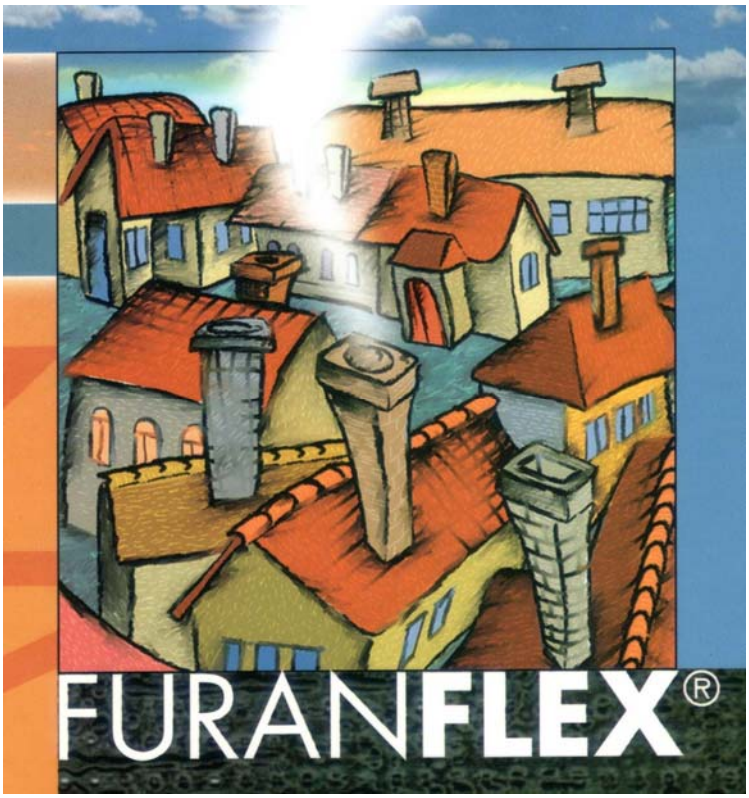
FuranFlex technology



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1. Material of the Furanflex chimney liner tube

The Furanflex chimney liner tube is made of so-called composite material. Composite is the name of plastics reinforced with high strength fibers used in the plastics industry. Composites are used to manufacture boats, airplanes, space rockets, tanks, and silos.

Composites consist of two main types of materials: reinforcement fibers and the plastic matrix embedding them. They have a distant similarity to reinforced concrete structures but here, in opposition to concrete iron, the reinforcement fibers are placed directly one next to the other, in high quantities.

From 1999 to 2004 April about 300 km Furanflex were inserted, 80% of this in West Europe
Diameters: 80-600 mm. Length up to 60 m.

2. Reinforcing fibers

Several types of reinforcing fibres used in composite materials, developed originally for the military airplane and space industry. The reinforcing fibers listed below (See pictures in appendix) have been used in civil applications so far:

- Glass fiber
- Carbon fiber
- Quartz glass fiber
- Ceramic fiber
- Kevlar fiber

Furanflex contains glass fibre reinforcement material; this is what we will concentrate on in the following.

Glass fibers have been manufactured for heat insulation purposes (tinsel) since the beginning of the last century. Its basic material is common glass; the thickness of the filaments is above 50 microns (1 micron = one thousandth of a millimetre) these filaments are brittle, of low strength and sensitive to corrosion.

The glass fibers applied for composites are made of a special material (borosilicate glass) and their diameter is 8-13 microns. They are flexible and have high strength.

Forms of appearance of glass fibers:

Thread made from filaments by twisting	Used for making thin glass textiles Insulation of fire-resistant curtains, printed circuit plates, electric engines
Yarn made from parallel filaments (Professional name: roving) Number of filaments in on yarn: 200-12.000	Winded composite tanks, pipes, pultruded rods
Woven roving textile Heavy textile (150-800 g/m^2)	Used for glass reinforced objects (boats, airplanes, etc.)
Glass mat. Non-woven material, made from cutted thin roving gluing to a mass of 150-900 g/m^2	Used for making reinforced plastic objects with less tensile strength

Properties of modern glass fibers

Density (specific weight)		2.6 kg/l (steel 7.8)
Tensile strength	Fibres	800-2500 MPa
	Fibre reinforced plastics	100-1200 MPa
	That of steel	400-1800 MPa
Flexibility modulus (rigidity)		73.000 MPa
	That of steel	210.000 Mpa

1 MPa = 1 N/ mm^2 = 10 kg/cm^2 (exactly 9,8)

Heat resistance	600^{o}C
Melting point	850^{o}C
Cold resistance	Unlimited
Corrosion resistance	Very good, for acids
	Good, for alkali

Reinforcing material of Furanflex

The reinforcing material of Furanflex is a textile woven from roving yarn.

Specific mass	330 g/m^2
Tensile strength crosswise	1000 N/cm
Tensile strength lengthwise	600 N/cm

In Furanflex there are three layers of textile glass folded one upon the other like the spiral spring in a clock. Thus each centimeter of the circumference of Furanflex hanging vertically endures a tensile load of 3x60=180 kg. E.g.: the circumference of a 130 mm Furanflex tube is 41 cm, thus the textile glass in it endures a load of 41x180 = 7.300 kg. The specific weight of this Furanflex tube is approximately 1 kg/m^2 (old unit); therefore 7.3 km long Furanflex could be suspended (if the upper adapter were able to endure it) without the breaking of the material. However, for safety reasons, a somewhat shorter liner tube than that is recommended to be suspend in one length.

3. Resin matrix

The resin matrix is the resin, which surrounds, embeds the reinforcing fibers and transfers the forces from one fiber to the other. An example, not good but useable, is reinforced concrete where the cement may play the role of a resin, while the glass fiber plays the role the reinforcement iron rods.

Before discussing the issues directly concerning Furanflex, it is necessary to clarify a few general concepts.

The world from the point of view of chemistry

The world surrounding us is built from approximately one hundred elements (atoms). However, millions of molecules can be constructed from those elements, with minimum 2 elements in them but there may be molecules created by dozens or even hundreds of atoms.

There are substances made up of pure atoms, like tungsten, pure coal or diamond, pure lead, aluminium, etc.

A few atoms construct a number of chemical substances only, e.g. oxygen as a gas consists of a molecule made up by two connected oxygen atoms. Another example is water constructed by molecules made up by two hydrogen atoms and one oxygen atom.

Inorganic substances contain no carbon atoms in their molecules. Generally, they do not burn. Inorganic substances are salt, gypsum, metal alloys, rocks, etc. Further inorganic materials are carbon dioxide, carbon monoxide that is the product of a burning process, although they do contain carbon atoms.

Without any exception, organic substances consist of molecules containing minimum one carbon atom in addition to many other atoms. The number of organic molecules is impossible to compute, both in nature and as a result of human activities. The whole pharmaceutical industry, a significant part of the chemical industry secures their wealth from organic molecules, a significant part of which was created by man. Organic materials generally burn. All foodstuffs (except salt), plants, living beings consist of organic substances.

What do we call plastics?

Plastics are liquid or solid substances, built up by identical or different organic molecules, linked to one another chemically in a repetitive manner, which do not exist in nature of their own right.

Plastics can be divided into two large families, thermoplastic and thermo set types.

Thermoplastics melt at a certain temperature; they can be moulded, and be used as solid substances in a certain range of temperature. Theoretically, they can be melted several times like candle. Thermoplastics make up the majority of the plastics produced, e.g. PVC, polyethylene, polypropylene, polystyrene, polymethylmetacrylate (plexi), etc.

"Poli" is a Greek word whose meaning is that there is more than one of something in a repetitive manner, like the feet of a "polip" /octopus/. Plastics are called in all languages polymers too because they are built from several identical molecules bound to each other chemically. They are named also “macro-molecules”.

Thermosetting plastics first appear in a liquid form, and after hardening they can no longer be made mouldable or liquid again, so they cannot be recycled. They are the so-called resins, which means thermosetting or cross-linking plastics. Humanity uses far less of them than of thermoplastics. Such are, e.g., Bakelite, polyester, epoxy, and etc. resin.

Binding of molecules

Let us imagine that individual molecules or atoms are represented by "eyes of a chain" of smaller or larges sizes and different forms.

If those eyes not coupled together like in a chain are poured into a bucket there is nothing to bind them, the whole thing can be poured out of the bucket as some liquid.

Now if we try to connect the different eyes of the chain in a row, chains similar to a snake will be formulated. The higher the number of the eyes of the chain, the higher the "weight" and at the same time the "length" of the macromolecule, and the "viscosity" of the polymer. If there is a mixture of such snake-like chains in the bucket, it is not certain that we shall be able to pour it out of the bucket, at first we would have to shake the bucket a bit. That is what thermoplastics look like. (The similarity of "shaking" is not a chance occurrence, under the influence of heat the molecules, the elementary particles perform increasingly stronger vibrations, the so-called Brown movement).

If the chains in the eye are linked to each other along a certain stretch not only in a straight line but at some places one chain is linked to the nearest chain, then an almost unmouldable, rigid system, a net in “three dimension” is formulated. It can no longer be poured out of the bucket; it can only be removed as a rigid, unsolvable material. It tries to keep its shape, we shake it in vain, that means, and it cannot be melted by heat. Those are thermosetting, i.e. cross-linked plastics.

The matrix of the resin Furanflex is a cross-linking resin of that type.

The matrix of Furanflex resin

The resin matrix of Furanflex consists of the mixture of twelve substances. This mixture is a dilute, honey-like liquid of black colour. In the mixture we can find different resins, other substances in a liquid state as well as solid particles of microscopic sizes. All the components have their own tasks.

Coming back to the similarity of reinforced concrete mentioned above, cement iron rod is the glass fiber, cement is the resin and the pebble's role resembles that of the particle of microscopic size.

Two main resin components can be found in the substance, phenol and furan resins. Both of them are known for their good heat, flame and corrosion resistance. Technologically, they are substances difficult to control, in opposition to polyester or epoxy resins.

The tasks of the resin matrix are the following:

- It embeds the glass fibers
- It protects the glass fibers from corrosion
- It forms a thin film of resin on the internal surface of the pipe
- It ensures perfect tightness
- It binds harmful free molecules (e.g. phenol and formaldehyde)
- It ensures heat and flame resistance for the finished liner pipe
- It ensures storability in a soft state
- It ensures hardening at the required temperature and during the time required

The hardened (cross-linked) resin is brittle and of low strength. It can only be applied as a structural material if reinforce fibers are added to it.

The process of hardening of Furanflex resin consists of three phases:

- Liquid state. It can be maintained for 14 days at a temperature of 22^{o}C.
- Semi-hard (so-called "B") state. It can be achieved by heat treatment in 4-6 days. It can be maintained for 4 weeks at room temperature and for months in a cold place. In this state, the substance can be melted and moulded a bit if it is warm.
- Hardened state. It cannot be moulded either warm or cold.

In order to fasten the resin to complete these three stages, there is need for the addition of a small amount of catalyst. The catalyst does nothing else but encourage the molecules to "connect".

