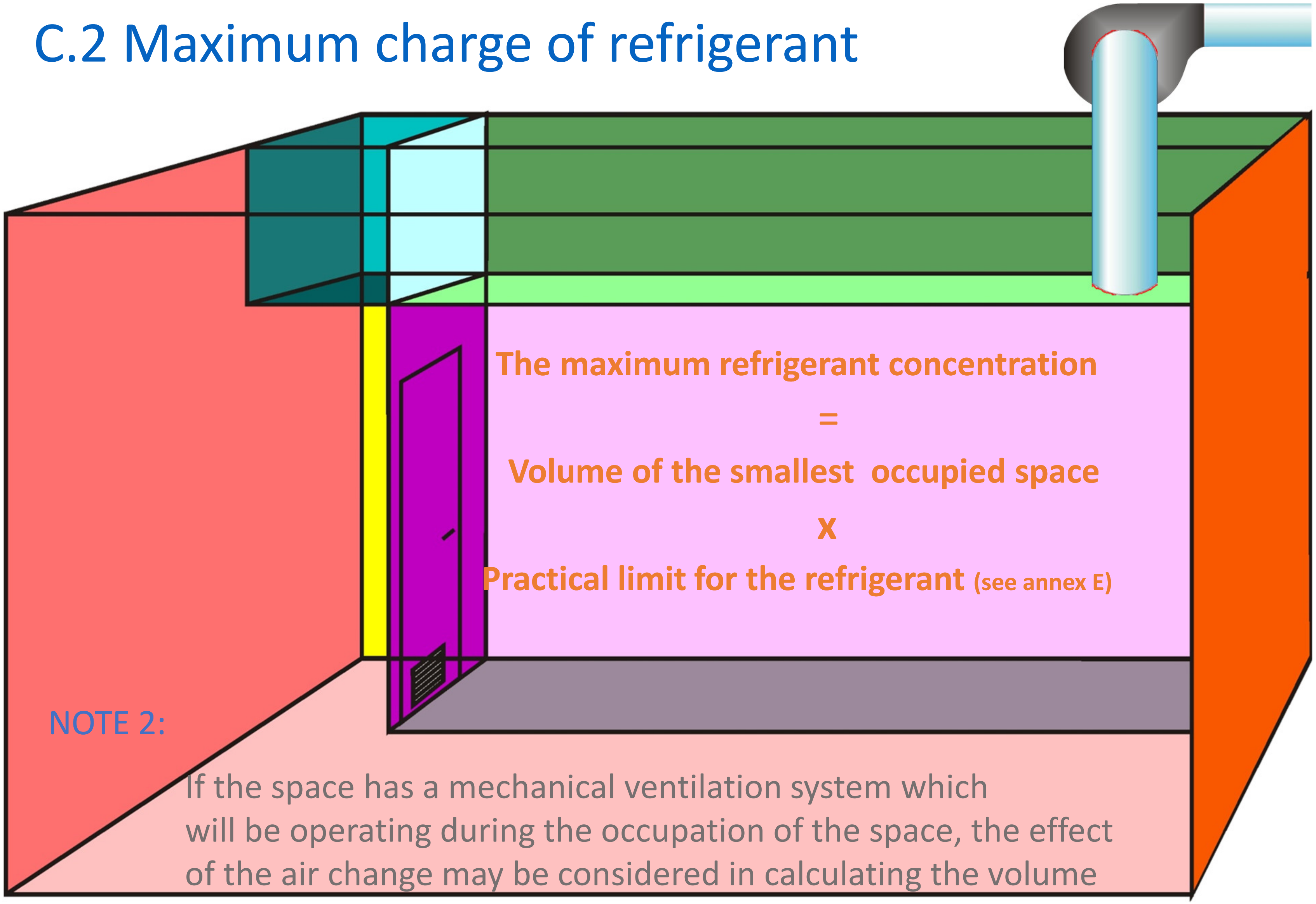
Complete space which is occupied for a significant period by humans. Where the spaces around the human occupied space are, by construction or design, not air tight, these are considered as part of the human occupied space, e.g. false ceiling voids, crawl ways, ducts, movable partitions and doors with transfer grilles.

human occupied space (chapter 3.2.2)




3.2.2.human occupied space

C.2 Maximum charge of refrigerant



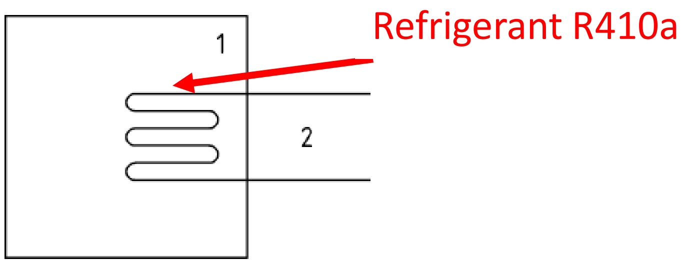
5.4.2 Direct releasable systems

The evaporator, condenser or gas cooler of the refrigerating system is in direct contact with the air or the substance to be cooled or heated. Systems in which a heat-transfer fluid is in direct contact with the air or the goods to be cooled or heated (spray or ducted systems) shall be treated as direct releasable systems.

5.5.1.1 Direct system

A direct system shall be classified as a direct releasable system if a single rupture of the refrigerant-containing circuit results in refrigerant release in the occupied space, irrespectively of the location of the refrigerant circuit (see Figure 1).

Direct systems are considered to be located in location class I (5.3 d) or II (5.3 c).



Key
1 occupied space
2 refrigerant-containing part(s)

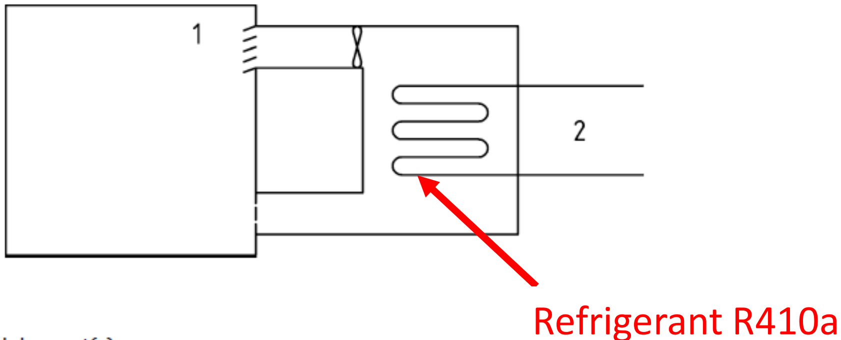
Figure 1 — Direct releasable system

VRF indoor unit into the room

5.5.1.3 Direct ducted system

A ducted system is classified as a direct releasable system if the conditioned air is in direct contact with refrigerant-containing parts of the circuit and the conditioned air is supplied to an occupied space (see Figure 3).

