

# DESIGN OF HVAC systems (code 39096) - (6 credits) - (Eng BUILDING + Eng MECHANICAL Master of Science)

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The course consists of:

- **Lessons (32 hours)** , in which they are carried mentioned theoretical arguments and some numerical examples ( always limited to a single topic in question).
- **Exercises (16 hours)** , in which , with the assistance of the teacher or his representative , students undertake the execution of a plant project ( a traditional heating system with radiators and / or a plant conditioning) in order to experience l'applicazione of concepts learned in real cases. The development of the project and the presentation of the works are necessary conditions for admission to oral examination.

In order to facilitate both the course and the exam , the planned program has been divided into "modules" , each with its own well-defined program and its educational materials support ( from time to time provided by the teacher ) . This choice also seeks to compensate, at least partially , the lack of a single reference text that can act as a " backbone " for the course .

Lessons (+ exercises) , for a total of about 48 hours, divided into 24 " modules " for a period of two hours each ( the programs of individual modules are shown later).

The remaining hours are left for the interim phase , for the clarifications requested by the students and compensate for delays in the development of the arguments.

## CONDITIONS OF COURSE

A successful attendance to lectures requires a good knowledge of the arguments in the course of Physics and Applied Physics latter is a prerequisite to the course with particular reference to:

- Basic concepts of mechanics ( speed, force , momentum , work, energy, power, basic laws of Newtonian mechanics);
- Concepts of applied thermodynamics ( work, heat , 1st and 2nd law , mass heat capacity and / or molar mass and energy balances for closed and open systems , gas and liquids perfect);
- Concepts of heat transfer (conductivity, convection, radiation and related fundamental laws ) ;
- Basic concepts of fluid mechanics ( pressure, flow, Bernoulli equation, pressure drop, operating machines ) .

## PURPOSE OF THE COURSE

At the end of the course students will be able to:

1. Make an initial analysis on the choice of the appropriate for a given type of building , knowing grasp the pros and cons of the available solutions .
2. Calculate the heat load in summer and winter (even with simplified methods ) of any building or civil service sectors.
3. For the most common types of installation , perform a preliminary design and be able to choose and designate the main elements (boiler, chiller , pumps , piping, terminal units, air handling units , air ducts ) .
4. Apply the first lay-out or reserve , in building design , the space needed for system components (power plants, refrigeration systems, air ducts , floor heating , etc.). .

## STRUCTURE AND COURSE

### 1. APPLIED THERMODYNAMICS ( Recall from the course of Technical Physics)

Closed thermodynamic systems , exchanges energy : heat and work interactions . Internal energy and 1 Standard. Model of ideal gas and perfect fluid : constitutive laws and specific heats, thermodynamic processes and their representation on the floors ( pv), (Ts), (hs) .

Open systems: concepts of flow ( mass and volume ) and power ( thermal and mechanical ), the definition of enthalpy, mass balance and energy.

Thermodynamic cycles forward and reverse , 2nd Principle , entropy representation in coordinates ( Ts).

Change of state : Gibbs phase rule , latent heat of evaporation / condensation , melting / solidification etc. .

### 2. HEAT TRANSFER ( Recall from the course of Technical Physics)

Phenomenology : conduction, convection, radiation and descriptive overview of the physical introduction into play.

General law of heat exchange for practical applications (Equation Postulate and Fourier , Newton 's equation): infinite flat wall and heat exchangers ( cocurrent and countercurrent ) surface, practical examples. Energy balances for heat exchangers . Thermal insulation.

### 3. MOVEMENT OF FLUIDS BY PIPELINE ( Recall from being Physics + depth )

Hydrostatic pressure. Flow of a viscous incompressible fluid not : equation of continuity and balance of momentum (eq. Bernoulli) , use of the two equations .

Viscous Newtonian fluids : viscosity , friction at the wall , viscous dissipation laminar and turbulent flow , the Reynolds number , influence of the surface roughness of the wall.

Continuous pressure loss : Moody diagram and diagrams of practical use for commercial pipes , localized pressure losses , localized loss coefficient method and the method of equivalent length. Falling of a pipeline. Elements of hydraulic symbols .