Furanflex resin is not harmful to health. It is demonstrated by the tests carried out by West-European institutes (see later). No dangerous compounds leave the resin in a temperature range of 100-600^{o}C. It is worth mentioning that the starting substances of Furanflex resin include dangerous compounds harmful to health as well. Therefore the mixture contains components, which render those harmful molecules harmless.

In case of sensitive individuals, the still wet resin, contacting the skin, may cause itching, rashes. It is easy to wash the resin off the surface of the skin with detergent- water. See in more detail in the Labour Safety description.

4. Internal foil tube

The still soft Furanflex tube is inflated and hardened with the help of the internal foil tube. (See sample in appendix)

The requirements to be met by the foil tube:

- - Elongation: min. 150%
- - Melting point: over 110°C
- - Thickness tolerance: +/-10 microns
- - Thickness: 150 microns (over ∅150 mm)
  120 microns (below ∅150 mm)
- Good corrosion resistance (resin resistance)
- Good removal properties
- Homogenous surface
- No "ironed" edge

The price of the foil tube is negligible compared to the price of the Furanflex pipe; at the same time it plays a decisive role in technology. If this tube with a thin wall breaks during the process of inflation and hardening, it leads to unpleasant consequences:

- In the case of a small hole, steam pressure drops. Hardening can be continued but the steam streaming out through the hole will "wash out" the resin from its environment. And that may jeopardise the tightness of the completed liner tube.

- In case of breakage of a higher dimension (several centimeters) no pressure can be created, and a new foil tube must be inserted (See Technological description) or, in the worst case, the defected pipe is to be pulled out and a new one is to be inserted.

Causes of breakage of the foil:

- Pressed down, weakened edge
- Unmelted material lump in the foil
- Defect as a result of external influence (perforation caused by concrete iron, wire)
- Unknown cause

The diameter of the foil tube is approximately 5 % smaller than the diameter of the hardened Furanflex. In theory, it should only elongate by 5 %, but it is able to do so by 30 times of that value. It may also happen that the foil tube adheres to the inner wall of the still raw Furanflex not yet hardened and the increase in diameter is carried out not by gradual elongation but at one place. It is comparable, for example, to the opening of a closed clamp.

The material of the foil is a mixture of poliolephines and it is light blue. It elongates like rubber and is not destroyed at the temperature of hardening.

This tube can be inflated “ alone” with steam with a diameter of up to 400 mm, it will not be destroyed at a pressure of 0.2 bars.

For the sake of safety, some of our partners requested two foil tubes for the Furanflex pipe with a larger diameter (exceeding ∅200 mm). This reduced the problems resulting from the breakage of the foil but caused difficulties as well.

The time of hardening significantly increased as a result of the insulation effect of the layer of air generated between the two thin foil tubes. Thus from the point of view of the breakage of the foil the safety technology is the following:

- A reserve foil tube is always in the working place
- An adapter kit suitable for changing the foil is applied (see the description of the adapter kit in the supplement)

Finally, some statistics. So far more than 320 km of Furanflex has been installed The total number of foil tube breakages was below 40. That seems to be low, but even that is not admissible as in the case of railway switches it is not admissible that at times some of them should switch wrongly.
For the guaratiee of Furanflex is important to use the adapter sets made by Kompozitor so as to be able to pull a new inner foil into an installed tube. This manoeuvre takes 10 minutes.

It is necessary to have a proper size spare foil at the working place. In practice the thermoplastic foil tube sizes are not determined by the diameter but the spread out width. This width is practically means the half width of the periphery. In case of Furanflex tubes this diameter is always smaller than the tube itself so to help you choose and order the correct width please find the following tablet:

Foil Diameter (mm)	Foil Half Width (mm)
80	115
90	130
100	145
110	160
120	175
125	180
130	190
140	205
150	220
160	235
180	265
200	295
225	335
250	370
275	410
300	445
325	470
350	520
375	560
400	600
450	670

The foil tube can be easily pulled out following the hardening of Furanflex. However, it is necessary to wait until the complete hardening of the liner pipe has occurred and the Furanflex is cooled down. If removal causes difficulties, air has to be blown between the foil tube and Furanflex with the Fast Blower or the foil tube has to be "vacuumed out" by the sucking application of the Fast Blower.

The foil used once cannot be applied again. It can be sold as waste to plastics manufacturers or burn in an oven. (It is a chemical, which is not dangerous, similar to paraffin). Dug under the ground, it is guaranteed to last for a thousand years, unfortunately (especially if it is not subjected to UV radiation).

5. External coating textile

A thin, high strength textile coats the external surface of the Furanflex liner tube. This layer of textile is actually a tube with a given diameter sewn from a textile material. Its tasks are the following:

- It determines the perimeter and diameter of the inflated Furanflex tube
- It protects the layers of the glass textile from bruises while being pulled in
- It absorbs the forces on the perimeter originating from internal pressure during inflation
- It absorbs the excess resin pushed outside by the internal pressure during steaming

On the basis of laboratory and practical experiments, the textile material, thin enough to make the Furanflex tube easy to handle but strong enough to bear the loadings, was selected.

Furanflex can be made and applied without an external coating as well. It can be advantageously used in cases where it is important that the inflated Furanflex should adhere to the wall surrounding it. Such a case is lining steel or aluminium corrugated tubes (flexible tubes). Here more resin "seeps out" from the Furanflex without coating into the "knurls", thus filling the grooves. But there may be other requirements, e.g. good adhesion of Furanflex to a brick wall.

In the above cases the material of Furanflex is to mature a bit longer in order to avoid its surface being "sticky".

Forces loading the liner tube

If a tube is under internal pressure, in its wall the stress (loading) is twice as high in circumferential direction, than in longitudinal direction. Therefore in the case of internal pressure it is always the circumferential force that is to be calculated. In theory, let us cut out a 1 cm wide ring from the tube. In theory, let us put the ring under internal pressure. Pressure will want to tear the ring into two parts; trying to make two half rings. The higher the pressure, the bigger the diameter, and the higher the force generated in the wall in circumferential direction. A numerical example:

Diameter of the chimney tube	250 mm (25 cm)
Internal pressure	0.3 bar
The force intending to tear the 1 mm wide ring is	25 x 0.3 kg = 7.5 kg

This force wishes to tear the ring into two half rings. At the points of breaking opposite each other diagonally the force is half of the above value, i.e. 3.75 kg

The tensile strength of the textile applied is 19 kg/cm in circumference, thus the safety is approximately 5-fold in this measurement.

According to our laboratory tests the tensile force at the place of sewing is reduced by 10-20%, so instead of 19 kg/cm we only have to calculate with a value of 15 kg/cm. Even so strength is significantly higher than the tensile force generated by the internal pressure in the wall of the liner tube.

Obviously, during the inflation of Furanflex a part of the internal pressure is exerted on the expansion of the foil tube, another part on shifting apart the glass textile layers. Consequently, the force loading the external textile coating is smaller than the theoretical one.

Anyway, it is to be taken into account that the bigger the diameter of a tube, increasingly higher the load on the wall of the tube at identical pressure. Thus if, e.g. a 100 mm diameter Furanflex tube is inflated with a pressure of 0.3 bar, in the case of a 200 mm diameter tube the same peripheral tensile force is generated at a pressure of 0.15 bar.

Interestingly enough, the external coating has rarely broken at the place of sewing (so far only twice). There have been a few breakages in the external textile, which did not occur at the place of sewing. So far the cause has not yet been identified unequivocally.

Unfortunately, textile (like paper) has so-called tear strength as well. That, for example, refers to a part of the material next to a place of damage. It is a known fact that if textile is slashed a bit, it is easy to tear. Tear strength is significantly lower than tensile strength. The breakages mentioned above may have been caused by a little damage in the external textile, e.g. a stone or metal cut a few fibers. In the Furanflex tube internal pressure is exercised on the weft fibers. It is quite probable that the cause of those breakages is that the external textile of Furanflex is damaged by something in the chimneystack during insertion.

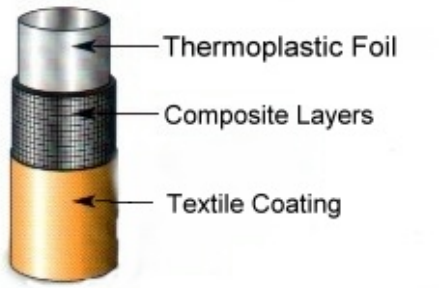
The material of the external textile is plastic fiber, which is flammable, but once it is impregnated with resin, it loses this property.

In cold weather there were defects (see later) where the resin was too rigid and while Furanflex was being folded the textile embedded in the rigid resin got broken. Therefore from the beginning of 2004 the material of the coating textile was changed with the values below:

Tear strength along the weft (crosswise)	19.5 kg/cm
Tear strength along the warp (lengthwise)	14.2 kg/cm

6. The structure of FuranFlex

The Furanflex chimney liner tube consists of the following components demonstrated in detail in the above chapters:



Thermoplastic Foil

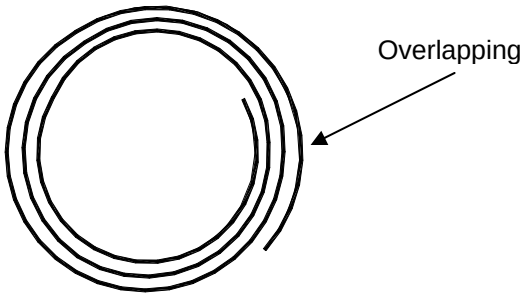
The thermoplastic foil tube size changes according to the diameter changing. It is used as a temporary part of the tube during the blow up. It secures that the steam can flows through the tube so as to let the heat transfer from the steam to the resin for setting it but it has to be gas tight and has to fulfil several other requirements. For know more about the thermoplastic foil see chapter 4.

Composite layer

The composite layer is the glass textile impregnated with heat resistant resin (pre preg). It is placed spirally in three layers between the foil and the textile coating.

Diameter =130mm

No. of layers= 3

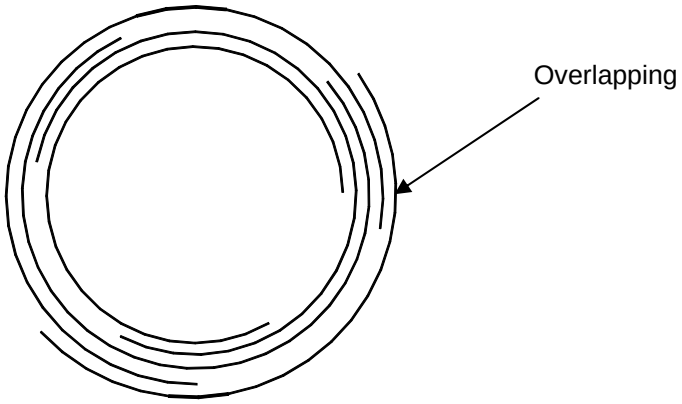


Up to Furanflex diameter 130mm the composite layer of the tube can prepare from using one 1300mm width pre preg.
On the picture above the three layers is prepared form one pre preg and has an overlapping on it, which are a tailpiece and not an extension.