Direct ducted systems are considered to be located in location class I (5.3 d) or II (5.3 c).



Key
1 occupied space
2 refrigerant-containing part(s)

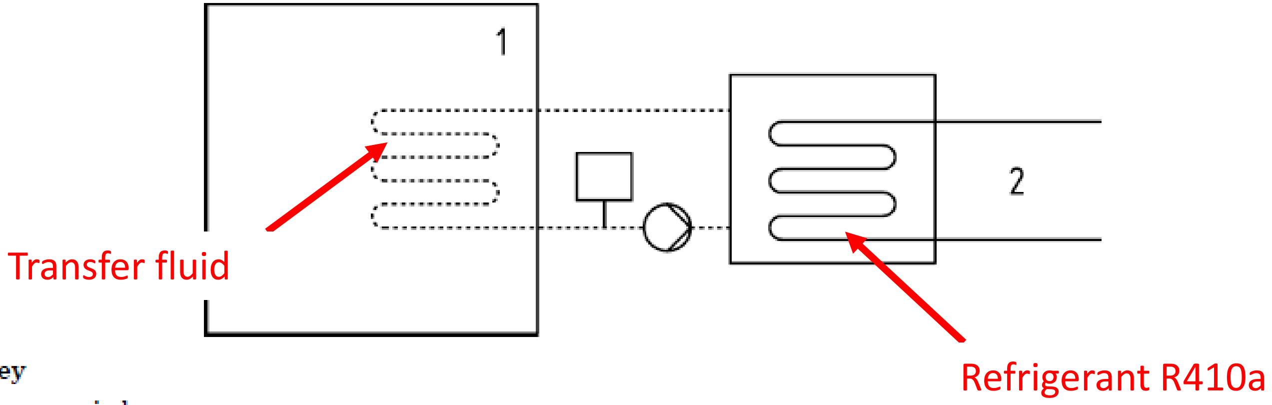
VRF indoor duct unit outside the room that supply air into the room

5.5.2.1 Indirect closed system

An indirect system shall be classified as an indirect closed system if the heat-transfer fluid is in direct communication with an occupied space and a refrigerant leak into the indirect circuit can enter into the occupied space if the indirect circuit also leaks or is purged (see Figure 5).

Indirect closed systems are considered to be located in location class I (5.3 d) or II (5.3 c).

NOTE A pressure relief device (or purger) on a secondary circuit is an appropriate method to prevent refrigerant leaking into the occupied space. Such a system is not considered as an indirect closed system, see 5.5.2.3.



Key

1 occupied space

2 refrigerant-containing part(s)

C.3.2.2 Occupancies except those on the lowest underground floor of the building

Where the refrigerant charge divided by the room volume does not exceed the QLMV, no additional measures are required.

Where the value is more than the QLMV but less than or equal to QLAV value, at least one of the measures described in EN 378-3:2016, Clauses 6 and 8 shall be applied. Where the value exceeds the QLAV, at least two of the specified measures shall be applied.

Audio Visual Alarm

Mechanical Ventilation

Emergency Shut off Valves

Detectors

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 378-3

November 2016

ICS 27.080; 27.200

Supersedes EN 378-3:2008+A1:2012

English Version

Refrigerating systems and heat pumps - Safety and environmental requirements - Part 3: Installation site and personal protection

Systèmes frigorifiques et pompes à chaleur - Exigences de sécurité et d'environnement - Partie 3: Installation in situ et protection des personnes

Kälteanlagen und Wärmepumpen - Sicherheitstechnische und umweltrelevante Anforderungen - Teil 3: Aufstellungsort und Schutz von Personen

This European Standard was approved by CEN on 3 September 2016.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

Mechanical Ventilation

6.3.3.1 Required airflow

For Q × RCL/10 < 1, the actual, not nominal, airflow of the mechanical ventilation shall be at least the quantity that satisfies Formula (3). For Q × RCL/10 ≥ 1 the airflow shall be determined according to Formula (4)

$$m=-\frac{10\times V}{Q}\times\ln\left(1-\frac{Q\times RCL}{10}\right) \qquad (3)$$

$$Q=\frac{10}{RCL} \qquad (4)$$

where

m	is the refrigerant charge in kg;
V	is the room volume expressed in m³;
10	is the expected maximum leak rate, in kg/h;
Q	is the ventilation airflow in m³ /h;
RCL	is the refrigerant concentration limit in kg/m³, as given in ISO 817.

10	is the expected maximum leak rate, in kg/h;
Q	is the ventilation airflow in m³ /h;
RCL	is the Refrigerant concentration limit in kg/m³, as given in ISO 817.

NOTE "ln" means natural logarithm.

A simplified calculation is given in Formula (5). The airflow that satisfies this formula can be employed instead of the value obtained above. However as a consequence of the simplification, it provides a higher airflow value.

$$Q=\frac{10}{RCL} \qquad (5)$$

Shut off Valves

6.4.2 Location

Shut off valves shall be located outside of the occupied space and shall be positioned to enable access for maintenance by an authorised person.

6.4.3 Design

Valves shall be designed to close in the event of an electric power failure e.g. spring return solenoid valves.

Valves in the refrigeration circuit shall be able to shut off the refrigerant flow in the event of a leak of refrigerant without unduly affecting the refrigerant flow in normal operation.

Detectors

8 Safety alarms

8.1 General

If alarms are employed to warn of a leak in the machinery room or the occupied space the alarm shall warn of a refrigerant leak in accordance with 8.3. The alarm shall be turned on by the signal from the detector in accordance with Clause 9. The alarm shall also alert an authorised person to take appropriate action.

8.2 Alarm system power

In cases where an alarm system is installed the power source of the alarm system shall be from a power source independent of the mechanical ventilation or other refrigerating systems which the alarm system is protecting.

NOTE Back up power using batteries can be used for the alarm system.

8.3 Alarm system warning

The alarm system shall warn both audibly and visibly such as both a loud (15 dB(A) above the background level) buzzer and a flashing lamp.

For a machinery room the alarm system shall warn both inside and outside the machinery room. The alarm outside the machinery room may be installed in a supervised location.

For an occupied space the alarm system shall warn at least inside the occupied space.

For access category a (see EN 378-1) the alarm system shall also warn at a supervised location such as the night porter's location as well as the occupied space.

Detectors

9.2 Location of detectors

The location of detectors shall be chosen in relation to the refrigerant and they shall be located where the refrigerant from the leak will concentrate.

The positioning of the detector shall be done with due consideration of local airflow patterns, accounting for location sources of ventilation and louvers. Consideration shall also be given to the possibility of mechanical damage or contamination.

At least one detector shall be installed in each machinery room or the occupied space being considered and/or at the lowest underground room for refrigerants heavier than air and at the highest point for refrigerants lighter than air.

