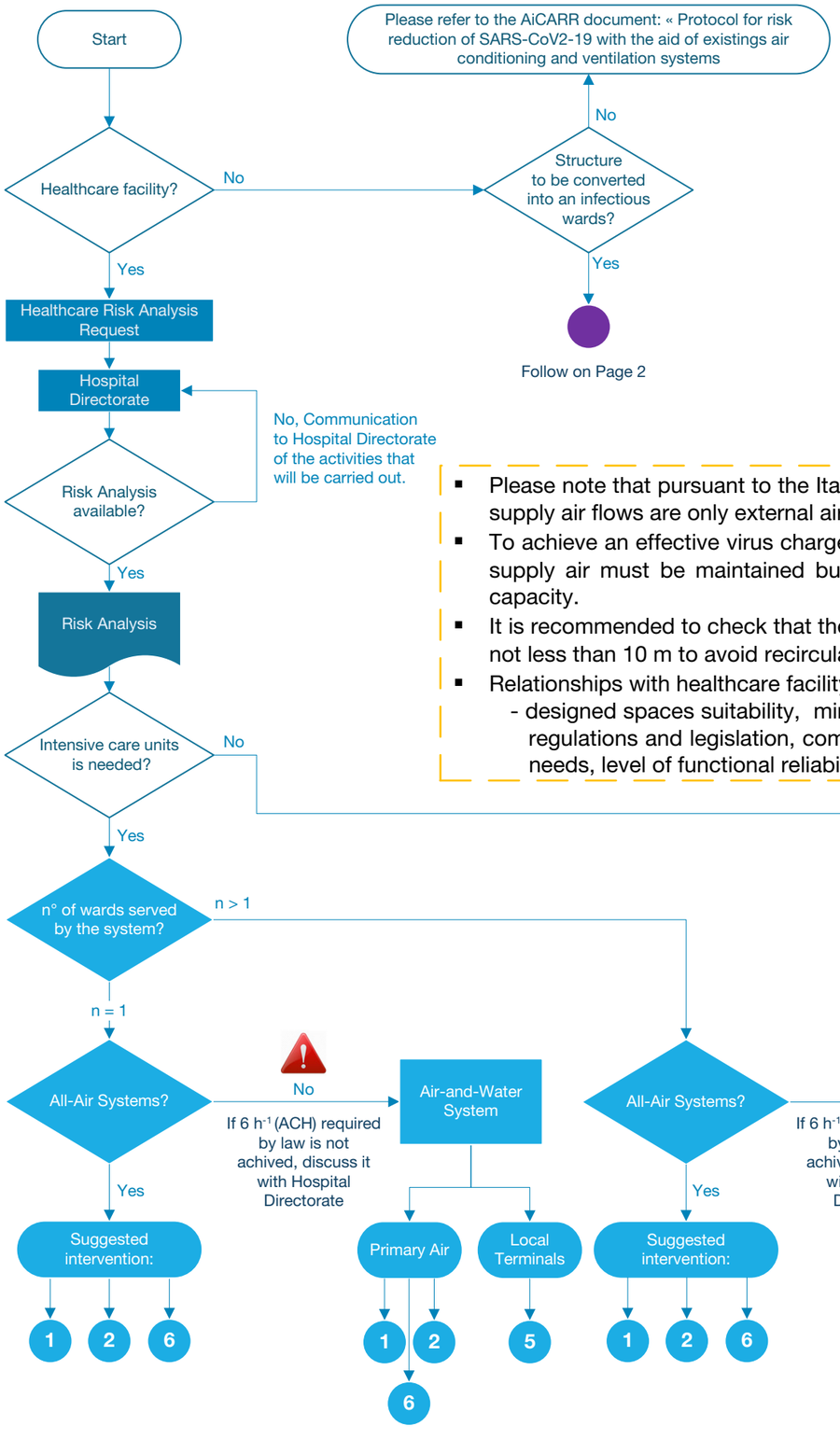
Cultura e Tecnica per Energia Uomo e Ambiente

PROTOCOL FOR RISK REDUCTION OF SARS-CoV2-19 DIFFUSION IN HEALTHCARE FACILITIES WITH THE AID OF AIR CONDITIONING AND VENTILATION SYSTEMS



PREMISE

On March 18th AiCARR has published on its web site the document «Protocol for risk reduction of SARS-CoV2-19 diffusion with the aid of existing air conditioning and ventilation systems". This new protocol is intended to complement the previous one for aspects relating to healthcare environments.

