

Building Constructions 4

Chimneys – combustion exhaust gas ventilation systems
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Budapesti Műszaki és Gazdaságtudományi Egyetem
Építész-mérnöki Kar Épületszerkezettani Tanszék

Chimneys – combustion exhaust gas ventilation systems (flue gas stacks)

- Chimney development: previously laid, single layer brick chimneys, which with the development of furnaces – along with increased condensation and corrosion effects – developed into multi-layer constructions seen today

- Definition: MSZ-EN 1443

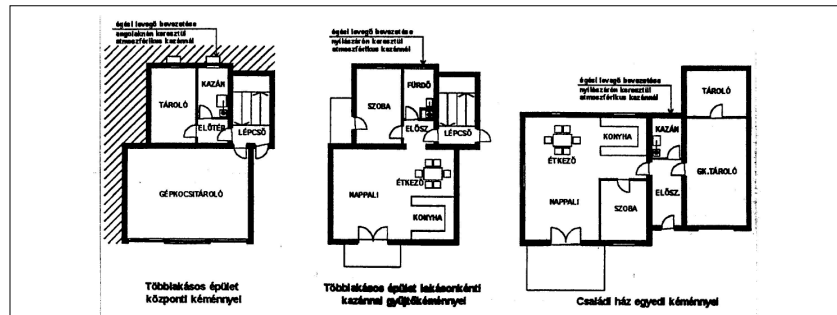
- The chimney and the building: we only deal with the location within residential buildings (see figure 1)

- Chimney functions: exhaustion of flue gases (traditionally), influx of fresh air for burning (nowadays)

- Chimney physics, operation: difference in density and temperature = difference in pressure
stack or chimney effect of gas tube
chimney pressure, vacuum, draft

- Draft intensity is influenced by: height of the chimney, resistance property of the cross-section, external air movements, temperature differences, general pressure conditions

Figure #1. Chimney location in residential building



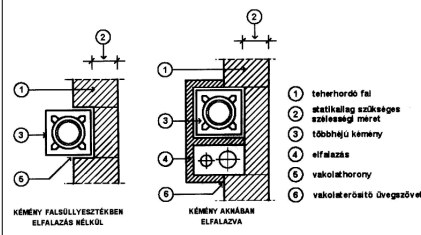
Chimney location foundation:

- may be unified with neighbouring wall or independent
- laid and silicate unit single layer (heavy) chimneys always require a foundation
- multi-layer metallic chimneys do not require a foundation

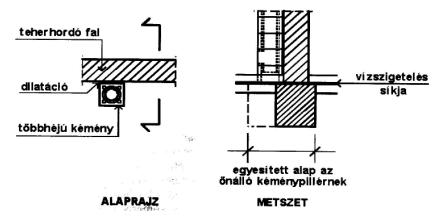
connection to load bearing walls:

- single layer chimney may be laid together, if the connecting wall allows (**dilatation, sinking**)
- multi-layer may be built adjacent to the load bearing wall, or in a cavity of the wall
- block chimney may not be chiselled or connected to partitions in any way

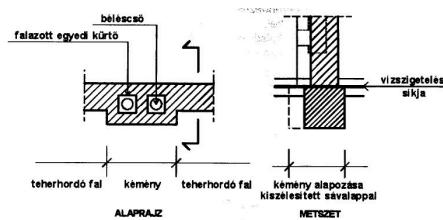
4. Chimney In a cavity of the wall



2. Chimney next to the main wall



3. Chimney laid together



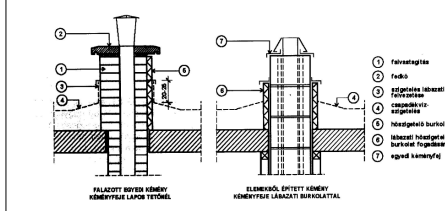
connection to slabs :

- chimney laid into load bearing wall must be removed from beams by min $\frac{1}{2}$ B. distance
- single laid or block chimneys must be located between beams in beamed slab, otherwise in slab cavity