9.3 Type and performance of detectors

9.3.1 General

Any suitable detector may be used and shall give an electrical signal at the pre-set value of the refrigerant or oxygen concentration (the pre-set value) that activates the shut-off valves, the alarm system, the mechanical ventilation or other emergency controls.

Detectors shall be continuously monitored for functioning. In the case of a detector failure, the emergency sequence should be activated as if refrigerant had been detected.

The pre-set value for the refrigerant detector at 30 °C or 0 °C, whichever is more critical, shall be set to 25 % of the LFL or 50 % of the ATEL/ODL, whichever is the lower value, as given in EN 378-1:2016, Annex E. The pre-set value for the oxygen deprivation detector shall be 18 % or higher.

Pre set Value
1000 ppm

The sensitivity tolerance of the detector shall be considered to ensure that the output signal is triggered at or below the pre-set value. The tolerance of the detector shall take into account the ± 10 % of power line voltage tolerance.

DANFOSS recommendations for alarm levels: EN 378:2000 & prEN 378:2006			National requirements		Comply: EN 378 / prEN 378			
			Sensor type	LEVEL I Personal safety (occupational) (TWA-values) [ppm]	Sensor type	LEVEL II (pre-alarm) [ppm]	Sensor type	LEVEL III (main-alarm) [ppm]
Ammonia	R717	Machinery rooms			EC	500	CT	10000
		Machinery rooms	EC	25	EC	150		
		Safety valves - vent line		–	SC	1000		
Carbon Dioxide	R744 (CO_2)		IR	5000	IR	10000		
Halocarbon HCFC	R22		SC	500[1])	SC	1000		
Halocarbon HFC	R134a, R404A, R407C,R410A, R507		SC	500[1])	SC	1000		
Hydrocarbon HC	R290, R600, R600a, R1270	Concentration ≤ 20% of LFL	CT	800	CT	2500		

[1]) 50% of TWA-value
Note: All proposed levels are ≤ the max. values in EN 378:2000 & prEN 378:2006

DANFOSS recommendations for alarm levels: ASRAE 15:2004			Comply: ASRAE 15:2004			
			Sensor type	LEVEL I Personal safety (occupational) (TWA-values) [ppm]	Sensor type	LEVEL II (pre-alarm) [ppm]
Ammonia	R717	Machinery rooms	EC	25	EC	500
		Safety valves - vent line		–	SC	1000
Carbon Dioxide	R744 (CO_2)		IR	5000	IR	10000
Halocarbon HCFC	R22		SC	500[1])	SC	1000
Halocarbon HFC	R134a, R404A, R407C,R410A, R507		SC	500[1])	SC	1000
Hydrocarbon HC	R290, R600, R600a, R1270	Concentration ≤ 25% of LFL	CT	800	CT	2500

[1]) 50% of TWA-value
Note: All proposed levels are ≤ the max. values in ASRAE 15:2004

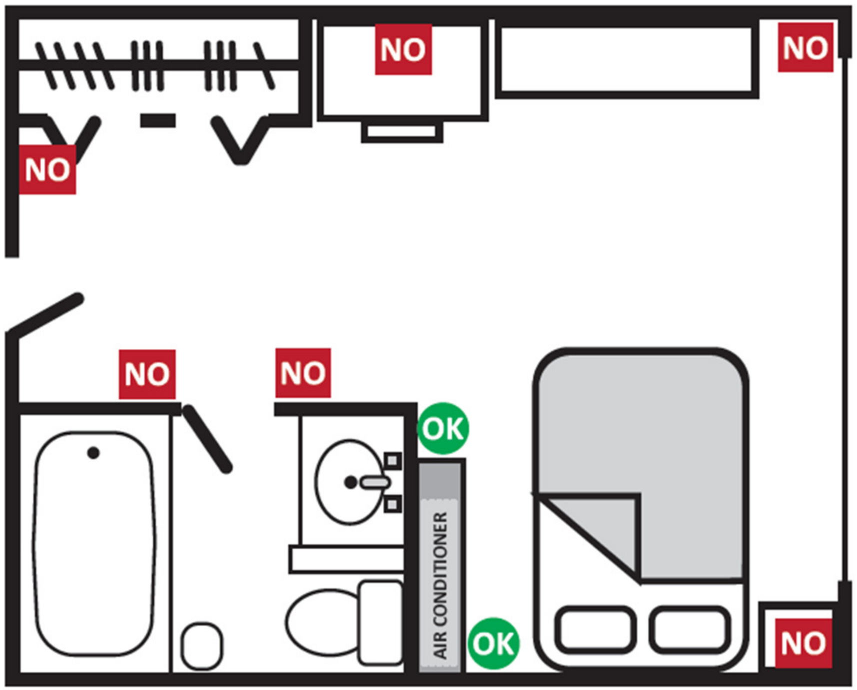
Detectors

9.4 Installation

The installation of the detector shall allow access for checking, repair or replacement by an authorized person.

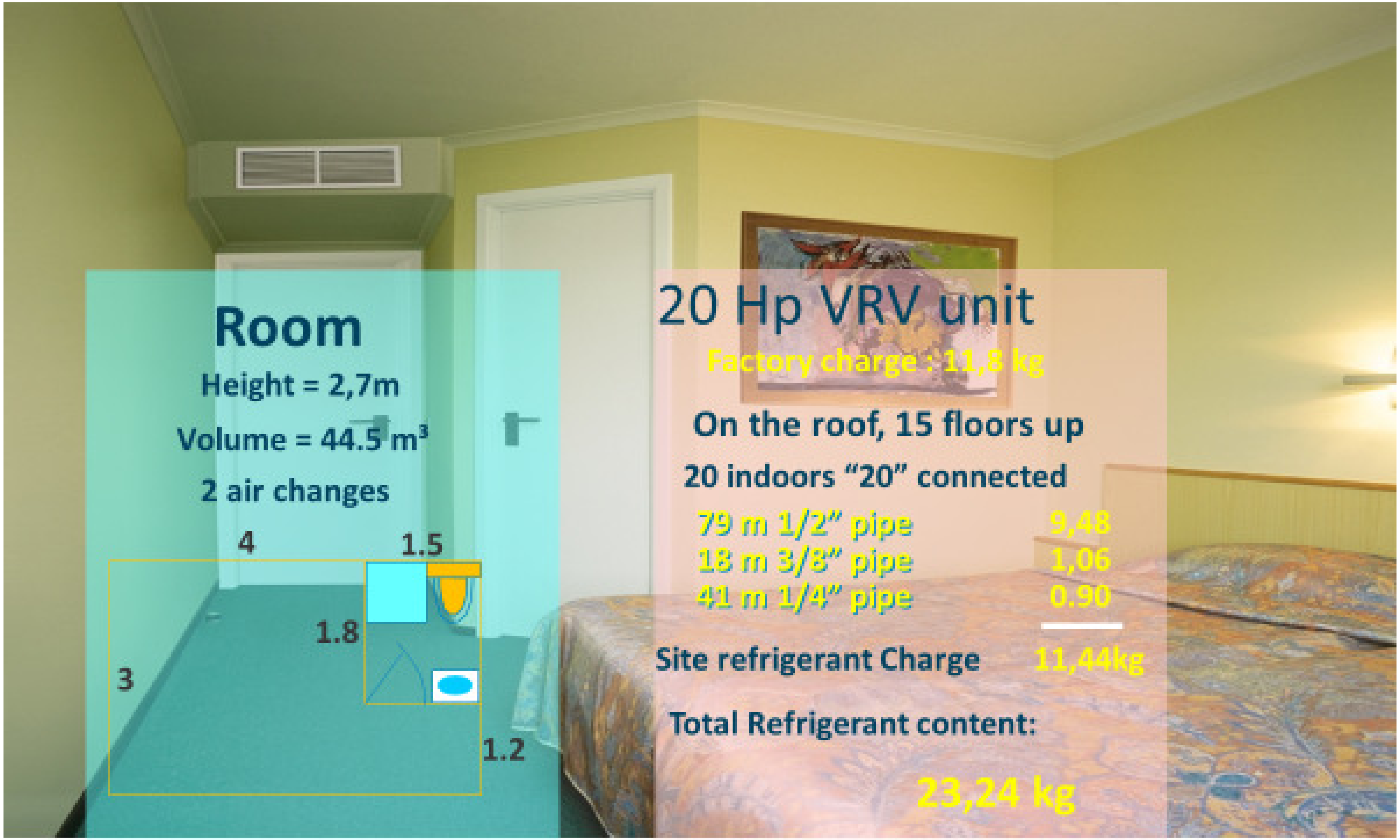
The detector shall be installed so its function can be verified easily.