This document is addressed to HVAC technicians and Healthcare Departments to provide indications on how to operate on existing systems or how to design and operate new systems when adapting existing spaces to healthcare facilities .

Starting from the basic principle that in the hospitalization of highly infectious patients the actions to be taken are:

- segregation both in terms of architectural layouts (for example air-lock) and in terms of systems (actions to maintain adequate pressure differences between different spaces in order to avoid cross contamination);
- airborne virus concentration dilution through high air changes rates, especially for intensive care units;
- outdoor environment contamination control through absolute filtration of the exhaust air.

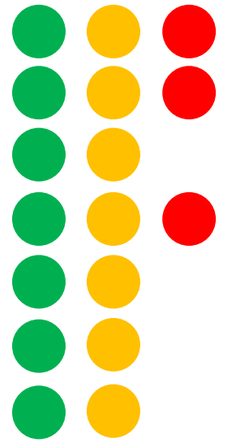
It should be noted that solutions suggested by this protocol are of an extraordinary and provisional nature dictated by COVID-19 national emergency and should be previously authorized by the Health Department.

WARNING

- Please note that pursuant to the Italian Presidential Decree of 14 January 1997, in intensive care units supply air flows are only external air without recirculation with a minimum of 6 h^{-1} air changes rate.
- To achieve an effective virus charge dilution in the ambient air not only the outdoor air fraction in the supply air must be maintained but it must be increased as much as compatible with the system capacity.
- It is recommended to check that the distance between the external air intake and the exhaust outlet is not less than 10 m to avoid recirculation.
- Relationships with healthcare facility managers are essential to establish with them:
  - designed spaces suitability, minimum standards to be achieved, every exceptions to current regulations and legislation, compatibility between required intervention work time and emergency needs, level of functional reliability of devices/supplies to ensure patients lives.

SUGGESTED INTERVENTIONS

1. SPACES DEPRESSURIZATION
2. EXHAUST AIR MANAGEMENT
3. INDOOR AIR RECIRCULATION
4. INTENSIVE CARE UNIT
5. TERMINALS CLEANING
6. ABSOLUTE FILTERS REPLACEMENT
7. HEAT RECOVERY UNITS DEACTIVATION OR BY-PASS



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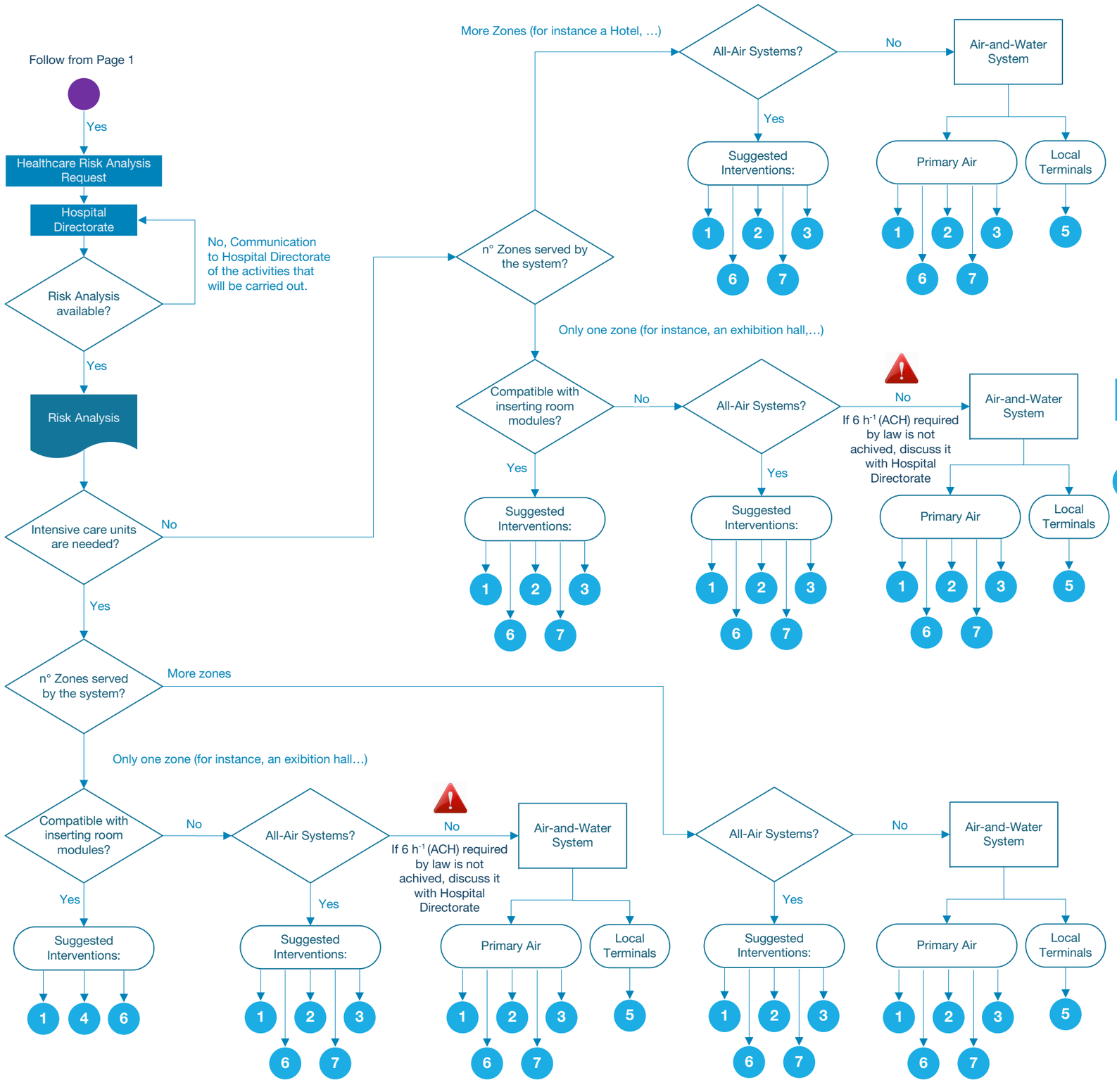