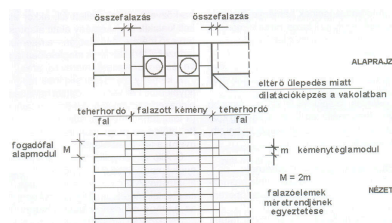
chimney head:

- above the top level of the building (roof) the brick chimney must be thickened by $\frac{3}{4}$ B. or must be covered with insulation
- chimney heads must in all cases be constructed with a frost resistant, visored solution
- high (>2.0 m) chimney head stability must be checked in all cases
- the connection of the chimney pillar to flammable roof structures must be made with a gap as of MSZ-EN standards: laid chimneys require min. $\frac{1}{2}$ B. gap while block chimneys require a gap and non-flammable fill (eg. glass or mineral fibre insulation)

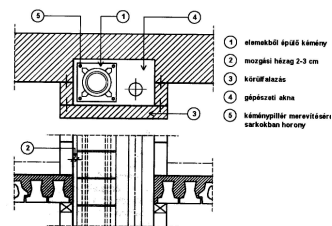
7. Chimney head



5. Chimney laid together- brick arrangement



6. Chimney In wall-cavity with prefab. floor joists



Relevant operational physics relations:

- $p_0 = p_{st} + p_{din}$
- p_0 = external pressure, 1.013 barx105
- p_{din} = air pressure = $\delta/2 \times w^2$
- w = wind speed, m/s, 3.6xm/s = km/h
- $p_{din 2} > p_{din 1}$
- $p_{st 2} < p_{st 1}$

Draft intensity relations:

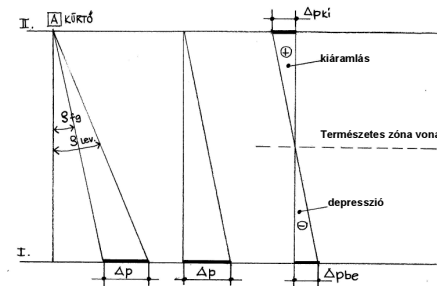
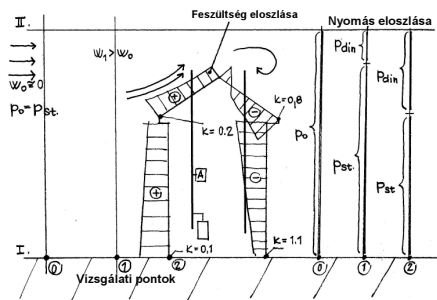
$$-\Delta_p = g \times h \times (\delta_{kl} - \delta_{lg}) = \Delta p_{be} + \Delta p_{ki}$$

where g = gravitational acceleration (m/s²)

h = chimney height (m)

δ = air and flue density (kg/m³)

8. Draft



Chemical relations:

- development of fuels

(town gas, coal, briquettes, natural gas, oil, pellets)

- the process of burning:

combustible material is unified with oxygen

= energy + CO₂ + smoke + water (steam)

not perfect burning = CO (danger!)

- acidic condensation

- re-cooling, vapour diffusion

(water vapour, carbonic acid, sulphurous acid, sometimes sulphuric acid)

occurrence of water vapour and relation to flue temperature:

1l oil burned: 0.8-1l/250 °C

1 kg. of wood burned: 1 l/250-400°C

1 kg. coal burned: 1.5-2l/200-500 °C

1 m3 of natural gas burned: 1.5l/ 100-120 °C

- - chimney corrosion=

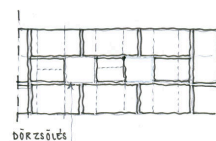
basic silicate structures will produce salts with acidic solutions

- selection criteria

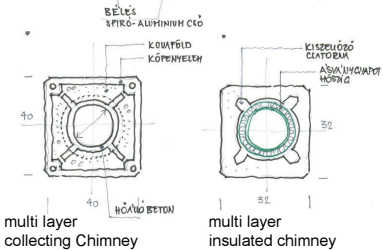
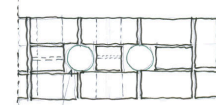
resistance to dampness as of MSZ-EN 1443 standard