The detector shall be protected to prevent tampering or unauthorised resetting of the pre-set value.



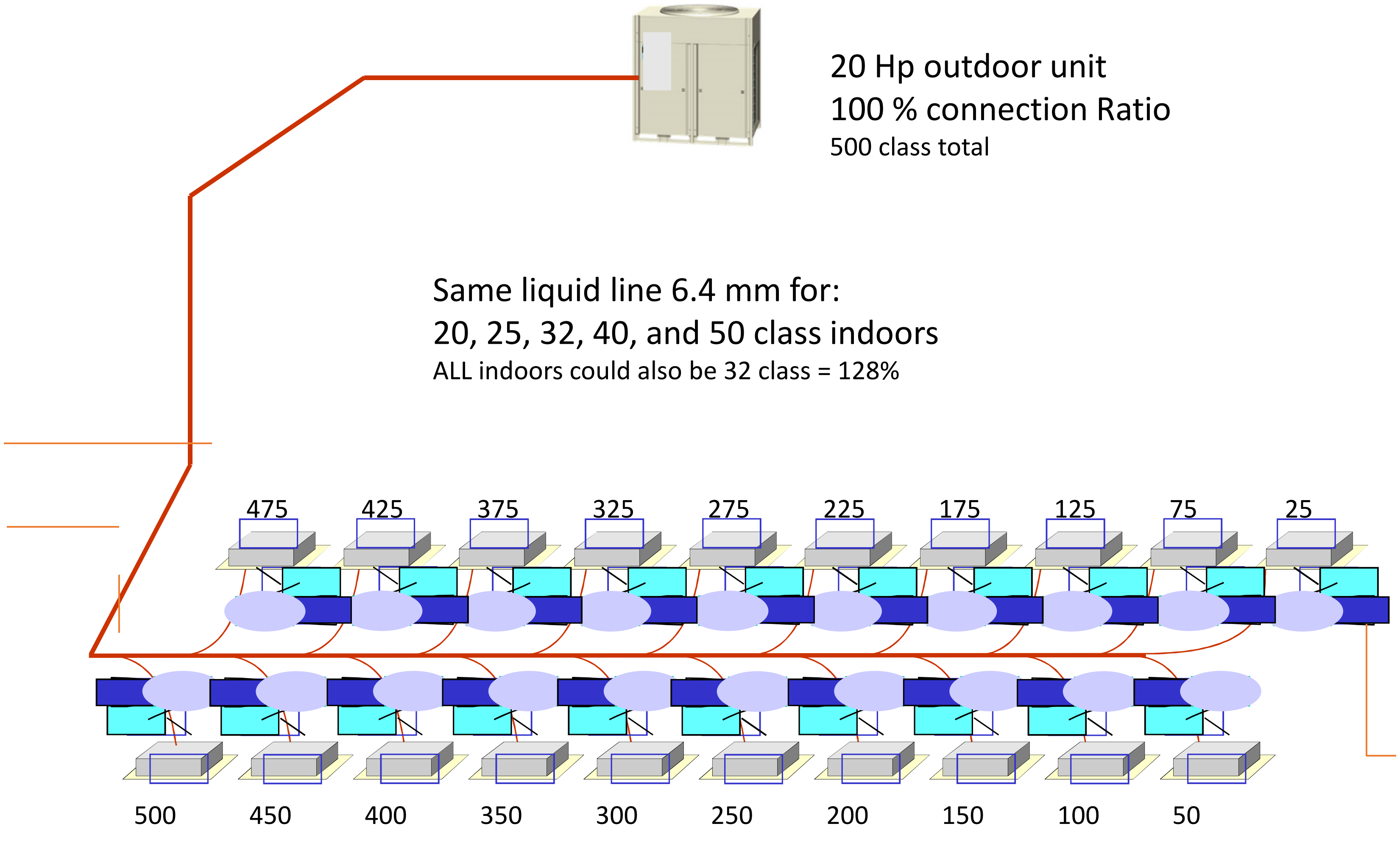
R-410A

Case Hotel Room



20 Hp outdoor unit
100 % connection Ratio
500 class total

Same liquid line 6.4 mm for:
20, 25, 32, 40, and 50 class indoors
ALL indoors could also be 32 class = 128%