LEGENDA

- INTERVENTIONS THAT REQUIRE ACTIONS ON CONTROL SYSTEMS
- INTERVENTIONS THAT REQUIRE MAINTENANCE STAFF ACTIONS
- INTERVENTIONS THAT REQUIRE OR MAY REQUIRE PLANT OR ARCHITECTURAL MODIFICATIONS

SUGGEESTED INTERVENTIONS DESCRIPTION

1 SPACES DEPRESSURIZATION

To transform existing ordinary hospital stays into infectives hospital stays, first of all it is necessary to increase the extract air to maintain these rooms in depression compared to other departments and or spaces for non-infected, it is therefore recommended to:

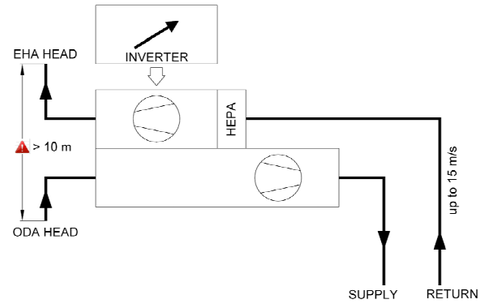
a. do not decrease the supply air flow but rather force the supply fan to provide the maximum possible flow by feeding its motor through inverter in order to increase its round speed remaining below its maximum allowed absorbed power;

b. feed exhaust air fan motor through inverter in order to increase its round speed as much as possible below its maximum allowed absorbed power (scheme 1) and insert an absolute filter on the exhaust outlet, after checking the available head; despite noise increase, in these situations it is possible to increase the air speed in return ducts even up to 15 m/s;

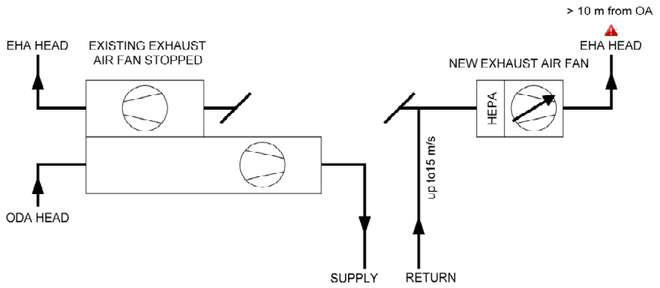
c. if applying a) and b) an effective depression, verified by smoke test, is not achieved, examine the possibility of replacing the existing exhaust air fan with a new appliance of adequate power and head (scheme 2) ; despite noise increase, in these situations it is possible to increase the air speed in return ducts even up to 15 m/s;

d. if still insufficient, it is necessary to install an autonomous extraction system (see schemes 3a and 3b) with fan and absolute filter block located in the corridor outside the healthcare unit. In the first case (3a) it is possible to keep the corridor in overpressure with a limited risk of cross-contamination, in the second case (3b) there is risk of uncontrollable infiltrations.