Practical procedure of dimensioning of a pipe ; characteristic of the circuit ( resistant feature ) .

### 4. FLUID MACHINES operating

Nomenclature: pumps, fans , compressors. Energy balance of an operating machine , expression of the pumping work and the power required by the pump , performance , characteristic curves .

Pumps : classification and characteristics typical .

Fans : classification and characteristics typical fields of application.

Compressors: schematic description of the main types ( volumetric and fluid dynamics ) and their field of application, working isothermal , adiabatic and polytropic , inter- cooling , multistage compressors .

### 5. Psychrometry AND HUMID AIR

Ideal mixtures of gases and vapors , partial pressure , pressure (tension) of steam , moist air , moist air characteristic variables ( X ,  $\phi$  , t , h ) , thermodynamic parameters ( p , h ) , diagrams of humid air: Mollier diagram and Grosvenor ( Carrier - ASHRAE), the definition of the wet bulb temperature and the dew point temperature.

Main elementary transformations of humid air ( mixing, heating sensitive, sensible cooling , cooling with dehumidification, adiabatic humidification , humidification steam ), typical transformations combined for winter conditioning ( warm mixture + + + humidifier reheat ) and for summer air conditioning ( mixture + cooling + reheat ).

## 6. HEALTH AND CONDITIONS OF INTERIOR DESIGN

The heat balance of the body : thermoregulatory mechanisms. Variables that influence well-being. Thermal stress. Action of radiating surfaces and temperature of the globe thermometer . Actual temperature. Choice of the internal conditions of the design . Classification of wellness facilities (heating, cooling , ventilation, ventilation, air conditioning , climate control, etc ...).

## 7. THE THERMAL CALCULATION FOR WINTER HEATING SYSTEMS ONLY

Design conditions. Steady state . Heat transmission through building structures : walls, ceilings, floors , etc. . (with examples) . Thermal bridges. Natural ventilation. Intermittent warming and start-up. Heating with total fresh air . Humidification and its influence on the heat balance. Overall heat balance of the building and the budget of the individual room. Definition of degree-day and seasonal simplified calculation of the energy requirements .

## 8. LAWS : L. 373/76 - L. 10/91 and subsequent laws

General concepts that inspired the legislation. Power calculation (UNI 7357) : definition of Cd , Cv , Cg and limits. Design of the plant . The limitations on energy ( UNI 10344) : Calculation of FEN, definition yields of production, distribution, regulation and issuance , verification of the average seasonal efficiency and FEN limit. Pipe insulation .

## 9. THE CALCULATION OF THERMAL SUMMER

External design conditions . Conditions change during the day. Energy balance of the environment affected : sensible and latent heat loads , the purpose of calculating thermal summer . Solar radiation through the glass ; definition of SHG and use of its tables, factor accumulation , screens, shadows . Heat transfer through walls and roofs, irradiated and non- CLTD definition and use of the related tables. Air infiltration. Internal heat loads . Various factors , losses. Determination of the conditions air to be introduced into the environment, air flow conditions and external air inlet treatments , budgets and energy requirements for individual treatments. Examples.

## 10. THE PRODUCTION OF HEAT 1

Fluid. Combustible gas network , LPG, diesel, fuel oil . Energy balance of a boiler. Constituent parts of a boiler for the production of hot water . Types of boilers : boilers autonomous (and classification) , medium power boilers fire tube , high power boilers and steam (only sketch). Atmospheric burners and air blast . Fireplaces and rules . Installation of boilers and autonomous rules .

## 11. PRODUCTION OF HEAT 2

Gas -fired power stations for the production of hot water with a power exceeding 35 kW : ex ISPESL regulations (collection " R" DM 1.12.75 ). Control devices and safety : block thermostat , thermostat operating , pressure lock , fuel shutoff valve , safety valve , expansion tanks , etc. . Analysis of the key executive of a power plant .

