Air-conditioning

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History

- First air treatment (fire, natural ventilation).
- Evaporative cooling (water spray, fountains)
  - Natural, mechanical ventilation **mine**
- 19 century energy transport, water, air system
- Mechanical ventilation, heating, cooling, humidification 19 century
  - **Fans**
- The 2nd-century Chinese inventor Ding Huan (fl **180**) of the Han Dynasty invented a rotary fan for air conditioning, with seven wheels 3 m (9.8 ft) in diameter and manually powered.
- In **747**, Emperor Xuanzong (r. 712–762) of the Tang Dynasty (618–907) had the Cool Hall (Liang Tian) built in the imperial palace, which the Tang Yulin describes as having water-powered fan wheels for air conditioning as well as rising jet streams of water from fountains.[4]
- During the subsequent Song Dynasty (**960–1279**), written sources mentioned the air-conditioning rotary fan as even more widely used
  - 16 century in europe, better design 18 century)

History Cooling

In 1758, **Benjamin Franklin** and **John Hadley,** a chemistry professor at Cambridge University, conducted an experiment to explore the principle of evaporation as a means to rapidly cool an object.

In 1820, English scientist and inventor **Michael Faraday** discovered that compressing and liquefying ammonia could chill air when the liquefied ammonia was allowed to evaporate.

In 1842, Florida physician **John Gorrie** used compressor technology to create ice, which he used to cool air for his patients in his hospital

James Harrison's first mechanical ice-making machine began operation in 1851 in Geelong (Australia).
Carl von Linde German engineer who developed refrigeration(**1870)** and gas separation technologies

History AC

- In 1902, the first modern electrical air conditioning unit was invented by **Willis Carrier** in Buffalo, New York.
- The first "air conditioner", designed and built by Carrier, began working on 17 July 1902. Designed to improve manufacturing process control in a printing plant, Carrier's invention controlled not only **temperature** but also **humidity.**
- **1911** air-conditioning, humid air, **psychometric**

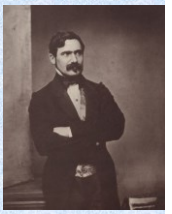
- In 1945, **Robert Sherman**, invented the portable, in-window air conditioner that cooled and heated, humidified and dehumidified, and filtered the air (Patent # 2,433,960 granted January 6, 1948).

Historiy ventilation

Indoor pollutants Italian doctor B. Ramazzini 1700

1859 Austrian law – the workspace has to be ventilated

Fresh air for person 1877
Max von Pettenkofer
(basic of hygiene as independent branch)
(max CO_2 1% - 30 m^3/h)



Air-conditioning

- Air conditioning is the process of altering the properties of indoor air to more favorable conditions. (**temperature, humidity, quality –no pollutants**).
- **Full air-conditioning** – all properties (heating, cooling, ventilation, humidification, dehumidification)
- **Partial air-conditioning** – just some of parameters includes **cooling.**

Ventilation

Ventilating is the process of "changing" or replacing air in any space to provide high indoor air quality

To control temperature, replenish oxygen, or remove moisture, odors, smoke, heat, dust, airborne bacteria, and carbon dioxide.

Ventilation is used to

remove unpleasant smells and excessive moisture, introduce outside air,

to keep interior building air circulating,

to prevent stagnation of the interior air.

Fresh air

Just for people					sleeping	46
Max CO2	Cmax	0.15%			seating	58
Metabolic heat	q	70	W/m2	→	work seating	70
Body surface	A	1.8	m2	Man 1.9	light work standing	93
Air density	ro	1.2	kg/m3	Woman 1.7	not heavy work	116
breath air volume	V1	0.975	m3/h	small activity	Heavy work, fast movement	110
CO2 in exhaust air	C1	4%			max	200
co2 in fresh outdoor air	Cp	0.035%				

$$V = \frac{V1 \bullet C1}{C\,\max - Cp} = \frac{0{,}975 * 0{,}04}{0{,}0015 - 0{,}00035} \qquad V1 = \frac{q \cdot A}{ro} \cdot 2.58 \cdot 10^{-6}$$

Fresh air	V	**33.9**	m3/h	

Fresh air

		l/s p. person.	8 m²/person l/s p. m²	l/s	m³/h person	m³/h m²
Ashrae		2.5	0.3	4.9	**18**	2.2
EN15251	I	10	1	18	**65**	8.1
	II	7	0.7	12.6	**45**	5.7
	III	4	0.4	7.2	**26**	3.2
EN13779	IDA 1	12.5		12.5	**45**	5.6
	IDA 2	8		8	**29**	3.6
	IDA 3	5		5	**18**	2.3

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25 m³/h

50 m³/h - I,IIa

70 m³/h - IIb,IIIa, IIIb,

90 m³/h – IVa, IVb, V

Indoor envirnment parameters

- Air temperature *ta* [°C]
- Relative humidity φ [%]
- Mean radiant temperature *tr* [°C]
- Air velocity *w* [m/s]
- Turbulence intensity *Tu* [-]

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Třída práce	M [W.m-2]	Kategorie	Klimatizované pracoviště: nastavení vytápění, tepelný odpor oděvu 1,0 clo: t_{omin} (t_{gmin}) [°C]	Klimatizované pracoviště: nastavení chlazení, tepelný odpor oděvu 0,5 clo: t_{omin} (t_{gmin}) [°C]	v_a [m.s⁻¹]	Rh [%]
1	≤ 80	A	±1,0	±1,0	0,05 až 0,2	30 až 70
		B	22 ±1,5	24,5 +1,5 -1,0		
		C	+2,5 -2,0	+2,5 -2,0		
IIa	81-105	A	±1,0	±1,0		
		B	20 ±1,5	23 +1,5 1,0		

Overall effect t*a, tr a w*

Operative temperature *to* [°C]

A 21 - 25.5°C
B 20.5 - 26°C
C 20 - 27°C

AC systems

To ensure indoor temperature, humidity and air quality

- Heating / Cooling
- Humidification / Dehumidification
- Fresh air, remove pollutants and odors.