8. Sensibility for condensation

Traditional brick (single layer) chimney

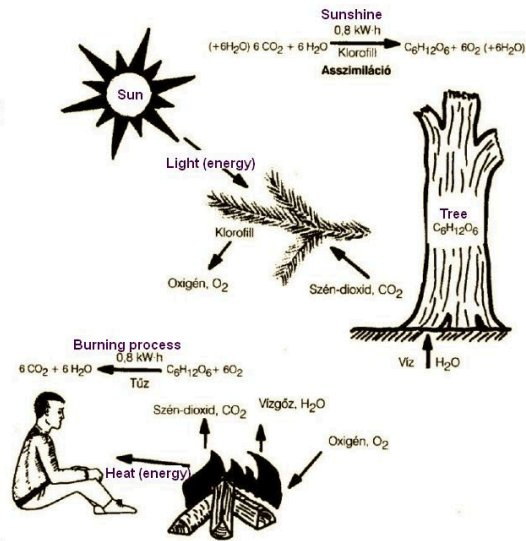


Traditional brick chimney with lining



Important – environment protection

If
you
burn
wood
you
use
spared
solar
energy



Vapour diffusion in chimneys

because:

- more optimal burning within heating units results with lower flue gas temperatures
- single layer non-insulated or multi-layer insulated but not ventilated chimneys result with condensation

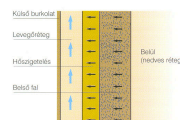
explanation of condensation :

- if the internal temperature of stack surface is < dew point
- if the stack surface temperature is the same as of the flue, but flue relative vapour content reaches 100 %, no more moisture is absorbed
- ie. the absolute vapour content of the flue would be greater than its maximum saturation, the excess vapour condenses and flows down on the chimney internal (stack) surface

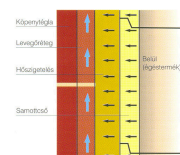
solution:

- insulation of stacks and ventilation along the whole height of the chimney
- connecting the chimney to the waste water system

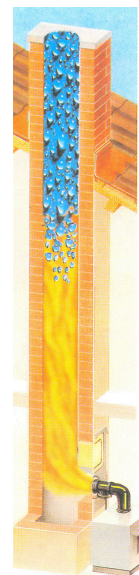
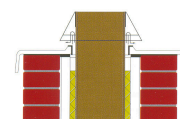
9. Ventilation and condensation



A nedvesség továbbítása szigetelt ház külső falán (példaként)



Nedvességszállítás a hátsó szellőztető UNI kéményben



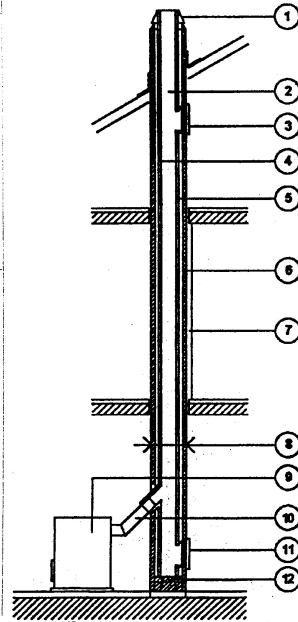
Basic chimney vocabulary

- 1 head
- 2 stack/flue
- 3 access/cleaning door
- 4 lining
- 5 insulation
- 6 crust
- 7 external covering material
- 8 multi-layer flue ventilation system
- 9 furnace
- 10 connection element
- 11 dust door
- 12 condensation collector

Classification of chimneys

- **Based on function:** single chimneys (60kW), collector and central chimneys
- **Based on burned material:** multiple and single use chimneys
- **Based on manufacturing:** atmospheric single furnace used single chimney – laid, single layer chimneys, lined single layer chimneys, multi-layer lightweight constructions
- **closed combustion space furnace, single use chimney** – single connection LAS chimneys, multi-connection LAS chimneys
- **According to furnace mode of operation:** stack is under draft or suction, over pressurized stack, damp operation chimney