All indoor units class 25

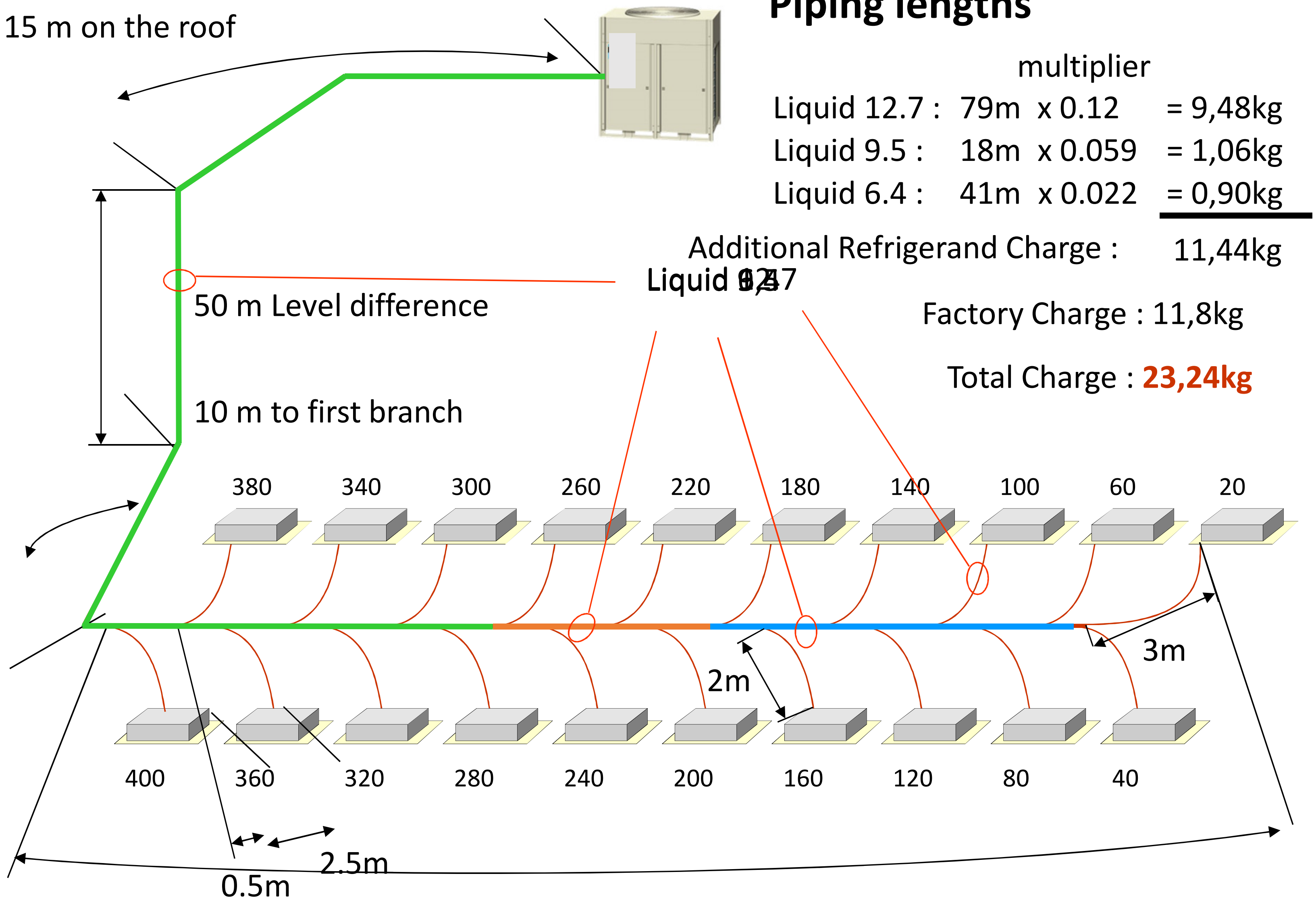
Piping lengths

		multiplier	
Liquid 12.7 :	79m	x 0.12	= 9,48kg
Liquid 9.5 :	18m	x 0.059	= 1,06kg
Liquid 6.4 :	41m	x 0.022	= 0,90kg

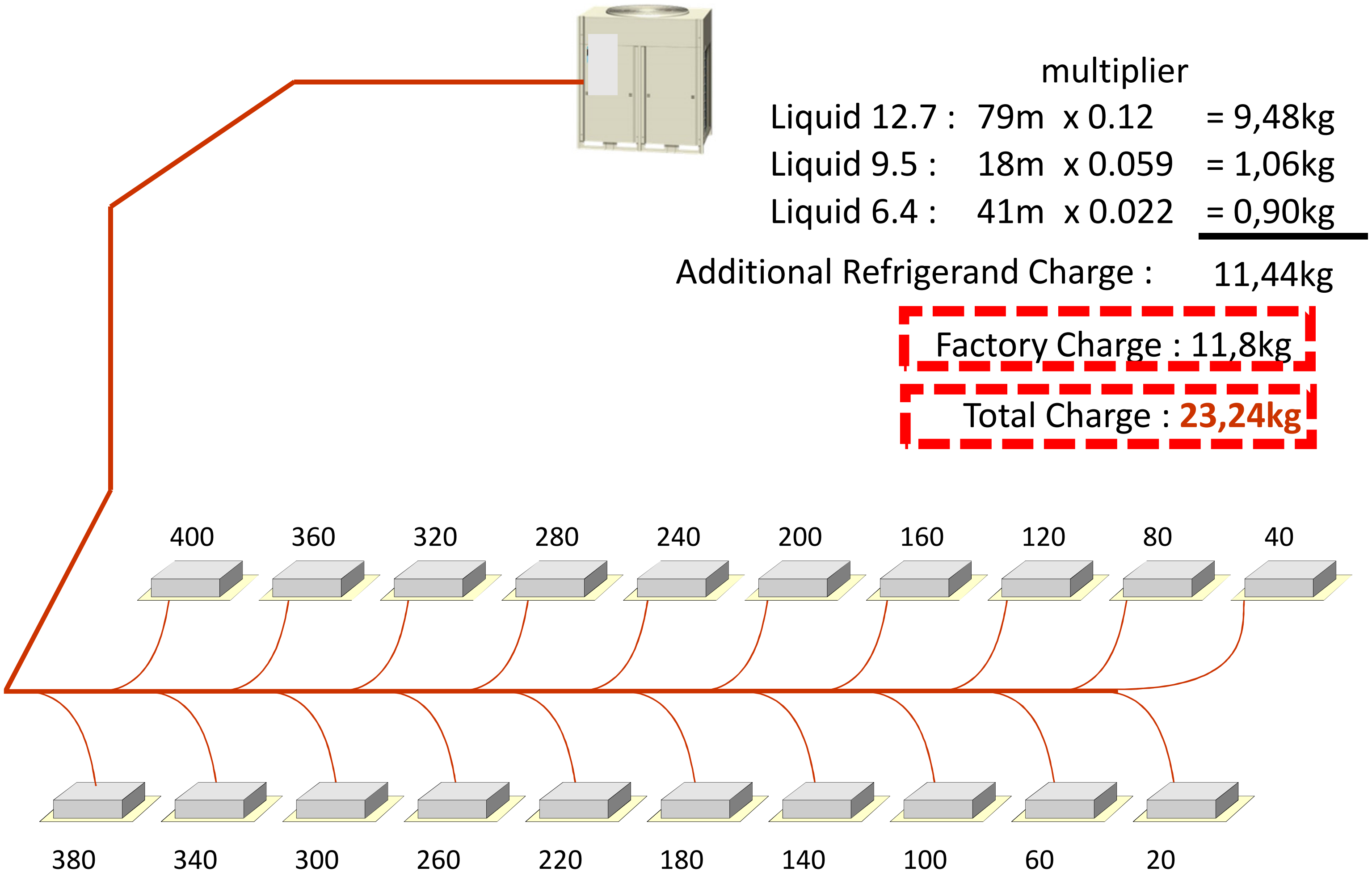
Additional Refrigerand Charge : 11,44kg

Factory Charge : 11,8kg

Total Charge : **23,24kg**



Longest length after first branch = 40m



		multiplier	
Liquid 12.7 :	79m	x 0.12	= 9,48kg
Liquid 9.5 :	18m	x 0.059	= 1,06kg
Liquid 6.4 :	41m	x 0.022	= 0,90kg