Up from the diameter of 140mm there is need for overlapping between two or more pre-pregs because one is not enough for this periphery. On the following picture you can see a tube of diameter 500mm.
Where Furanflex has overlapped layers the thickness increase there.

Number of layers= 3

Diameter =500mm



The spiral structure allows the glass textile layers -that constituting the liner tube- to slip one over the other in the honey-like resin bath under the influence of heating by steam and the pressure exercised on the internal foil tube.

Textile coating

The textile coating is actually a tube sewn from a high strength textile. When the tube is blown up with steam the composite layers are pressed against the textile coating and then to the wall of the stack to be lined or they find their place in the chimney as an independent cylindrical tube. The textile coating only change in size depending on the diameter, however, the "composite layer" changes in its structure in addition to its size. To know more about the textile coating see chapter 5.

7. The heat resistance of FuranFlex

On the basis of domestic and foreign official qualifications, Furanflex is suitable for conducting flue gasses with a temperature of maximum 250°C during the operation of gas and oil heated boilers. The Swedish qualification permits the application of Furanflex for wood-heated systems as well under certain conditions up to a temperature limit of 350°C.

The manufacturer set the temperature limit of 250°C for the sake of safety. Official tests were carried out at temperatures significantly higher than that value. E.g.:
Heat resistance tests of Furanflex

Qualification tests

Hungarian	6 hours	500°C
Austrian	6 hours	500°C
French	1 hour 10 times	300°C
	1 hour 15 times	400°C
Italian	alternating	350°C

Furanflex passed the above tests.

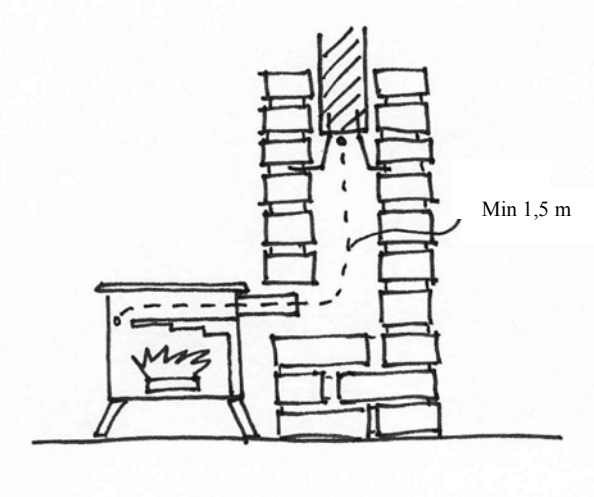
The Swedish qualification permits the application of Furanflex for wood-heated systems as well under certain conditions up to a temperature limit of 350°C.

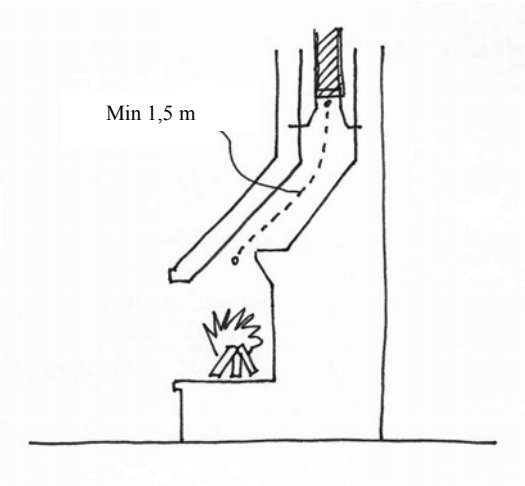
- There should be a heat exchanger above the combustion chamber of wood-heated boilers
- The boiler is to be connected to the Furanflex liner tube with a stainless steel pipe at least 1.5 m long from the expected flame height
- The temperature of the flue gas may not exceed the value of 350°C

In respect to the generation of soot, the Swedish standpoint is that in the case of chimney fire all the liner tubes are destroyed so they have to be changed. In case of cleaning, attention should only be paid to not using hard instruments made of metal. The related drawings included in the Swedish technological description are presented below.

Modern environment-friendly ovens, whose output flue gas temperature is lower than 350°C, are suitable for being lined with Furanflex in case certain stipulations are met.

- *The Furanflex tube with the biggest diameter permitted which lies against the wall of the stack is to be used.*
- *The FuranFlex liner tube should not be insulated.*
- *A lower stainless input profile should always be used.*
- *The Furanflex liner tube must not be exposed to flames. The minimum distance between the bottom of Furanflex and the output opening of the oven must be 1.5 m.*





Presently in Sweden Furanflex liner tubes can be found above more than 5000 (!) wood-heated boilers.

The 1.5 mm thick wall of Furanflex can be burnt with a gas flame of a temperature around 1000°C for minutes, consequently it resists a strong impact of fire for a long time.

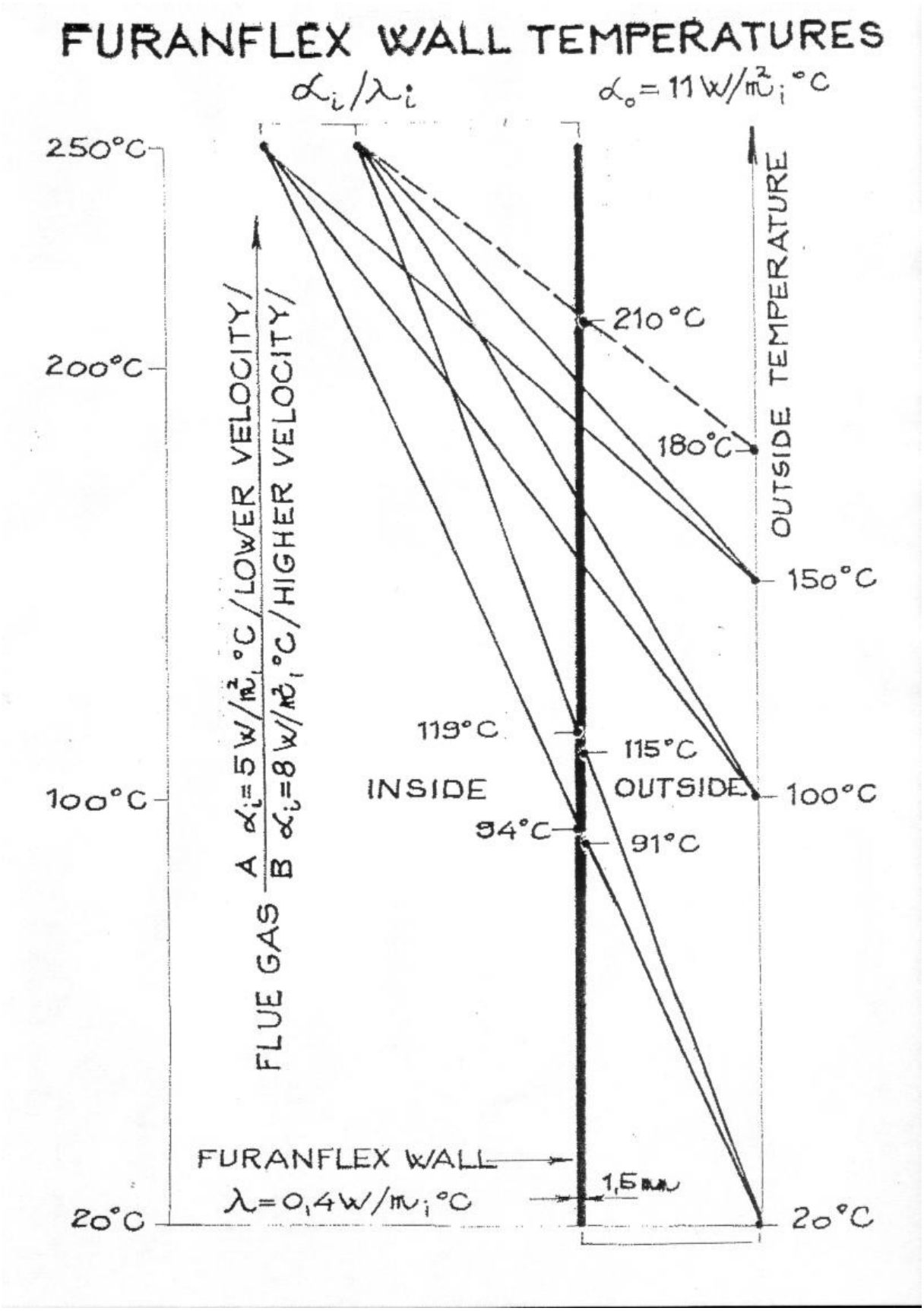
The cold resistance of the material of Furanflex is unlimited. It will not become rigid at low temperature either.

The temperature of the internal surface of the liner tube is always lower than that of the flue gas flowing in it.

Flue gas Temperature	**Internal Wall Temperature (calculated)**	**External Wall Temperature (measured)**
250°C	94 - 119°C	91 - 115°C

The wall temperature of the liner tube depends on the temperature of the air around it, the flow rate and temperature of the flue gas. To demonstrate all that, a graph is attached on the following page

It is not necessary to apply external heat insulation for Furanflex. In case it is done, e.g. mounting in the open air, it is purposeful to carry out heat technology calculations in order to prevent the overheating of the external side of the tube wall. The overheating of the external side is dangerous because here air containing 21 % of oxygen is present.


FURANFLEX WALL TEMPERATURES
α_i/λ_i
$\alpha_o = 11\,W/m^2{}_i\,°C$
250°C
200°C
100°C
20°C
FLUE GAS A $\alpha_i = 5\,W/m^2{}_i\,°C$ /LOWER VELOCITY/
B $\alpha_i = 8\,W/m^2{}_i\,°C$ /HIGHER VELOCITY/
OUTSIDE TEMPERATURE
210°C
180°C
150°C
119°C
115°C
INSIDE
OUTSIDE
100°C
94°C
91°C
FURANFLEX WALL
$\lambda = 0{,}4\,W/m_i\,°C$
1,5 mm
20°C

8. Corrosion resistance of FuranFlex

Furanflex has an excellent resistance to the following impacts:

- Strong and weak acids
- Solvents
- Petrol, oil

It is resistant to weak alkaline solutions (up to 12 pH).

It is not resistant to strong alkaline solutions (above 12 pH).

The pH indicates the acid or alkaline concentration of a solution. pH 7 is neutral like water, pH 1 is strong acid, pH 14 is strong alkaline solution.

It is not allowed to clean e.g. a FuranFlex tube (ventilation tube in the kitchen) from fat deposition with concentrated oven cleaning liquid. Under that impact the artificial resin swells and is destroyed in the course of a few hours.

It is unlimitedly resistant to acidic condensate generated in the chimney. The precondition for that is that there should always be a thin layer of resin on the internal surface of the glass textile. Glass fibres are less resistant to corrosion than artificial resin.

The following points are worth mentioning:

- Aluminium liner tubes take a short time to degrade in chimneys. The causes of that is not only internal, acidic corrosion but also the external alkaline materials, e.g. plaster, lime, cement.
- Aluminium liner tubes for chimneys are not allowed in Europe.
- Stainless steel corrugated tubes (flexible) are not allowed to use in chimneys in Europe. (Below the wall thickness of 0,2 mm)
- 10 year warranties are granted for rustproof steel tubes with thick walls (0.8-1.0)
- A 25-year warranty of corrosion resistance may be granted for Furanflex.