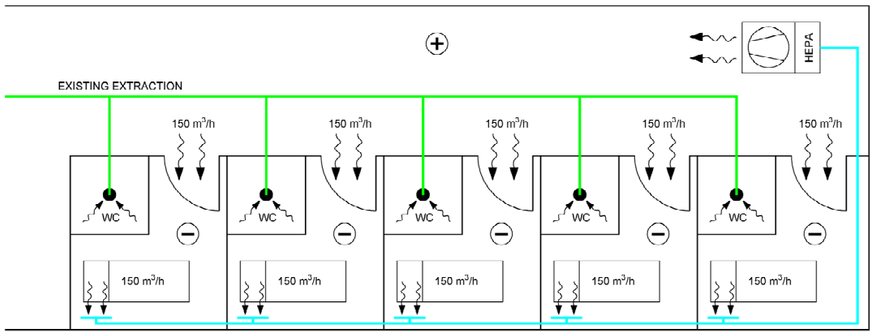
SCHEME N.1 – Insertion of inverter on exhaust air fan motor and of HEPA filter



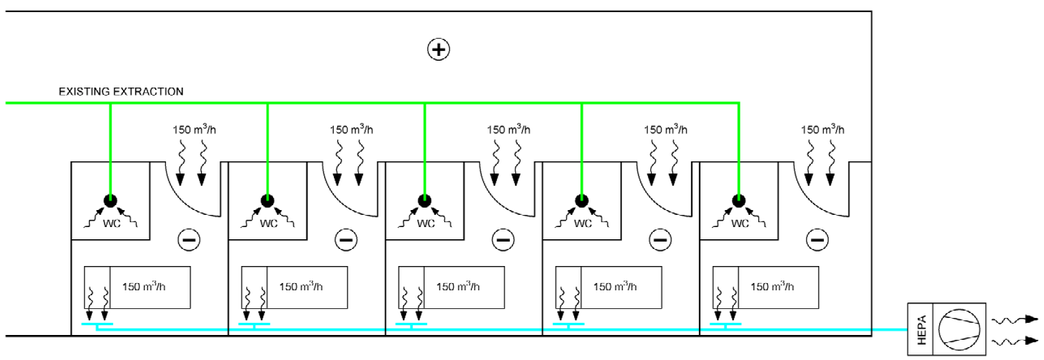
SCHEME N.2 – New block with HEPA filter and exhaust air fan with inverter



SCHEME N.3a – Internal extraction fan in the department corridor



SCHEME N.3b – Extraction fan outside the department



Note to schemes 3a e 3b: to maintain a minimum depression, an extraction flow rate of about 150 m^3/h is recommended for invectives hospital stay of about 25 m^2.

It should be remembered that isolation of infected spaces respect to other healthcare spaces is an essential provision and the principles expressed above must be applied according to the intended use and the existing systems typology; specifically:

A. In the presence of **local terminals with primary air system**, space transformation into intensive care unit is strongly discouraged; indeed:

- The supply air flow rate (usually about 2 h^{-1}):
  - is too low, compared to a recommended flow rate of 10-12 h^{-1} and a regulatory minimum of 6 h^{-1};
  - cannot be diminished to create depression;
  - compatibly with the existing situation, it should be forced to the maximum.
- The extract air sometimes:
  - is allowed to flow out naturally due to the overpressure in the rooms;
  - occurs from the dedicated toilet, if any, with extraction fan (fixed at 6 h^{-1}, or intermittent with 12 h^{-1}), however not adaptable to new requirements;
  - occurs from the corridor and should be decreased as much as possible to keep it in overpressure in respect of hospital stays.

In conclusion, major renovations would be needed.