10. Vocabulary



Chimney constructions

1) „Open” burning area systems - "gravity fed", atmospheric burner – decompression in the flue – combustion air supply from the room – **this is the past**

- Single layer flue
- Multilayer flue

2) „Closed” or „Sealed” burning area systems - „fan fed” burner – overpressure in the flue – combustion air supply from the open air - **this is the present**

- Single LAS chimney
- Multiple LAS chimney
- Multilayer flue + fresh air supply pipe

1) „Open” burning area systems

Atmospheric furnace, single dedicated chimney (decompression in the flue): single layer chimney

Laid / brick chimneys :

Use:

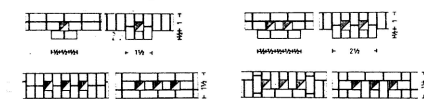
-as single or central heating chimney it is **not accepted** anymore, may only be used as secondary or fireplace chimney and only with lining

design and construction rules:

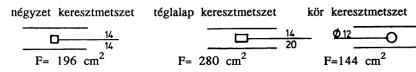
- brick laid stack **minimum 14x14 cm**
- only out of solid, standard bricks with a mortar quality of min. H10
- up to 280 cm² area, may be located within wall section, otherwise separate structure is required
- in 1 brick flue max 2-(3) furnace can be connected
- above roof frost resistant brick must be used and cover stone with drip nose

13. Brick bonding of flue in wall

14 * 14 cm-es kürtők építése falszakaszban, belső falaknál

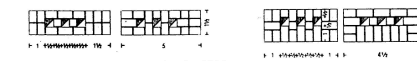


11. Cross section of brick flues

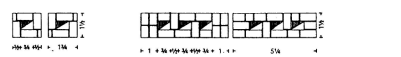


12. Brick bonding of flue in detached chimney

14 * 14 cm-es kürtők építése falpillérben



14 * 20 cm-es kürtők építése falpillérben



20 * 20 cm-es kürtő építése falpillérben



Rules of single layer chimneys:

Offset of flue (important at reconstruction)

1. max. 30° from vertical
2. only in one direction
3. max. horizontal distance is 2 m in one step
4. max. two times
5. max. horizontal distance altogether is 3m
6. never in floor construction (only in wall)
7. in offset bricklayer must be perp. to direction
8. in easing corrosion-protected steel reinforcement

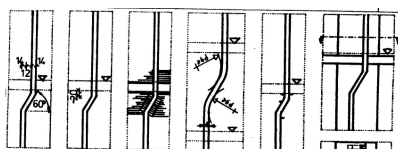
further rules:

- Not to drill/chisel into the wall of laid flue
- at wall end at least 25 cm solid wall next to the flue
- on the open-air-side of a laid single layer flue min. 25 cm solid wall must be, or other solution (thermal ins., air-gap)

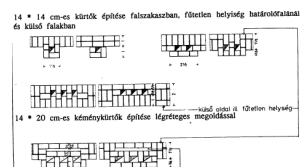
Important

At the moment there is no such brick solution, which fulfills the present Hungarian rules. ☹️

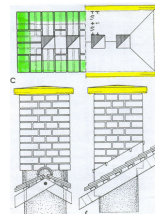
14. Offset



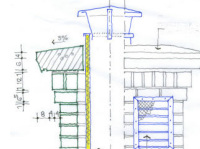
15. Brick bonding next to open-air



16. Head / cover stone in open-air



17. Flue + ventilation duct



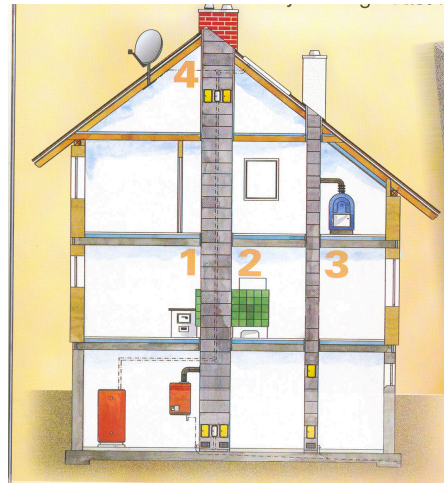
**Atmospheric, single furnace used chimney
(decompression in the flue)
Multi-layer system**

reason for use:

to protect from corrosion in the chimney we need easily built construction, with long expected lifetime, and suitable for other fuel (when we run off the gas)