Recently thermoplastic, extruded rigid and flexible plastic chimney tubes have been introduced to the market. They have a good resistance to corrosion; they may be applied up to 120^{o}C. They are not manufactured with larger diameters (150 mm).

The surface of Furanflex may be attacked and made dull by UV radiation in the course of 5-8 years. The surface concerned may be coated with heat (350^{o}C) and weather resistant paint offered by Kompozitor Ltd.

9. Heat insulation ability of FuranFlex

The heat conductivity factor of Furanflex is 0.4 W/m,°C

Other structural materials_

Stainless steel	16.0
Carbon steel	55.0
Aluminium	300.0
Silver	1.000.0
PUR foam	0.04

(Data for information)

The following conclusions can be drawn from the figures above:

Furanflex belongs to the family of heat insulation materials rather than to that of metals conducting heat.

Compared to stainless steel, its ability of heat insulation is 16:0.4 = 40 times better at identical wall thickness.
If we take into account the differences in wall thickness, 0.8 mm for metal and 1.6 mm for Furanflex, the above number is doubled. Thus Furanflex is 80 times better than stainless steel from the point of view of heat insulation.

In practice, that means the following:

- The draft of the chimney increases in a perceptible manner
- In theory, a smaller chimney cross section is also appropriate
- The air supply of gas boilers improves
- It compensates for the influence of the local change of the diameter, due to the deviations

It is to be noted that a better flue gas flow is promoted by the smooth internal surface of Furanflex too.

10. FuranFlex qualification test

From the point of view of life and property safety, all the objects built into chimneys must have a permit of aptitude. The authorised national qualification institutes on the basis of the standard tests valid in the given country issue those permits. The results of another country are not accepted automatically, they may at best make the procedure somewhat easier. (In the case of the EU, the test aspects will probably be uniform.)

The Furanflex liner tube has been granted aptitude permits in the countries below:

Hungary
Norway
Sweden
Baltic States
Italy
France
Czech Republic
Austria
Switzerland
Slovakia

In some other countries the tests are under way. (No local tests are necessary in England and the Benelux States.)

The process of qualification is accompanied by a great deal of technical and administrative exercise. Documentation, results of own tests, etc. are requested. A few observations:

The test temperature is highest in Hungary and Austria (500^{o}C).

The conditions are the strictest in France, e.g. annual visits are paid to Kompozitor Ltd. for control purposes.

In the following the test data of Furanflex will be described on the basis of the Test Protocol No. 1999 of ÉMI M-214. That test did not directly serve the issuance of the aptitude permit but it was necessary for the development programme of Kompozitor Ltd. (The test was carried out by taking into account the prescriptions of the valid MSZ 14779:1998 and the Swedish SS 02 48 31 standards.)

The description of the test (see Figures attached)

- The Furanflex liner tube (with a diameter of 130 mm) was built with the valid technology into the brick chimney stack, 6 m tall, free to walk around, in the laboratory of ÉMI
- Heat sensors are placed inside the chimney at distances of 1-1meter
- Heat sensors are mounted on the external wall of the chimney as well
- The appliance generating mobile flue gas is joined to the lower inlet point of the liner tube

- The inflow of the flue gas of the required temperature is started in accordance with the test program
- The flue gas temperature is measured at the inlet point and above it
- Temperature is measured on the external wall of the chimney
- Prior to each phase of heat loading and then 24 hours afterwards, the liner tube is cooled down and placed under pressure and its tightness is measured (loss of air)

In accordance with the Hungarian (and Austrian) standard, the qualification of chimneys consists of four heat loadings as described below:

	Temperature	**Time**	**Objective**
Phase I	200°C	6 hours	Drying phase e.g. in case of structures like plaster
Phase II	350°C	6 hours	Chimneys heated with gas
Phase III	500°C	6 hours	Chimneys heated with oil
Phase IV	1000°C	0.5 hour	Solid fuels

Following the individual phases, the chimney is cooled down and then heated again.

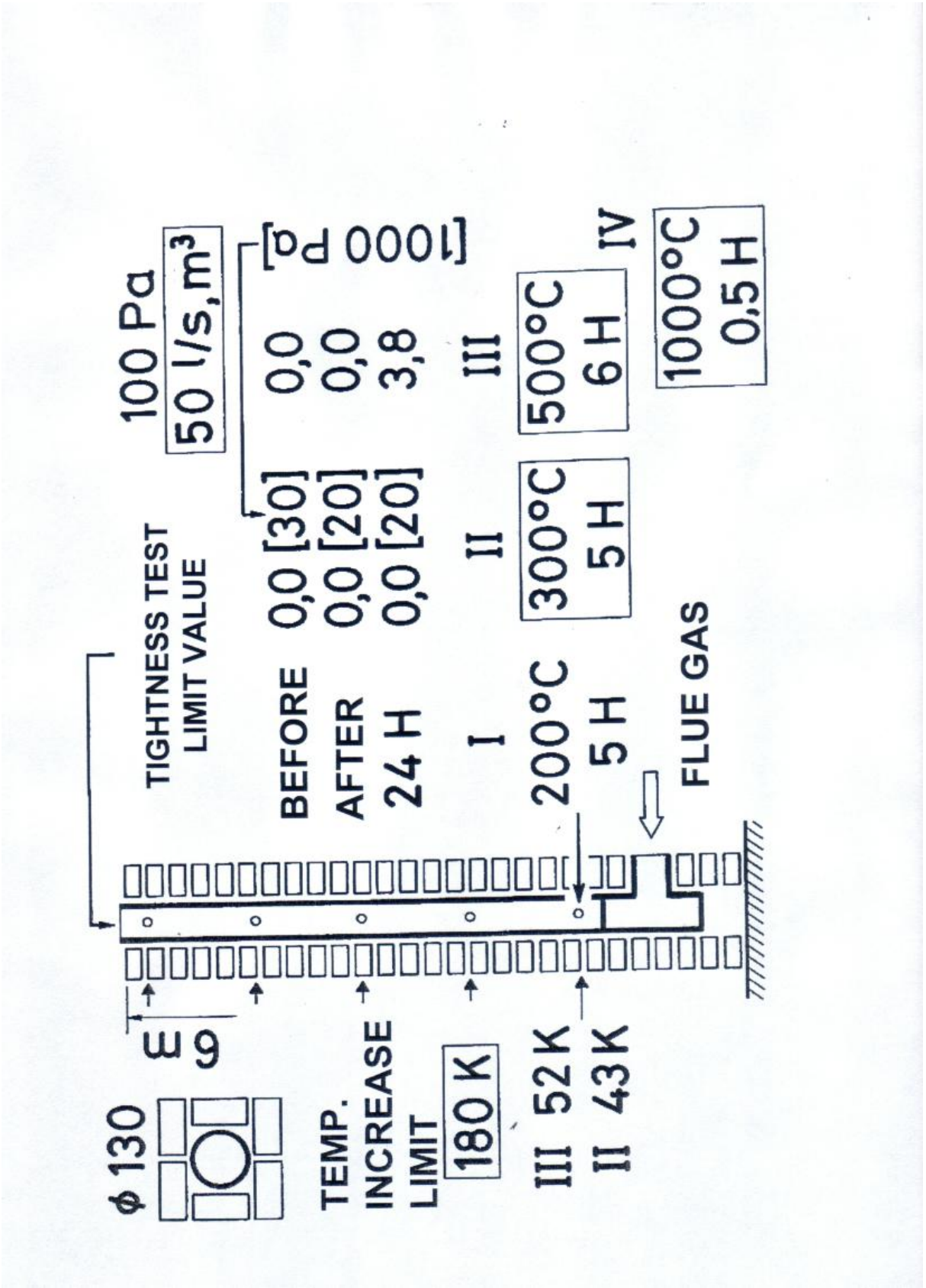
The results of Furanflex were the following (see supplement):

- The Furanflex pipe was not damaged /visibly/
- Air filtration following phase II was "0" liter
- Air filtration following phase III was "0" liter,
- Following 24 hours 3.8 liters *(allowed 50l)*
- Temperature rise of the external wall following phase II was 43°C *(allowed 180°C)*
- Temperature rise of the external wall following phase III was 52°C
- At a temperature of 1000°C tightness could not, wall temperature could be measured (310°C)

At a special request, phase IV was included too (requested by the Swedish partner). The question was if a case like that occurred at all, how Furanflex would behave. Furanflex did not collapse; it remained in its place as a white, loose tube.

The results of the test are favourable. The low temperature rise of the external wall was evaluated as very good.

For the temperature of the external wall of the brick chimney is measured too. This temperature may not exceed a temperature rise of 180°C during the test.
The measurement results of Furanflex were extremely good, at a temperature of 350°C the temperature of the external wall was 43°C, its temperature rise was 52°C in the range of 500°C. See picture on the following page.



Remarks about the tests

The valid standards regarding chimney tests were formulated by taking into account only inorganic materials (metal, bricks, concrete) in the majority of countries. However, in a

number of Western countries in relation to Furanflex, containing organic materials /resin/, independent test reports were required controlling the generation of cancerogenous substances that may leave the liner tube at different temperatures.

Such tests were carried out by the Danish Dansk Toxicologi Center and the German Institut für Ökologische Chemie. From the latter report:

At a temperature of 100^{o}C	the emission of harmful substances was not detected
At a temperature of 300^{o}C	the emission of harmful substances was not detected
At a temperature of 600^{o}C	the emission of harmful substances was not detected
At a temperature of 1000^{o}C	nine harmful substances were found

A remark about the last test at 1000^{o}C:

- The quantity of harmful (polycyclic) substances was one millionth of a gram in respect to one gram of the material tested
- The test was carried out with gas chromatography where there is no oxygen present. At this temperature all organic substances burn immediately in the presence of oxygen.

This argument of ours was accepted everywhere. In our view, it would be important to test all the organic substances (plastics) to be built into chimneys in accordance with the above.

11. FuranFlex liner tube sizes

Furanflex liner tubes can be ordered with 22 different diameters in a range of diameters of 80-500 mm (see Supplement).

In view of the fact that the external textile coating determines the diameter, more exactly the perimeter of the tube, in between diameters can also be produced. An in between diameter means that the sizes indicated in the table may be deviated from with a value of + 5 - 10 mm. For a step larger than that, there is need for an internal foil tube of a larger size, which is to be manufactured separately.

As regards the length of the Furanflex tubes, the following are to be taken into account:

- The liner tubes may be ordered in the given length necessary for application
- In the smaller range of diameters (up to 150 mm) liner tubes may be ordered so that
- The piece of the necessary size is to be cut off by the one placing the order while the rest is to be stored by him. In this case the length of the tube is 35-40 m, or even more at individual requests
- In the case of tubes of a larger size than the former ones, they are generally ordered with the necessary size. In Hungary Furanflex of the largest size was applied in Balatonfüred with a diameter of 500 mm and a net length of 52 m. (The installer was Thege Bau Ltd.)