Additional Refrigerand Charge : 11,44kg

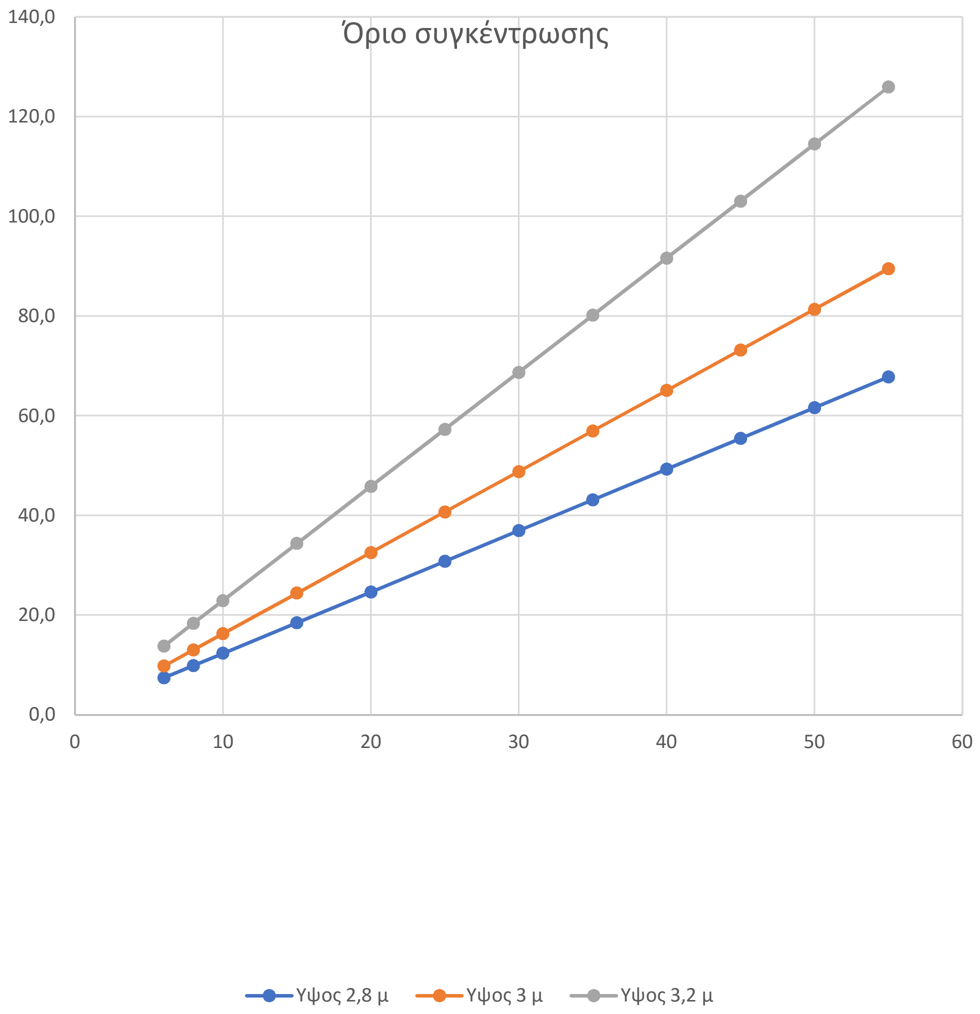
Factory Charge : 11,8kg

Total Charge : **23,24kg**

EN378 Part 1 Annex E : Practical Limit Concentration for R-41OA : $0.44\ kg/m^3$

We can add part of the air changes to the volume : 59 x 0.44 = 25.96kg

Factory Charge per Outdoor unit



HP	Kg	Total Kg	Allowable m3
8	5,9	11,8	26,8
10	6	12	27,3
12	6,3	12,6	28,6
14	10,3	20,6	46,8
16	10,4	20,8	47,3
18	11,7	23,4	53,2
20	11,8	23,6	53,6

Which space / room need to be considered to determine the refrigerant charge limits

1. Any space which contains refrigerant-containing parts
2. The volume of the smallest, enclosed, occupied space shall determine the refrigerant limits
3. Multi spaces
   - **Multiple spaces that have appropriate openings (that cannot be closed) between the individual spaces or are connected with a common ventilation supply, return or exhaust system not containing the evaporator or condenser shall be treated as a single space.**
   - **Where the evaporator or condenser is located in an air supply duct system serving multiple spaces, the volume of the smallest single space shall be used**
   - **If the air-flow to a space cannot be reduced to less than 10% of the maximum air flow by the use o fan air flow reducer, then that space shall be included in the volume of the smallest human occupied space.**

Some "simplified" examples

office

200m², smallest meeting room = 16m²

Existing openings between the rooms (falls walls, common ventilation etc) ?

Yes → 200m²

No → 16m²

bank

200m²: Public area, 'falls" offices of 20m², and a separated vault / safe room (10m²)

Condenser in air supply duct system (eg Chiller+AHU, VRV+VAM, …) ?