In the event that the emergency forces this type of use, it is necessary to introduce an autonomous air extraction system as described in (2) that maintains the healthcare unit in a strong depression by recovering air from other rooms, excluding the toilet, and agreeing with the Hospital Directorate the non-compliance with the minimum ventilation level required by law.

B. In the presence of a **All-Air system**, space transformation into intensive care for infected patients is subject to:

- compliance verification with the project data agreed with the responsible Hospital Directorate;
- enhancement of the supply air flow rates in the intensive care area both by acting on fan motor as described at point (1), and by recalibrating the supply ducts network in favour of the intensive care area;
- enhancement of air extraction and expulsion.

2 EXHAUST AIR MANAGEMENT

The expulsion of the exhausted air from hospital stays or infectious departments must be subjected to absolute filtration (filters H13 or H14):

1) If you can use the existing systems, check for air expulsion that:

- it is possible to install HEPA filter before exhaust air fan (with canister if available, in the alternative, if not available, provide for replacing the filter with suitable PPE following the instructions of the RSPP), and to maintain it according to the instructions of hygienist;
- a short circuit with the outdoor air intake must be avoided, thus try to have a minimum distance between the exhaust outlet and the intake of 10 meters, placed upwind of exhaust outlet respect to predominant winds;
- it is possible to connect easy with the control system center, if not, install clogged filter luminous-acoustic alarm as visible/audible as possible.

2) If it is necessary to provide new independent auxiliary extraction duct:

- where applicable, the recommendations/provisions of the previous point apply;
- create a new air intake duct from the rooms concerned, even inside them, providing it with : intake terminals possibly positioned behind the head of the infectious bed (s); extraction air fan with absolute filtration (with canister if available, in the alternative, if not available provide for the operation of replacing the filter with suitable PPE following the instructions of the RSPP) with soundproofed box, placed in inspectable position and maintainable safely for both patients and heahlthcare operators;
- if possible introduce a duct silencer.

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3 INDOOR AIR RICIRCULATION

Since the virus can survive in air for several hours, it is necessary to prevent possible contamination of indoor air by eliminating air recirculation, when it exists and in case of intervention on non-healthcare structures, (recirculation in healthcare environments is prohibited due to risk of cross contamination independently of SARS-CoV2- 19).

Local terminals - such as split units, fan coils and VRF systems for heating and cooling - only recirculate air of space used as healthcare facility and represent a low risk of spreading the virus, in nearby wards, especially if they are subjected to continuous and accurate cleaning and sanitizing. However, their presence is not compatible with infectious intensive care unit stays.

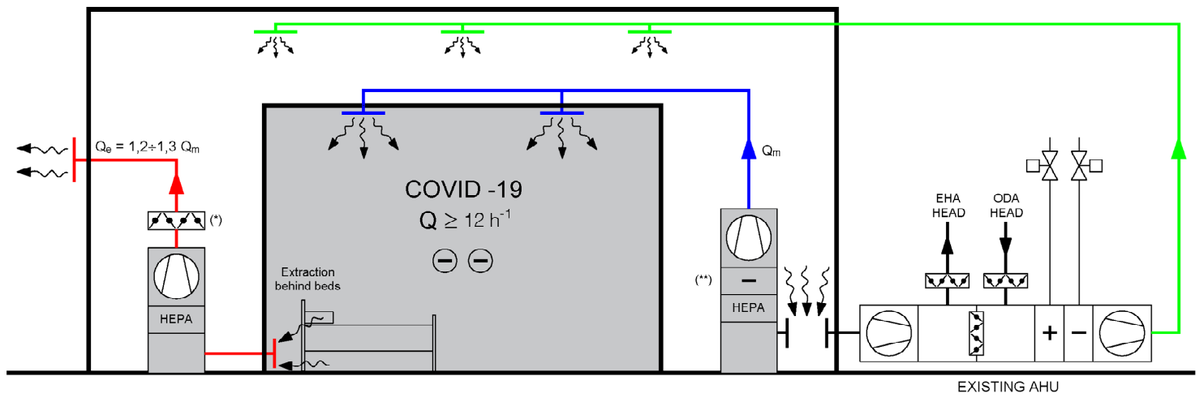
In hospitals, indoor air recirculation is allowed only in the operating theatres; in case of interventions on SARS-CoV2-19 patients, it is recommended not to modify HVAC systems but it is sufficient to have post-intervention decontamination period lasting to be defined with Hospital Directorate.