When determining the sizes of length, it is necessary to take into account the extra length needed to close the upper and lower ends of the tube, which may be approximately 500-800 mm at the top and at the bottom.

Selection of the tube diameter

A few aspects of the selection of the diameter of the liner tube of the Furanflex chimney are listed below:

- In the Furanflex liner tube the flow conditions are considerably better than in brick chimneys or in flexible metal pipes.
- The hardened cross-section of Furanflex, if it does not contact with the hard wall of the chimney, is circular.
- If Furanflex contacts with two or four opposite walls of the rectangular chimney, in the first case it will take the shape of a horse- racing field, in the second case that of a rectangle with rounded corners (see later)
- In lining chimneys with a circular cross-section (e.g. corroded aluminium pipes), an identical diameter is to be selected. It is to be taken into account that during inflation-heat treatment the diameter of Furanflex will increase by a few mm

In the journal of the French gas supplier, Gaz de France an article was published on Furanflex technology. As excerpt from it is quoted below:

"A few questions causing headaches:
- It is impossible to insert a pipe with a diameter of 250 mm into an existing rectangular chimney of a size of 400 x 200 mm.

- Flexible stainless steel chimney pipes do not grant the necessary guarantee in their horizontal notches against corrosion.

Novelty in the chimney industry
The Furanflex method licensed in 8 countries of Europe offers a new possibility in lining chimneys" /End of quotation/

The specific mass (weight) of Furanflex liner tubes is to be found in the table attached. In large sizes the mass of the tube represents a serious technical problem. E.g. in the case of the chimney in Balatonfüred referred to, the mass of the liner tube was 310 kg. It had to be carried on a "stretcher" by several people to the vicinity of the lower opening of the chimney.

It is emphasized again that this load is not significant from the point of view of the upper suspension. Staying with the example of Füred, there the adapter head of Kompozitor Ltd. was used, whose diameter is 133 mm and its perimeter is approximately 41 cm. Dividing the above weight by the perimeter, a load of approximately 7.6 kg is exerted on a width of 1 cm on the perimeter. Obviously, it is important that the adapter head should be in the middle of the tube so that suspension should not represent an asymmetrical picture.

Diameter (mm)	Furanflex kg/m
80	0,82
90	0,92
100	1,01
110	1,10
120	1,19
130	1,28
140	1,46
150	1,55
160	1,64
170	1,78
180	1,83
190	1,92
200	2,01
225	2,24
250	2,46
275	2,78
300	3,01
325	3,08
350	3,33
375	3,58
400	3,83
450	4,33

12. Storage of FuranFlex

Furanflex is a "living" substance like cheese, yoghurt, and wine. In its storage, aspects are to be taken into account, which differ from the storage of bricks, gravel, and metals.

In its form of manufacturing, Furanflex is a soft, flat tube, in the material of which, more exactly in its part of resin, two parallel processes take place.

One of the processes is slow drying where the water partially leaves the resin (3-8%) through the external textile coating. During drying the material will be increasingly harder, "rougher" and may reach a stage where the liner tube may not be moulded, inflated, etc. at room temperature.

The other process is a slow chemical reaction, in the course of which increasingly more molecules are bound together and " cross-linking" takes place. As a result of the molecules linking together, new water molecules are eliminated which leave the product also in the form of drying (steam is generated under the influence of heat). This chemical process will result in the material becoming increasingly "denser", the viscosity of the resin will increase and after a certain period of time it becomes hard and impossible to mould.

If we perceive the material of Furanflex becoming suspiciously "hard" and we are not certain whether we should dare to insert it into the chimney, we must investigate the cause of the hardness of the material. If hardening occurred primarily as a result of drying, the addition of heat and extra moisture (see later) will make the material soft and possible to use.

If hardening is the result of the chemical process, this state is irreversible and there is no other choice but throw the substance into the waste storage container.

To determine the two states, instruments costing millions of forints (infrared spectroscope) may be used but the human hand will do as well. Taking the material of Furanflex into our hands, squeezing it tight with our palms, and waiting for about half a minute, we warm the material up a bit. If the material of Furanflex softens a bit and may be moulded like dense wax, we are faced with drying only. We are lucky, the material can be used.

If the material of Furanflex remains rigid, contrary to other phenomena of life, in spite of the squeezing of our hands, it is not a good sign but the worst possible one in this profession. There is no other choice but the waste storage container.

To avoid the latter case, the circumstances of storage are very important. In the following we shall summarize those aspects.

A humid wine cellar with a temperature of 14-16^{o}C would be ideal for the storage of Furanflex. Here the material can stay for several months even, especially in the company of good wine. But, to be scientific again, the following aspects are to be adhered to:

- The Furanflex should not be stored in the sun, not even for a short time, except if we wish to warm it up. In this case, it is to be turned, spread in order to ensure an even warming up.

Furanflex can be stored at:

- Over 30°C)1 day
- At hot environment (26-30°C) 3-4 days
- At room temperature (20-23°C) it can be stored for 2-3 weeks
- At lower temperature (20-15°C) the storage time is 1-2 months
- Cooled (2-4°C), like apple, it will last for 2-3 months
- Not store under 0°C
- The listed above are valid if proper packed.
- When Furanflex is put once more into a package it is advisable to wet the material slightly before put and close properly in a plastic foil.

In a cooled or deep frozen state the material "freezes" a bit and becomes hard. It is recommended to place the freezing Furanflex tube at room temperature one day before insertion and warm it up a bit. In that case, vapour precipitates on the surface of Furanflex, which is too cold. It may be harmful if the material was too "fresh" originally too; therefore there is no need for "additional" water. For then the material becomes "overly watered" and it will easily become fluid while being inflated, with lots of resin pearling through the external textile coating.
Earlier a reference was made to the stage where if the material of Furanflex is already a bit hard but can still be saved and the situation may be remedied by the addition of water. In practice it means that a few hours, perhaps a day prior to insertion the tube is sprinkled with water from the outside. Some experienced constructors go as far as to simply dip the whole folded Furanflex package into a tub and bathe it like a baby in lukewarm water.
An incubator for prewarming was made in France. The Furanflex package is placed on a plate to be heated electrically with a heating surface of a temperature of 40-60°C. The whole thing is closed with a box-like lid. That is the way the material of Furanflex is softened prior to insertion.
Experiences are not unequivocal in respect to deep-frozen storage. In theory, Furanflex may be stored deep-frozen even for years.
It could be verified with experiments as well. Being aware of that, Kompozitor Ltd. built a storage room with a temperature of- 18°C. However, there was an observation of the product having been slightly damaged during being deep-frozen. Such a phenomenon exists in respect to foodstuffs as well; there are fruits whose taste changes as a result of deep-freezing.

The topic has not been closed because the Furanflex products need to be transported over increasingly greater distances causing no small problems in the summer heat. That could be greatly helped by deep-freezing.

13. Preparation of chimneys for Furanflex lining

Prior to the insertion of the Furanflex liner tube, the selected chimney needs to be prepared. The main aspects are the following:

- Assessment of the state of the chimney
- Authority procedures
- Clarification of the flow conditions
- Dimensioning if necessary
- Determination of the diameter and length of the Furanflex liner tube
- Test by camera
- Constructional repair of the chimney (if necessary)
- Assessment of the places of slanting (permitted value of slanting is maximum 30^{o})
- Identification of critical places, chiselling of edges (e.g. in case of slanting) (see figure)

- Elimination of protruding objects (bricks, concrete iron, wire, etc.)
- Ensuring an even cross-section

- Placeability of the frame of the upper adapter head
- Placeability of the lower adapter structure
- Building a winch if necessary

- Ensuring a place for steam generation, supplying electricity, water
- Placement of air compressor, electricity supply
- Building the place of joining T profiles to the chimney
- Determination of the direction of the insertion of Furanflex
- Transportability, placeability of packaged Furanflex on the sight of construction

14. Insertion of the FuranFlex tube

The insertion of the Furanflex tube into an existing chimney is performed as follows:

- Prior to the operation of insertion, the T-tap joint as well as the other fittings (e.g. cleaning) are to be placed into the opening formulated beforehand
- In the case of smaller diameter and smaller mass, the Furanflex liner tube is to be inserted into the chimney from above
- A precondition of the above is that the mass of the liner tube could be properly moved and placed on the roof, in the vicinity of the chimney
- As an example, the upper limit is 30 m of the tube with a diameter of 250 mm. It is about 75 kg which can be moved by two persons
- In the case of insertion from above, it is advisable to bind a thin rope to the bottom of the liner tube and then let it down and "lead" the soft liner tube (and not pull it) with the help of the rope. This operation is important especially at the slants.
- It must be made sure that the tube should not "fall" into the chimney from above
- It is purposeful to mount the upper head of the adapter to one end of the Furanflex tube beforehand
- The head must be fixed to the upper frame structure of the adapter with the help of squeezing screws or pins
- It must be made sure that the upper frame should not tip, fall off the chimney which might cause an accident (e.g. secure it with a rope or a chain)
- While letting the tube down, care must be taken that it should not "twist away". The tube is folded half-width lengthwise.
- The edge of the folding should be watched in order that it should arrive on the same side at the lower opening of the chimney. (Of course, that may happen even if the liner tube is twisted 360^{o}).
- The liner tube led into the chimney passes through the vertical pipe of the T-profile and similar profiles
- At the lower end of the Furanflex tube a closing ring is pulled on the liner tube, which will be joined by the lower steam collector. The ring is temporarily fixed in the necessary place against sliding off
- After that, the Furanflex tube cut to the appropriate length is led out of the chimney opening close to horizontally and fixed to the lower head of the adapter. (In the case of an arched adapter head, the Furanflex tube need not be led out; it will remain in the chimney in a vertical state.)
- During the whole operation care must be taken that the Furanflex tube should not be damaged. If a one-millimeter break occurs in the external coating, it will be slashed further, causing serious damage. (The whole tube is to be thrown away if it can be pulled out at all)

- In the case of large-sized Furanflex tubes, the liner tube is to be pulled into the opening of the chimney from below
- To do that, the upper head equipped with a chained lever ring is to be mounted to one end of the Furanflex tube at the lower level of the chimney
- A winched lever structure hindering running back is to be placed above the upper opening of the chimney (or in an appropriate place on the roof)
- Care must be taken that the winch should be at the appropriate height because there must be room for the chained ring, the adapter head and the Furanflex tube widening conically from the head
- One end of the Furanflex tube being on the lower level is to be joined to the upper head
- With the help of the winch, the tube is to be pulled into the opening of the chimney slowly, while the rest is to be handed on helped by hand continuously in order to avoid the tube getting stuck or damaged
- The winch is to be stopped with the upper adapter head at the appropriate height
- At this time the upper frame structure cannot be used, the full length of the tube is hanging from the lever
- The mounting and placement of the lower adapter head are similar to those of the liner tubes of smaller sizes

It is advisable to have the adapter heads fixed with ABA squeezing rings. Two rings are sufficient in the case of very small sizes (diameter of 80-110 mm). In the case of greater diameters and lengths (diameter of 130 mm, length of 10-15 m) 3 rings, in the case of larger sizes 4 rings are recommended to use.