Yes → 10m²

No → 200m²

hotel

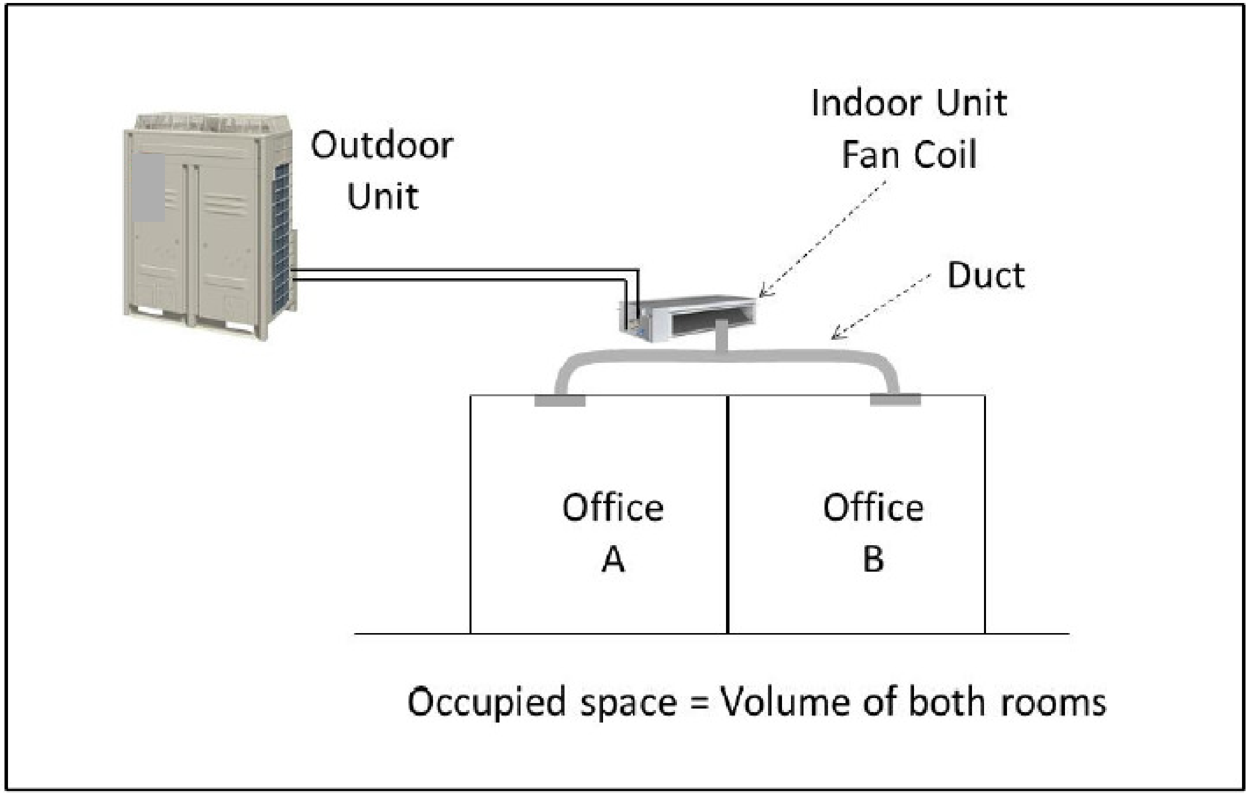
common area, 50 bedrooms (around 25m²) + real separated ventilated bathroom of 8m²

Common ventilation system? Air flow rate is always above 10% of max possible rate? Even if empty