Suggested usage

1. **Chimney for central heating in flat**
(within the construction period)
2. **Chimney for single heater (fireplace, cockle)**
(within the construction period)
3. **chimney for spare heating equipment**
(extension, later built-in attic)
4. **multi-function chimney:** next to the lining in lateral flue can be ventilation, pipes (sun collector), cabling



21. Multi-layer chimney in family house

**Chamotte pipe chimney systems
working method:**

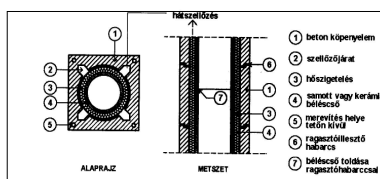
1. like double layer ventilated wall system, in the corners 4 pices of ventilated stack
2. basic element of the system: acid and heat-resistant, chamotte pipe
3. the vent stacks dry the pipe

design rules:

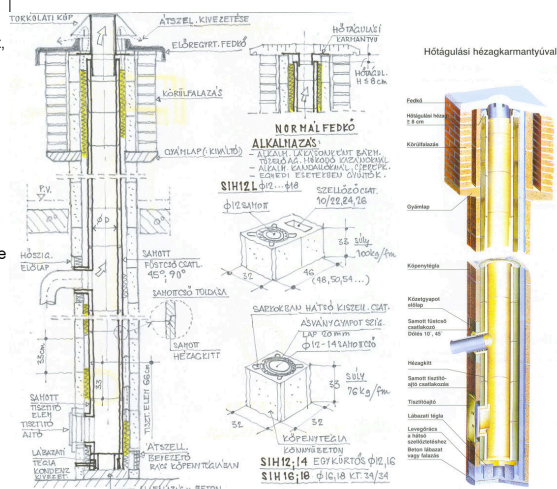
- foundation is needed (80-90 kg/fm)
- expansion joint at the head
- ventilating air inlet and condensate outlet at the bottom
- above the roof reinforcement is necessary

technical data:

- production: 22% crude chamotte, on 40 bar prepressure
- suitable for smoke from coal, firewood, oil, gas burning
- pipe Ø14-20 cm, cover 32/32 or 39/39 cm
- can be 1, 2 or 3 flue + vent stack
- one connection per floor



22. „Back-ventilated” chimney system



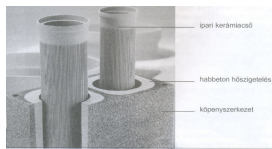
working method, technical data:

1. when back-ventilated → same as chamotte
2. totally insensitive against condensate, acid resistant, more airtight than chamotte
3. made of: 5% crude chamotte + industrial porcelain, on 400 bar pressed
4. mainly for closed and condenser type furnace

main rules for multi-layer chimneys:

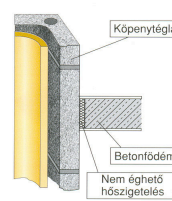
- cleaning door and condensate outlet must be built in
- examining and cleaning door in the attic
- in shaft min. 3 cm, from roof construction min. 5 cm gap, felt up with non-combustible material (rock/glass-wool)
- If higher above the roof than 1,5 m, reinforcement is necessary

23. Ceramic pipe chimney

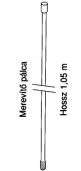
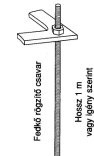
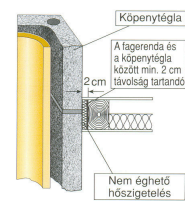


24. Details

Beton



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Metal chimney

working method:

- can work both as aspirated or pressured chimney
- back-ventilation is not needed, **totally insensible for condensates and totally air-tight**
- dry assembling technology

technical data:

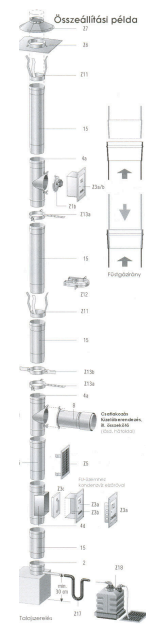
- can be used in chimney forced by only gravitation
- available as single pipe (for posterior installation as well), and pipe-in-pipe form (with thermal insulation between)
- usable for 30 -600 °C smoke temperature
- high-alloy steel (alloy elements: titanium and molybdenum)
- 0.4-1 mm thickness
- diameter Ø 80-600 mm

design rules:

- light, 3-6 kg/m, can be fixed anywhere
- lengthening with taper joint in chimney forced by only gravitation, with sealed taper joint in pressured chimney
- offset with prefabricated rigid bent element max. up to 30°
- In open air cover is necessary

25. Metal chimney

taper joint



Chimney location and head positioning requirement:

- the chimney end must in all possible conditions be above the roof
- facade outlet only in special situations!
- should not dirt the surroundings (sparkles, scale, smoke, deposits)
- pL value: in the central continental areas 25 Pa, on seaside 40 Pa (In Hungary, where wind speeds are > 80 km/h, also 40 Pa)

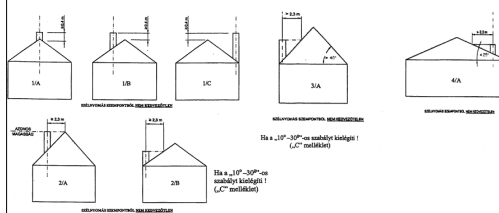
dimensioning relations:
for chimneys under draft or suction

$$p_H = p_z + p_R + p_L$$

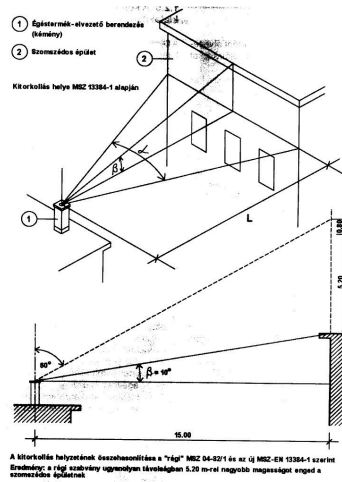
Rules:

OTÉK 74, 80 §
MSZ-EN 13 384-1, 2
GMBSZ

10/b Head position at pitched roof



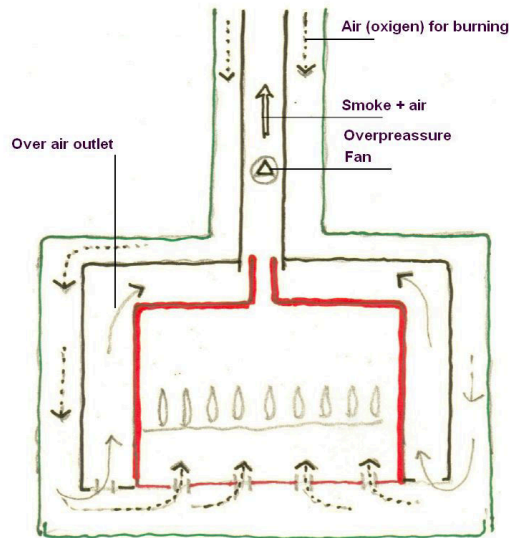
10/a Head position – neighbouring building



Old building - new building in the city



„Closed” or „Sealed” burning area systems - „fan fed” burner – overpressure in the flue



Single or collecting chimney for „closed” furnace LAS chimneys

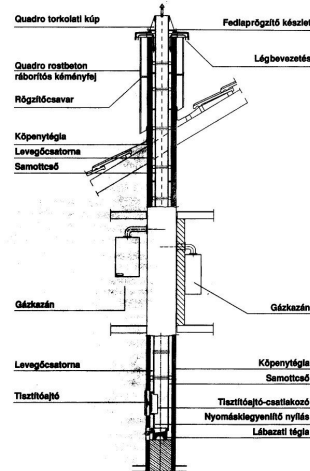
Reason:

1. well sealed windows, no filtration, **no oxygen for combustion**
2. artificial ventilations everywhere (exhaustion), → result decompression, possibility of smoke back-stream, CO (toxic), CO₂ concentration rises,
3. combustion-air removal at „open” furnace → (no flame), result **blow-by**

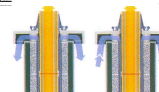
working method:

- into „closed” furnace combustion-air arrives from the **open air** forced by ventilator
- if the air-smoke path is the same, pipe-in-pipe chimney is made, in the centre the smoke runs out, between the two pipes the combustion air comes in
- if the path is different separate pipe is installed for the combustion air
- there is no need to contact the furnace room with open air (inner room)
- the smoke is driven out by overpressure, → smaller pipe cross-section
- because of the over-pressure **strict air-tightness controll is must** (not to let smoke into the room - 40-200 Pa test overpressure)

26. LAS chimney arrangement



concurrent and counter current chimney



A hagyományos, egyenáramú működési rendszer (a kazán az égési levegőt nem a kéményről szeli a tüzelőanyaghoz a levegőt).

Ellenáramú működés. A tetejéről érkező levegő előmelegszik a belső cső felületén, növelve ezzel a tüzelőanyaghoz a levegőt.

Connection possibilities of LAS chimneys

legend:

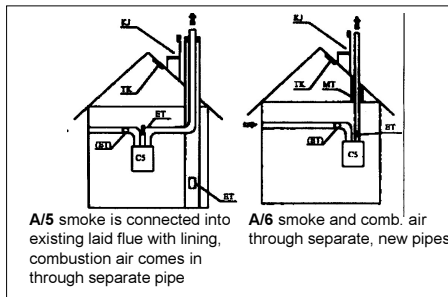
ET - control / cleaning door
M - gauge hatch min. 12 mm diameter
KJ - chimney sweeper footway
TK - roof access door
MT - fire protecting cover

features of connections:

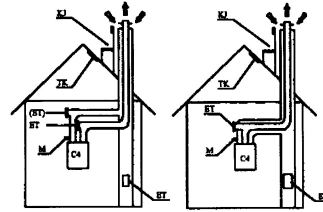
A/1 - A/2: to control the existing flue (internal surface of the laid brick flue) (soot deposit, air-tightness)

A/3-A/4: lower cost, because the smoke is driven out through laid brick flue, only with low pressure level, through large cross-section flue is possible (low air-tightness level)

A/5-A/6: because of the separate path of combustion air there is no pre-heating (of air), less condensate

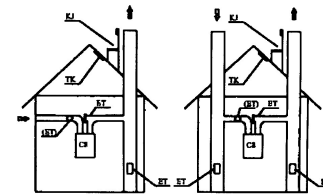


27. Connection schemes of LAS chimneys



A/1 smoke and combustion air through laid brick flue, but separate path

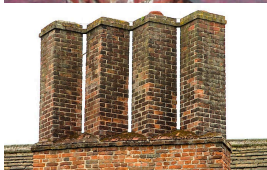
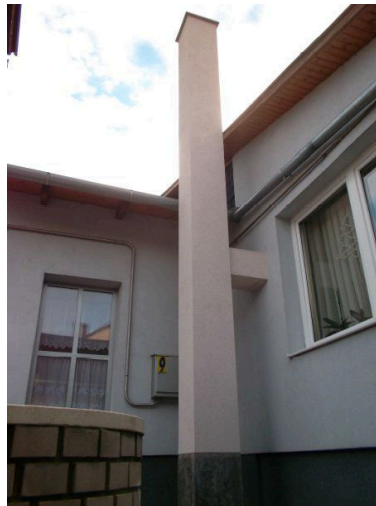
A/2 connection into laid brick chimney, smoke through lining, combustion air around lining



A/3 smoke through existing laid brick flue (without lining), combustion air through separate pipe

A/4 smoke and combustion air through laid brick flue, but separate chimney body separate pipe

Thank you for your attention!



...and do not construct chimneys this way!!!