Having carried out the above operations with great care, we can start the operation of inflation hardening.

15. Hardening of the FuranFlex liner tube

The process of inflating and hardening the liner tube, inserted in the chimney, controlled and mounted with fittings, consists of the following steps:

Trial inflation

The aim of the trial inflation is to check the following prior to the process of hardening:

- The proper insertion of the fittings of the adapter closing the end of the tube
- The tube is free from twisting
- The tightness of the tube

The trial inflation is to be carried out with air. The advantages of trial inflation with air are the following:

- The process of hardening will not start
- The operation is faster than if it were carried out with steam
- By closing the tube inflated with air, it is possible to perceive a possible drop in pressure
- If inflated with steam and closed, the steam will immediately condense and its pressure will drop

For trial inflation with air, small-sized garage compressors can be used but they have serious drawbacks:

- Compressors operate in a range of maximum 6 bar which can be controlled, in opposition to the range of a tenth of a bar required by the technology
- Small pressures are uncertain to be set on the structures determining pressure in compressors
- Excess pressure may burst the inner tube or even the wall of the chimney
- Compressors supply low quantities of air, therefore the time of inflation increases

Obviously, compressors may not be banned for Furanflex technology but in that case no guarantees may be granted for the Furanflex tube. In the case of the application of compressors, blow off valves opening at a pressure of 0.4-0.5 bars are recommended to use.
For the above reasons, a Fastblower has been developed. It supplies high quantities of air at a pressure below 0.2 bar guaranteed.
An example for the speed of inflation: to inflate a Furanflex tube, 54 m long, with a diameter of 500 mm, with a garage compressor takes 45 minutes. If a Fastblower is used, it only takes 5 minutes and it is safe.
In a trial inflation, the taps are to be closed in the lower and upper adapter heads and then it is necessary to wait for a few minutes and watch the pressure drop in the liner tube. At this time the steam generator has already been attached but the water in it has not yet reached the temperature of boiling. Pressure can be read from the pressure meter of the steam generator.

The twisting of the Furanflex tube may be perceived by vision or with a camera or by dropping a ball. Those operations are made possible by the adapter head.

In the case of twisting, the tube is to be taken out, rearranged and inserted again. (We have not yet heard about such cases.)

If there is a pressure drop, i.e. the manometer drops to zero in a few minutes, the tube is to be pulled out. In the case of a small drop of pressure, hardening must not be forced. Steam flows out through a hole somewhere and washes out the resin in its vicinity. The liner tube will not become compact.
It is not recommended to carry out the trial inflation with steam also because if the taps are closed, pressure will drop in a short while since the steam will start condensing inside the tube. Vacuum may develop which may crush the Furanflex tube.
If the pressure drops following inflation with air or after letting in steam - and that is indicated by the pressure meter on the steam generator - it means a break in the wall or in the textile which is looked upon as an accident (see chapter 18) and the necessary steps to eliminate it must be taken.

Inflation and hardening

Following the trial inflation, the flow of steam may be started. The tap on the head of the upper adapter is to be opened a bit in order that the steam could press out the air in the tube. When the steam has appeared at the tap, the following steps are to be taken:

- In cold weather and in the case of large diameters, the tap has to be left open a little in order that the air should leave the tube and the steam should flow upwards
- Following the appearance of the steam, the tap is to be set to the smallest slot and let the steam "pipe" continuously
- The upper tap may be closed at times, in such cases the pressure of the steam increases but new air gets with the steam into the system, collects at the top and hinders the hardening of Furanflex as an insulation buffer
- Steam-air automatic valves, which open when, air flows and closes when steam flows, may be applied with good results. Their advantage is that there is no need to "watch" the upper valve on the roof. Even in case of mounting such an automatic device there is need for a closing tap for purposes of safety.

Considerations relating to hardening

- Steam pressure should not exceed the value of 0.1 bar at the beginning (0.1 kg/cm^2)
- The ABA clamps on the upper and lower heads are to be tightened again because under the influence of heat resin will first soften, become fluid and the steam will start to seep beneath the clamps
- When the liner tube has visibly inflated, pressure may be increased a little
- The larger the diameter, the lower the pressure to be used because the higher the peripheral tensile force in the tube
- The higher the pressure used, the more resin will be pressed out through the textile coating
- The higher the pressure used, the more certain it is that the layers of Furanflex will stick together

- If it is felt by touching that the material is no longer "liquid", pressure may be increased a little (but not above 0.3 bar!)
- The higher the pressure, the higher the temperature (at 0.1 bar app. 100°C, at 0.2 bar app. 104°C, at 0.3 bar app. 106°C)
- Increase of pressure must not be abused just for reasons of saving time
- It is recommended to "post harden" the already hardened liner tube in a higher pressure range, i.e. at a higher temperature
- Furanflex offers its good corrosion and heat resistance properties only in a state of complete hardening

The most important piece of advice in respect to the hardening of Furanflex is a great deal of experience and precise work

The end of hardening

Furanflex may be considered to harden if it gives a metallic sound when knocked at both at the top and at the bottom. That is a good sign but what is the situation inside the tube? It is better to steam the chimney for another 20 minutes or so following the appearance of the metallic sound. The inside of a chimney may be colder than the ambient temperature. There was a case in Sweden where the completely hardened Furanflex tube "slipped" into the chimney following the elimination of the upper fittings. The reason was that the chimney cooled down significantly during the night and the weather was warm during the day. The parts of the Furanflex tube sticking out of the chimney hardened easily but the material inside the chimney, which had cooled down during the night, could no longer harden.

Conducting of condensed water

In the case of the steam generators supplied by Kompozitor the condensed water generated in the liner tube flows back into the water tank of the boiler by opening the tap on the head of the adapter, from where a pump presses it back into the steam chamber of the boiler.

It is important that not too much condensed water should collect at the bottom of the liner tube for the following reasons:

- If the input steam must bubble through the condensed water, it will cool down and it is necessary to wait for hours until the completion of hardening
- An automatic valve may be built into the pipe of the returning condensed water, which will close when steam appears, and open when water appears. Its use provides a high degree of safety.

Hardening of large-sized tubes

Approximately 10 kW energy is sufficient for the hardening of small-sized tubes (diameter maximum 150 mm, length maximum 12 m). Electric steam generators (3 x 3.5 kW) meet that purpose. For larger sizes, only gas-heated devices may be applied (20-25 kW).

For very large sizes (diameter 400-500 mm, length 30-35 m), two or more steam generators, bound parallel, are needed. One gas unit is 22 kW, for large sizes as much as 30-60 kW

energy may be required. The large-sized lower adapter head is formulated in a way that steam can be conducted into it from three steam generators separately. A conical throttle can be placed on the thread at the end of one of the input tube to increase the flow rate of the steam. For experience has demonstrated that the steam is reluctant to flow into the upper regions and there it condensates on the internal tube wall in a few seconds. However, it is "shot out" above from below at a high rate, it has no time left for condensation and it is at the highest point in no time.

Steam generating devices

Electric and gas-heated devices have been developed for Furanflex technology which meet all the technological requirements as well as the West-European (and domestic) prescriptions. The requirements to be met by steam generators:

- Permit of the authorities (dangerous operations!)
- Qualified manufacturer
- One unit not heavier than 60 kg
- Can be enlarged with units of 10-80 kW
- Providing pressure in three steps
- Automatic operation
- Low maintenance requirement
- Simple structure

The devices supplied by Kompozitor Ltd meet those requirements. More that 100 of them have been operated in West-European countries for a long time.

The types of steam generators are the following:

Unit heated with electricity	3 x 3.5 kW (3 x 16A)	Type “E”
Unit heated with gas	20-22 kW	Type “G”

(This unit cannot work alone; it must be coupled to the electric unit. In this case the electric unit makes the control of water level and supply, pressure level etc. It is possible to connect more than one “G” unit to the “E” unit)

Command unit	Type “V”

(Similar to the “E” unit, but without electric heating device)

One electric unit (10kW) and two gas unit (2x20 kW)	Type “E2G”
One command unit and one gas unit (20kW)	Type“ VG”

There were some cases, when 3 “G” units were coupled to the “V” unit
The needed gas bottle is 19-22 kg PB (propane-butane)

16. Fittings of the FuranFlex liner tube

The fittings used for the Furanflex liner tube are similar to, or identical with, those used for traditional chimney systems. The following elements are necessary:

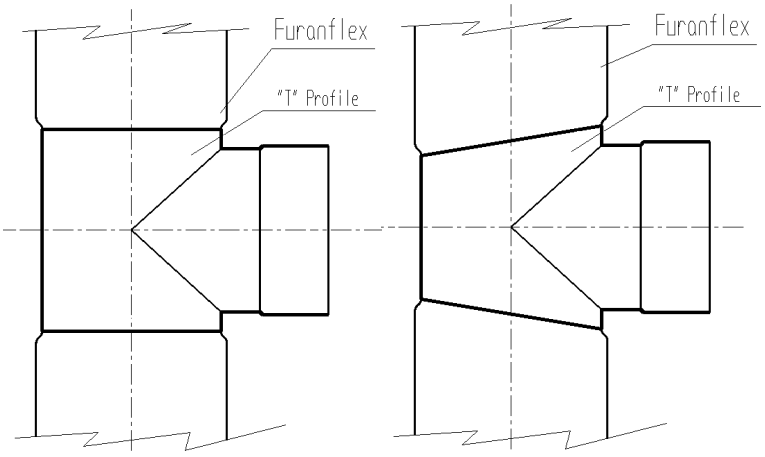
"T" profile

It is similar to the traditional "T" profile. The diameter and length of its horizontal input pipe meet the standard dimensions.

The vertical section of its pipe is different from the usual one in the following:

- It has no sleeves since Furanflex is not extended but simply pulled through the profiles
- Its vertical pipe section is short, at the top and at the bottom it is only a few centimeters longer than the diameter of the pipe

Such "T" profiles are to be manufactures separately for Furanflex technology. When inflated, Furanflex is pressed against the internal wall of the "T"profile, while its diameter is increased a bit at the place where it leaves the profile. Consequently, it cannot be moved along the solid Furanflex tube.

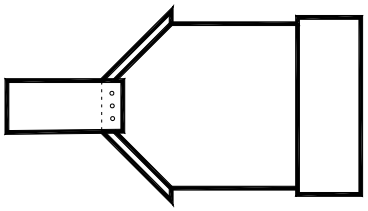


Strapped Connector

It is similar to the "T" profile. The diameter and length of its horizontal input pipe meet the standard dimensions.