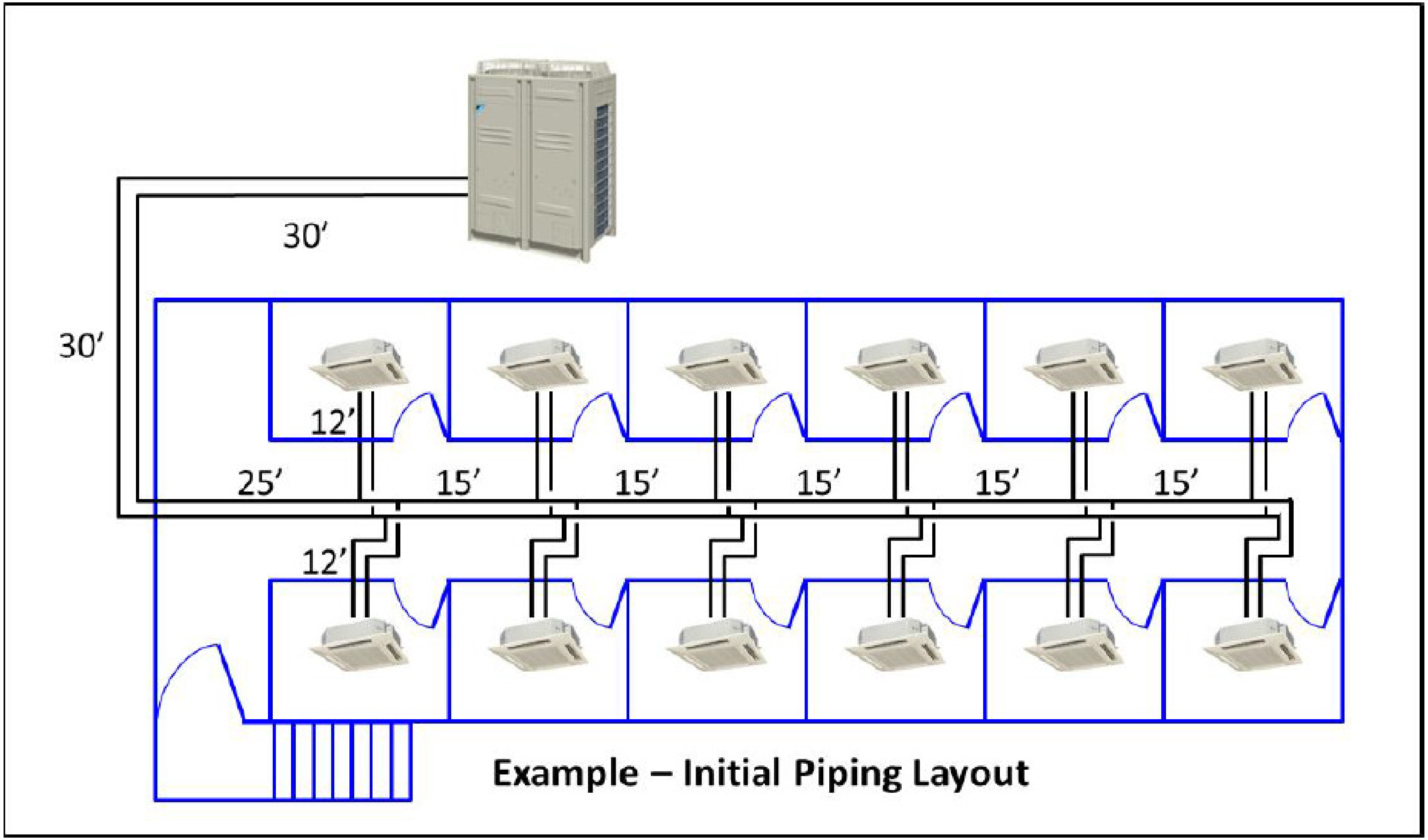
Yes → Total m²

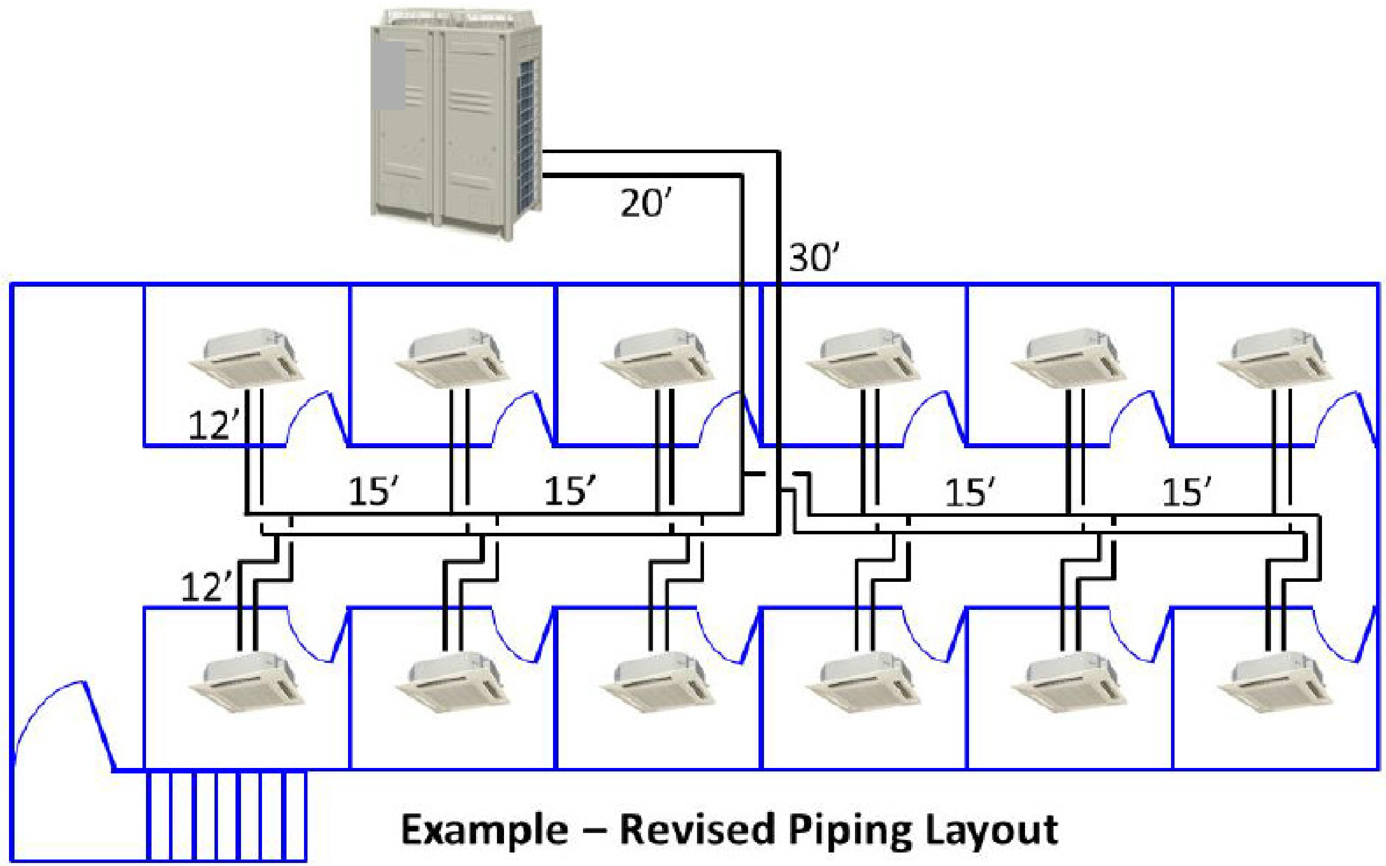
No → 8m²

Multizoning application



Pipe network balance

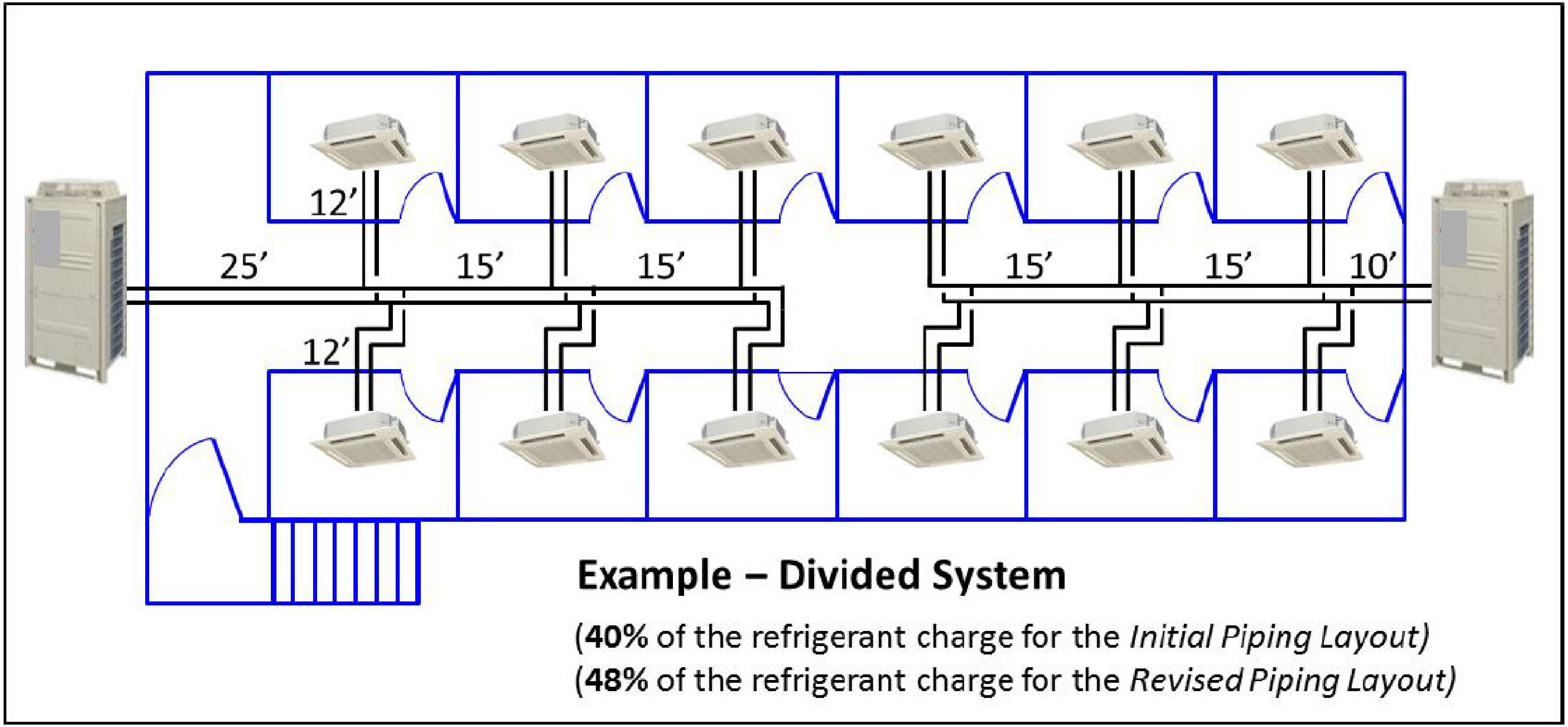




Example – Revised Piping Layout

(**83%** of the refrigerant charge for the *Initial Piping Layout)*

System Division



Thank You