- Fans, coils (heting, cooling), humidifiers, filters.
- Central or terminal units
- Cooling source, heating source

AC

– **Comfort systems-**
Thermal comfort of people
(office, halls, flats, some industry, hospitals, hotels….)

– **Technological systems –**
Functionality of mechanical, chemical or biological technologies
(industry, clean rooms, laboratories …)

Ventilation and AC

- **Natural ventilation**
- **Mechanical ventilation with air heating (IAQ, air temperature)**
- **Hot air heating + ventilation**
- **Partial air-conditioning**
- **Full air-conditioning**
- **Special systems** (clean rooms, computer rooms..)

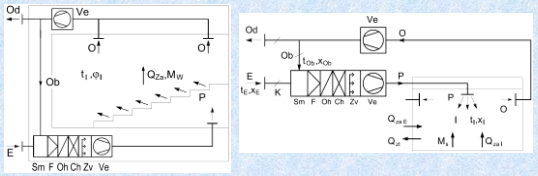
AC systems

- **Air systems –** all air, big, ventilation ability
- **Water systems-** Water, smaller pipes, flexibility.
- **Refrigerant systems-**
- **Combined systems**

	10 kW		
	Air	Water	
	26 °C	12 °C	10 kW
	16 °C	6 °C	205 kJ/kg
			1250 21.2766
Capacity	1.01 kJ/kgK	4.2 kJ/kgK	
Density	1.2 kg/m3	1000 kg/m3	0.049 kg/s
Flow rate	0.83 m3/s	0.00040 m3/s	0.000039 m3/s
Velocity	10	0.8	1 m/s
Surface	0.0825 m2	0.0005 m2	0.000039 m2
Diameter	0.324 m	0.025 m	7.05 mm

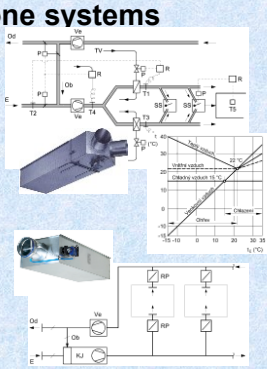
Air system, one zone

Central air handling unit



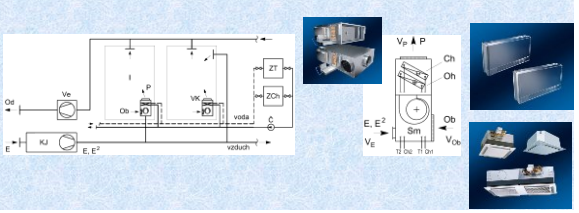
Air multizone systems

- **Air two channel system,** usually high pressure, 2 airs in ducts mixed in the room terminal unit.
- **Variable Air Volume system VAV,** Centrally treated air for each room flow rate control.



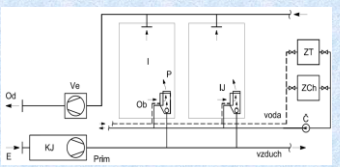
Water systems (fan-coil)

- Circulation air in the room is treated, Fan Coil (cooling, heating), filter, fan, coil 2 pipe (cooling), 2 pipe switch (cooling/heating), 4 pipe cooling heating,



Induction units, cooling beams

- Centrally treated air (dehum), induction units in each room. Nozzles with induction effect, secondary air cooled/heated.



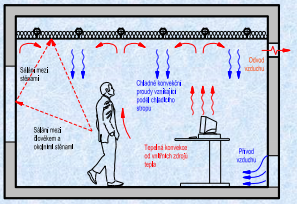
Chilled ceiling

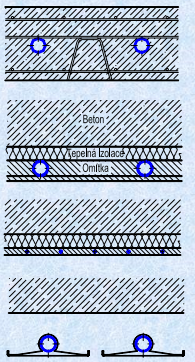
Heavy

slab cooling, concrete activation,

Light

Open

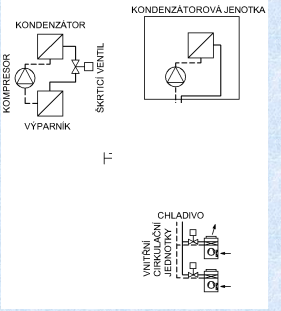




Refrigerant systems

- **Refrigerant circuit**
- **Compressor**
- **Condensator**
- **Reduction valve**
- **Evaporator**

- **Outdoor unit**
- **Indoor unit**



Chladivové klimatizační systémy

- **Split systems**,
- **Multi-split systems**,
- **VRF (VRV)**
- **VRF-R (VRV-R)**.
- Ventilation ?