4 INTENSIVE CARE UNIT

When setting up temporary intensive care units within large already air-conditioned existing structures, such as exhibition centres, gyms, warehouses, etc. (scheme 4), it is suggested to take into account thermal load for the new built environments of about 60 W/m^2, so identified:

- Reference area for intensive care unit bed: 15 m^2/bed;
- Equipment: 600 – 800 W/bed about 50 W/m^2;
- Lighting: 5 W/m^2;
- People: 5 W/m^2;
- Minimum outdoor air flow ≥ 10/12 h^{-1} with a minimum of 6 h^{-1} as required by Italian decree DPR 14/01/1997;
- Supply air temperature ≥ 18 °C;
- Relative humidity between 40 e 60 % as required by Italian decree DPR 14/01/1997.

SCHEME N.4 - COVID-19 intensive care unit layout



(*) Calibration dumper or variable flow fan (EC motor).
(**) Direct expansion post cooling coil.

5 TERMINALS CLEANING

Droplets and an important fraction of the aerosol precipitates on horizontal surfaces and therefore it is necessary to clean and sanitize them with adequate equipment at least once a day.

For correct cleaning of system terminals (radiators, fan coils, vents, etc. ...) only qualified personnel, equipped with suitable Personal Protective Equipment (PPE) and following well-defined procedures, must be used.

Any intervention carried out incorrectly and/or without using PPE would result in not reduction but in risk increase.

Equipment: vacuum cleaner with HEPA micro filter (filter capable of retaining 99.9% of micro particles) and telescopic rod, cloth and color-coded bucket.
Products: multipurpose detergent for surfaces cleaning .
Operating technique:

- Clean the surfaces with a vacuum cleaner with telescopic rod.
- Wash with cloth soaked in detergent solution.
- Leave to dry.

6 ABSOLUTE FILTERS REPLACEMENT

Absolute filters must be inserted in workmanlike manner to avoid leaking contaminated air; thus, penetration test must be carried out on terminals of air conditioning system to check the filtration efficiency, including the correct sealing of the filters and the correct sealing of their frame to channels and vents to avoid bypass of unfiltered air through leaks.

If possible, use suitable canisters for the absolute filters (safety filter holder containers or alternatively use of suitable PPE when removing them) that guarantee maximum containment, protection of the environment and of maintenance operators, which watertight seal is certified in class 3 according to ISO 10648-2 at +/- 6000 Pa.

7 HEAT RECOVERY UNITS DEACTIVATION OR BY-PASS

Rotary heat exchangers must always be stopped, to avoid a possible, however improbable and remote, contamination of outdoor air with exhaust air. Upon restarting, wheels must first be sanitized.
For the same reason, any other type of membrane based enthalpy heat exchangers must be by-passed.
In case of cross flow heat exchangers, instead evaluate opening of by-pass damper in order to increase the outdoor air flow. If there is a calibration damper on the outdoor air by-pass line giving the same pressure drops of the heat exchanger, the damper must be opened as much as possible, always compatibly with the fan motor electrical absorption.

PROBLEMS RELATED TO ACTIVITIES OF OPERATORS IN CHARGE OF PLANTS MANAGEMENT AND MAINTENANCE

In any modification/enhancement of HVAC systems serving COVID-19 departments or in any case areas where patients affected by COVID-19 are treated, operators must be specifically trained on the risks and, in particular, operations must be implemented considering every possible precaution that protects their health, such as:

- surface disinfection prior to all operations, taking care to follow instructions for products used;
- adoption of all PPE suitable for required operations with control of this use by foremen of cleaning companies;
- correct transfer and safety isolation of all removed parts, taking into due consideration virus survival time on their surfaces;
- posting, where necessary for risk prompt identification, of signs identifying plant parts subject to potential SARS-CoV2-19 infection (for example, identification of ducts and expulsion grids of the AHUs serving the COVID-19 areas);
- recording (date, operation carried out, etc.) of maintenance operations and/or plants upgrading/modification, for example to allow interpretation of any statistical evidence or identification of any anomalies.
- check at least 2 times a day medical oxygen production and distribution plant functioning and correct feeding to departments of as well as, even several times a day, its distribution manifolds to check the absence of lamination phenomena due to the high demand of the oxygen itself with consequent freezing and interruption of the service; this malfunction is in fact potentially lethal, especially for patients affected by SARS-Cov2-19.