## 12. PRODUCTION OF COLD 1

Inverse thermodynamic cycle (refrigerator): energy balances. Definition of COP. Chillers and heat pumps . Compression refrigeration cycle : creation, refrigerants commonly used representation of the cycle on the (p

- h), energy considerations. Rack, with two-stage compressor, working with R 134a ( Tetrafluoroethane -  $\text{CH}_2\text{FCF}_3$  ).

### 13. PRODUCTION OF COLD 2

Refrigeration machines used in the practice of conditioning : classification and typical parameters of performance. Description and analysis of the main components, guidelines for the selection. Measures for installation: partitioning, accumulation of cold water flow. Choosing the condensing fluid (air, water loss, water tower), hints on cooling towers.

Outline of absorption refrigeration machines.

### 14. RADIATOR HEATING SYSTEM AND SYSTEM PANELS RADIANT FLOOR

Radiators, cast iron, aluminum, steel : description and generality. Nominal thermal emission according to UNI 6514.

Procedure sizing of : choice of radiators, determination of the water flow, calculation of the distribution network ( choice of paths and diameters of pipes, choice or verification of the pump through the calculation of the pressure drops ); accessories ( valves, gate valves, thermostats and thermostats, thermostatic valves). Design, in principle, a heating system with underfloor heating.

### 15. PLANT WINTER / SUMMER CONVECTORS

Fan coils: classification, general, operating parameters, choice.

Process plant design : method of choice of fan coil units, determination of water flow ( summer and winter ), the choice of the system diagram and calculation of the distribution network ( pipe diameters, pump selection ), calculation and choice accessories.

### 16. SYSTEM FULL AIR 1

Plant scheme to all air, general, mass balances and energy balances, return air, fresh air, return air, air ejection Relative pressure environments.

Central air handling units : choice of treatment, description of the component devices ( dampers, filters, heat exchangers, humidifiers, water and steam, fans).

### 17. ALL SYSTEMS AIR 2

Channels of distribution: notes on the methods of design and construction details.

Work on the problems related to the spread of indoor air, the input unit of the treated air ( vents, anemostats, grids, etc. ).

### 18. OTHER TYPES DI SYSTEM

Primary air systems and fan coils, radiant panels, heaters, finned tubes. Cabinet air conditioners, "split system."

### 19. INDUSTRIAL PLANTS

Typical problems of industrial heating. Stratification. Infiltration and stack effect. Heating with fan heaters, radiant, hot air generators. Heating and ventilation. Summer ventilation and conditioning adiabatic.

## 20. AUTOMATIC

Regulation on off thermostats, humidistat's , pressure switches. Concept of differential .

Modulating control of heat exchangers : for variation of flow rate and temperature change on the primary or on the secondary . Water diverter valves and mixing valves , air shutters.

Overview : Regulators pneumatic, electric , electronic ( analog and digital) . Overview : Action proportional (P ) action proportional + integral (PI ) action proportional + integral + derivative (PID) .

## 21. FUNCTIONAL DIAGRAM OF PLANT

Description and analysis of some functional patterns characteristic of the plant.

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## BIBLIOGRAPHY OF REFERENCE

Lecture notes prepared by the teacher.

Publication AERMEC : elements of ventilation and air conditioning systems. (\*)

AERMEC publication : introduction to air conditioning. (\*)

C. Pizzetti : "Conditioning and Refrigeration " (2 volumes) - Ed Tamburini Masson 3rd ed.

Dall'O ' - Palmizi : Heating - CLUP Ed.

L. Agnoletto - P. Romagnoli - O. Saro: Law 10/91 Guide - requirements for building design and plant engineering. PEG editions.

Rumor - Strohenger : Heating, Ventilation, Air Conditioning, Energy Recovery, Sanitary - Ed HOEPLI .

CALEFFI company : technical notebooks.

N. Rossi: "Handbook of thermal engineering " - Ed HOEPLI.

(\*) Not available protocolled but temporary use at the library.

## METHOD OF EXAMINATION

The examination includes :

- delivery of the documents related to the laboratory activities (at least one week before the exam date);
- oral examination : discussion of the work and theory.