In the vertical section of the connector we can find only the strapping. When inflated, Furanflex is pressed against the strapping of the connector, while its diameter is increased a bit at the place where it leaves the profile. This connector has several advantages:

- Lightweight and small, easy to work with it.
- Spare material on the connector (less price)



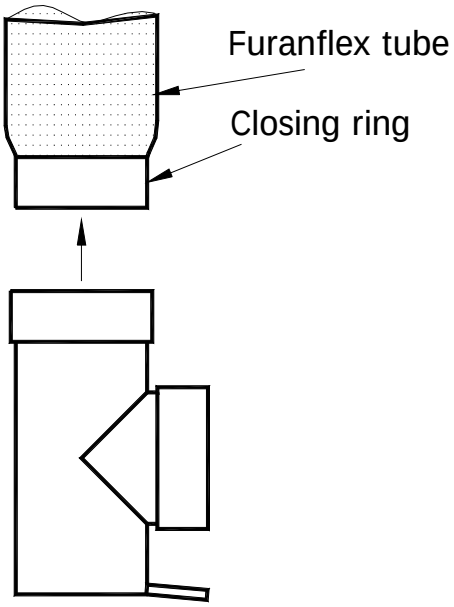
Strapped Connector

Closing ring of the liner tube

It is an element not used for traditional technologies. It is to be placed at the bottom part of the Furanflex tube prior to inflation. Its task is to ensure a precise external diameter at the bottom of the liner tube to which the cleaning-condensate vessel can be joined with a sleeve.

The part of the hardened Furanflex sticking out of the wall is cut off at the lower edge of the ring. During inflation the liner tube "swells" into the ring, which is solidly fixed at the point where it was placed.

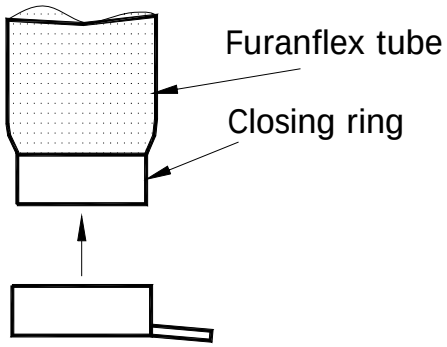
The external diameter of the ring closing the tube fits the fitting it is joined to; its height is 8-10 cm.



Condensate &
Cleaning Profile

Cleaning device

All the licensed cleaning device can be used for the Furanflex liner tubes. Kompozitor manufactures a simplified condensate-cleaning profile, which can be pushed up to the bottom of the liner tube like the top of a cylindrical metal box. It meets the technical requirements perfectly.



Simplified condensate
& cleaning device

The structural material of the fittings

It would be ideal to manufacture all the fittings from Furanflex material. The experience gained in Hungary and abroad in this respect in several years is the following.

- It has not yet been possible to manufacture the above profiles from composite materials in an economical and competitive manner
- Within the Furanfix programme, Kompozitor is working on a technology of that nature but serial production has not yet started
- Furanflex users abroad similarly use stainless steel fittings
- In large sizes (diameter 400-500 mm) profiles made of composite materials would be significantly more expensive than stainless steel

From the point of corrosion, the above situation may be characterized as follows:

- In the case of "T" fitting, only the horizontal, more heated branch meets directly the flue gas, here no acidic condensate is generated
- This is the hottest point along the path of the flue gas
- The vertical part of the “T” piece the tube is not exposed to corrosion influence
- The cleaning-condensate vessel is easy to change

17. Some static about FuranFlex

What is it that actually holds the Furanflex liner tube in the chimney? Why does it not slide down?

To answer that question, we requested the expert opinion of the French institute of qualification CSTB. Granting the French permit for application was preceded by extremely strict tests and sight visits.

The certificate for install the Furanflex was issued by CSTB in two steps.

The first permission was issued for the method of application in which Furanflex comes in contact with the wall of the chimney to be lined. That is what they call lining (chemisage). Here the supposition is that the hardened Furanflex leans against the wall, brushes against it, bows a bit and expands in it. In a word, it does not collapse.

The second permission was preceded by further tests. This certificate refers to the method of application where Furanflex stands in a tall chimney without an external support, without a structure of suspension, as a lonely tube. In this case the bottom of the liner tube is loaded by the weight of the complete length of the tube.

This form of lining of the chimney is called tubage.

The bottom of plate-like structures loaded vertically leans out, staggers, and loses its mechanical stability under the high force of its own weight. The experts of CSTB intended to determine with experiments how tall the Furanflex tube can be which, in case it is standing on its bottom, its lower edge will not get dented, collapsed.

Diameter of Furanflex (mm)	Theoretical height (m)	Permitted height (m)
140	858	286
160	2475	825
275	897	299
340	606	202

Remarks:

- It can be seen that the French applied a 3-fold safety factor for the permitted length of Furanflex.
- For safety reasons, they prescribed that in case the distance of the internal wall of the chimney from the external surface of Furanflex standing on its "own foot" reaches 50-60 cm on either side, a simple propping structure is to be incorporated every 20 meters in order to hinder excessive bending out.

18. Emergencies

In the following we shall describe a few emergencies, which did not occur frequently in the history of Furanflex.

Gas shortage, heat generator broke down

Valves are to be closed. Pressure in the Furanflex tube is to be maintained at any cost by compressor, Fast Blower, even not letting the liner tube harden in a flat, deformed state in the chimney

Electricity shortage

Valves are to be closed. Foot pump for inflating airbeds is to be secured for maintaining internal pressure. Maybe compressor with battery is to be applied. It is important that the tube should not be deformed before electricity is available.

Breakage of inside foil tube

Foil tube is to be changed. If it is not possible to insert a new foil tube (for lack of appropriate adapter kit, reserve foil or expertise), then the damaged liner tube is to be pulled out. In case the foil tube breaks, guarantee for the product is only granted if Kompozitor Ltd supplied the used closing adapter heads.

Breakage of external textile coating

The liner tube is to be pulled out of the chimney immediately. To assist that, the sucking side of the fast blower is to be joined and the tube is to be flattened. The other possibility is that one or even two new foil tubes are to be inserted and hardening occurs very slowly, at a very low pressure below 0.1 bars.

Furanflex hardened in a state of deformation

Furanflex hardened in a twisted, flattened form is a serious problem. In this case, it is better to get the liner tube out of the chimney, which is almost hopeless without opening the chimney.
If strong alkaline solution is used to spread on the tube, Furanflex will soften in a day or two when it is easier to scrape it out. However, that is a dangerous operation.

A solution is the chained, hydro-engine high speed rotating motor used for beating cleaning of chimneys of bricks, concrete. Thege Bau- Kompozitor developed a machine like this for the renovation of collecting chimneys. It breaks the liner tube into pieces. The problem is with the declinations since the machine is unable to penetrate into some of them.

19. Fire, -Health, -Environment protection

Fire protection

Furanflex soft tube is a material classified "D" from the point of view of fire danger, i.e. it is moderately dangerous. In its soft state it contains water. During hardening no compounds causing fire or explosion are generated. When the material solidifies, further water molecules are generated. The majority of the water content of the material evaporates at the temperature of hardening.

The internal foil tube in the Furanflex tube is a material easy to burn but as a result of its low mass as well as its completely closed position, it represents no danger of fire.

The gas-operated steam generator used for the hardening of Furanflex may be a source of fire danger (and that of accidents). Kompozitor Ltd. only markets gas-operated steam generating appliances, which possess the necessary, permits of the authorities that are accepted in West-European countries too. The danger of fire is enhanced by the fact that the steam generators are frequently set up in cellars of low volume. It is necessary to take care of proper ventilation and the conducting away of the flue gas of the steam generator.

The used cleaning material. Flammable materials (acetone, benzine, alcohol) must not be used for cleaning hands, tools, and machines.

For cleaning, lukewarm water with detergent of high concentration (approximately 5%) is appropriate.

Health protection

The basic material of Furanflex contains, among other things, phenol and furan resins as well as formaldehyde. Substances appropriate for the binding of dangerous components are applied in the manufacturing technology of Furanflex. In the state of transportation of the liner tube, the majority of the free molecules of the above compounds are already in a bonded state. A mild, characteristic smell can be felt in the course of the lining technology but the concentration of the substances getting into the air (in accordance with the measurements of the professional company) is smaller by orders of magnitude (approximately ten times) than the permitted MAK value. (See the data sheet enclosed) (The MAK value is the permitted concentration of a given dangerous substance in the air (mg/m^3)

In the course of installation, the matrix of the Furanflex plastics is soft at the beginning, becoming even more dilute under the first influence of heat. When it gets in contact with a hand, it leaves a mark on its surface. It is to be washed off with water with detergent or soap in it as soon as possible and then the hand is to be spread with protective cream. In the case of individuals with sensitive skin, it may cause symptoms of itching or skin rashes. That is why it is necessary to use protective cream and gloves where possible. The best type of hand crème, which is most highly recommended, is the FÁMA hand cream made from marigold for labour safety purposes. Manufacturer: FÁMA Medical Cosmetics and Chemical Ltd., 1031 Budapest, Vizimolnár u. 6.

If the resin gets into someone's eyes, it is necessary to flush the eyes with clean, lukewarm water for about 15 minutes and then consult a doctor.

The rules related to fabrication in the metal industry are to be adhered to when cutting, drilling, grinding the finished, hard liner tube.
It is necessary to use protective glasses and gloves.

The electric appliances, both the instruments and the points of electricity supply must be available in good condition, in accordance with the standards.

The steam used by hardening has a temperature of 100-110^{o}C ,which can cause serious injuries. Only qualified, perfectly safe steam generators, damage-free tubes may be used. It is of basic importance that the steam generator should be equipped with a multi-step pressure setting system. The pressures determined in the technology must not be exceeded.

Environment protection

The cut off pieces of Furanflex are qualified as "dangerous" material from the point of view of environment protection. Here "dangerous" does not mean that it is poisonous or explosive but that it does not degrade by itself within a short period of time.
Household wastes contain a great deal of such "dangerous" material, which is failed to be notice by the "green" only. People with good feelings are instinctively protectors of their environment. In our case, the following has to be done:

- If communal wastes (rubbish) are simply taken to the incinerator, these wastes may be taken there together with the rest as well
- The "dangerous" wastes collected must be transported to a company specializing in wastes disposal, e.g.

ONYX Ltd.
2510 Dorog, Bécsi út 04/6
Hungary

- Kompozitor Ltd. takes back wastes of Furanflex at the time and in the quantity agreed upon beforehand. It has those wastes, together with its own wastes, transported to the wastes disposal sight, without any extra costs.
- The internal foil tube may be burnt like paraffin. (See Description)

20. Supplements

A substance with no danger of explosion

1. Furanflex is a substance with no danger of explosion. It contains free water molecules and in the course of the process of polymerisation new water molecules are generated. Furanflex and the resin substance in it can also be stored and transported like e.g. wood products belonging to class "D".

2. Phenol and furan molecules are present in Furanflex in a chemically bonded state.

3. Furan in itself is not a dangerous substance. Some furan compounds have chloral atoms, which belong to the compounds dangerous to the environment. But this is not our case.

4. The material of Furanflex was tested by the German "Institute für Ökologische Chemie" with the following results:

Test temperature	Test results
100°C	No dangerous volatile substances
300°C	No dangerous volatile substances
600°C	23 different organic substances, none of them cancerous. Their quantity is a microgram (10) in a gramm of the substance.
1000°C	Nine polycyclyc compounds are born which are cancerous. However, irrespective of their quantity being negligible, in reality these compounds burn immediately at this temperature. During the gas chromatography test applied the oxygen is excluded from the test device. In the case of chimney fire, there is oxygen present because there is no burning without oxygen.

Furanflex and lightning

In respect to lightning, the following remarks can be made:

The components of Furanflex

Component	Properties
Reinforcing material	Glass textile (boron silicate E glass fibers developed because of their electrical insulation properties)
Matrix (impregnating) material	A mixture of thermosetting polymer resins. (In the electricity industry they are used for insulation)
Additives	Non-metallic minerals (like marble powder)
External textile	Fine liner textile from polyester fibers

Electric properties of Furanflex compared to other materials:

Material	Dielectric constant (ε)
Porcelain	5-6,5
Glass	3,5-4,5
Thermosetting resin	3,5-4,5
Thermoplastic fibers	2,2-2,7
Marble	8,4-14
Vacuum	1

The components of Furanflex are dielectrics, electric insulation materials.

The specific resistance of the components of Furanflex compared to other materials (Ohm.m)

Copper	0,000.000.017	Ohm.m	($0{,}0017.\ 10^{-6}$)
Steel	0,000.000.15	Ohm.m	($0{,}15.\ 10^{-6}$)
Wood (dry)	10.000.000.000,0	Ohm.m	(10^{9}-10^{13})
Porcelain	100.000.000.000,0	Ohm.m	(10^{10}-10^{11})
Glass	100.000.000.000,0	Ohm.m	(10^{11}-10^{12})
Resin	1.000.000.000.000,0	Ohm.m	(10^{12})

High electric resistance means good insulation properties. The elements constituting Furanflex are good electric insulators.

Lightning strikes objects, which are the tallest and have the best conductivity. Furanflex as a chimney liner tube represents no source of danger from this point of view.

3 mm thick panels are made from Furanflex material. They are used in electric switchboards. The measured dielectric puncture safety is 3.5 kV.

21. Application of Furanflex for ventilation pipes

The Furanflex chimney liner tube can be used for repairing ventilation pipes up to 200oC. In such cases the alkaline value of the condensate generated or the chemicals used for cleaning may not exceed pH 12. The same holds true for air-conditioning pipes as well. Close to 50 % of the Furanflex tubes have been used for the repair of ventilation pipes in Stockholm.
Its permit No. 235 of SWEDCERT Quality Control Institute certifies incorporation in ventilation pipes.
Independent institutes (in Denmark and Germany) have certified that Furanflex emits no dangerous by-products between 20-600^{o}C.
In the case of repair of ventilation pipes with Furanflex, we grant a guarantee of 25 years as well.

22. Cleaning of the Furanflex chimney liner tube

General considerations

The Furanflex chimney liner tube can be used for gas- and oil-heated boilers where the peak temperature of the flue gas may not exceed the value of 250°C. Furthermore, the Furanflex material is used for ventilation pipes as well as vertical pipes conducting rainwater.

- In the case of gas heating, the chimney pipes do not get contaminated.
- In the case of oil heating, a thin layer of soot may be deposited on the internal wall of the liner tube.
- A layer of grease may be deposited on the surface in case of ventilation pipes and exhaustion pipes in kitchens.
- In the case of technological ventilation, depositions of unknown origin may occur.
- In the case of pipes conducting water, scale generation may occur.

The cleaning method of Furanflex depends on the materials to be cleaned and the resistance of Furanflex.

Mechanical cleaning

The Furanflex liner tube may be cleaned with a brush with natural or plastics bristles and textiles. Brushes with metal bristles may not be used.

Burning out

The Furanflex liner tube may not be burnt out.

Cleaning with chemicals

- It may be cleaned with acidic chemicals without any limitations.
- Alkaline chemicals may be used for cleaning up to a maximum concentration of pH 12 only. Following cleaning, the alkaline material left on the surface is to be eliminated. Substances applied, e.g. for degreasing household ovens may not be used in a concentrated form. Strong alkaline solutions soften the material of Furanflex.
- Of solvents, acetone, benzine, alcohol may in theory be used, however, their application is to be avoided for danger of fire and explosion.
- Furanflex may not be cleaned with materials containing abrading granulose materials.

23. Furanflex geometry

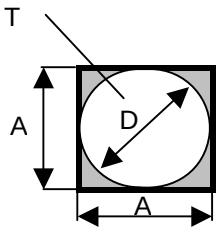
In the following we are going to examine the geometric position of Furanflex in rectangular chimneys with varying diameters. For it is the advantage of Furanflex that it may adopt different forms in addition to circular segments.

1. FuranFlex with circular cross-section in rectangular chimney

Furanflex may be inserted into a square or rectangular chimney by adopting a cylindrical form during inflation; thereby its cross-section will be circular. In this case, the diameter of Furanflex will always be identical with the smaller size of the chimney opening.

Square chimney

In chimneys with a square opening, Furanflex with a circular cross-section will touch all the four sides of the chimney but will not be deformed. The cross-sections will be the following:



Cross-section of square opening $A \cdot A = A^2$

Cross-section of circular segment $T = \frac{D^2 \pi}{4}$

D= Cross-section of Furanflex inflated freely

T= Cross-section of Furanflex with circular segment

Q= Cross-section of Furanflex with no circular segment

(By cross-section we mean area in cm2)

If the necessary Furanflex cross-section is known, the diameter of FuranFlex is easy to determine.

$D = \frac{4 \cdot T}{\pi} = 0{,}785 \cdot T$

$\frac{4}{\pi} = 0{,}785$

In theory, therefore, the area of the circular cross-section placed into the opening of the square fittingly is 78.5% of that of the square, irrespective of the sizes. For more precise calculations, the internal diameter of Furanflex is to be taken into account as "D", which is approximately 3 mm smaller because of the wall thickness in the case of all sizes.

A numerical example:

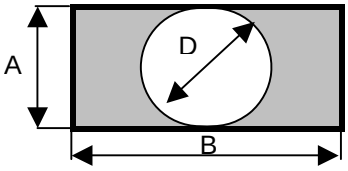
Chimney opening	140mm x 140mm
Cross-section	196 cm^2
Furanflex external diameter	140 mm
Furanflex internal diameter	137 mm
Cross-section	147 cm^2

Obviously, it cannot be followed by practice because:

- Furanflex expands a few mm when inflated
- The size of the chimney opening is not precise
- There is an established line of Furanflex sizes which is recommended to adhere to

Rectangular chimney

In the case of rectangular chimneys, Furanflex with a circular diameter only comes in contact with the two longer sides of the chimney. In this case, the cross-section proportions are determined as follows:



Cross-section of rectangular chimney: $A \cdot B$

The percentage proportion of the cross-section of circular Furanflex compared to the rectangular chimney in %:

$$\frac{D^2 \cdot \pi}{4} \cdot \frac{100}{A \cdot B}$$

Numerical example:

Chimney size: $A \cdot B = 20 \cdot 14cm = 280cm^2$

Furanflex diameter: D = 14 cm

Cross-section proportion: $196 \cdot 0{,}785 \cdot 100 / 280 = 54{,}95\%$

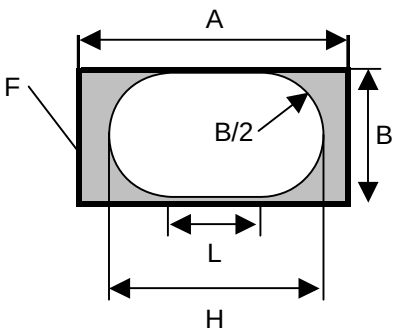
So in this case the cross-section of the circular Furanflex is only 55% of the lined rectangular chimney. That is why, in the majority of cases, chimneys with rectangular cross-section cannot be lined with rigid tubes of circular segment with the proper diameter.

It is in this connection that the journal of Gas de France (French Gas Supply Company) wrote in its article on Furanflex the following:

"It is impossible to insert a liner tube with a diameter of 250 mm into an existing chimney of 400 x 200 mm". Therefore, if there is a new boiler whose flue gas pipe has a diameter of 250 mm, in vain do we have a chimney with a much larger section, it can only be lined with Furanflex.

2. Furanflex in the shape of horseracing field

In rectangular chimneys, Furanflex may be placed so that it comes in contact with the two longer wall surfaces only at a given length, not touching the shorter wall, or at one point only.
In the case of rectangular chimneys, the question always is what the diameter of FuranFlex to be inserted into the chimney to achieve a given cross-section, should be.
To determine that, first it is necessary to compute the perimeter of Furanflex to be inserted into the chimney.



The perimeter of Furanflex following inflation
$C = 2 \cdot L + B \cdot \pi$ Where

C= the perimeter of Furanflex

L= the length of Furanflex coming in contact with, and leaning against, the wall of the chimney
B= the size of the shorter side of the chimney

Q= the cross-section of Furanflex following inflation: $Q = \frac{B^2 \cdot \pi}{4} + L \cdot B$

The diameter of the Furanflex tube to be inserted, if we know the necessary cross-section, can be determined from the perimeter of the shape of Furanflex formulated in the chimney. In order to define the perimeter, it is necessary to know the length of contact. It can be concluded from the above equation if we know the necessary cross-section of Furanflex to be inserted.

$$L = \frac{4 \cdot Q - B^2 \cdot \pi}{4 \cdot B}$$

From the data known already, first the perimeter of Furanflex of non-circular shape must be determined that, of course, is identical with the perimeter of Furanflex to be inserted. (The perimeter of a flexible tube, unable to elongate, is always identical, no matter what shape it is moulded into. Circular shape constitutes the biggest cross-section in the case of a given perimeter, the area of any other shape can only be smaller than that).

The perimeter of Furanflex shaped like a horseracing field

$$C = 2 \cdot L + B \cdot \pi$$

The diameter of Furanflex of circular cross-section belonging to this perimeter

$$D = \frac{C}{\pi}$$

Numerical example

We have a rectangular chimney with the following dimensions:

A = 400mm B = 200mm

A Furanflex tube with a cross-section of Q=500 cm^2 is to be inserted into it. It is to be determined what "shape of a horse-racing field" this tube will adopt, what its length will be, whether it can be inserted into the opening of the chimney.

At first the length of contact L is to be determined (everything is calculated in cm)

$$L = \frac{4 \cdot 500 - [400 \cdot 3{,}14]}{4 \cdot 20} = \frac{744}{80} = 9{,}3cm$$

The radii of the two semicircle arches are to be added to the length of contact

H= the complete length of Furanflex

H = 9,3 + 10 + 10 = 29,3 cm

Thus Furanflex with the desired cross-section can be inserted into the opening of the chimney whose length size is 40 cm. Let us check the calculation. To do so, we shall use the equation relating to Q.

$$Q = 500 = 400 \cdot \frac{3{,}14}{4} + 9{,}3 \cdot 20 = 314 + 186 = 500cm^2$$

So we can see that the calculation was precise

In the next step, the perimeter of Furanflex to be inserted into the chimney is to be determined

$$C = 2 \cdot 9{,}3 + 20 \cdot 3{,}14 = 81{,}4cm$$

The perimeter of the Furanflex liner tube must be the same, thus its diameter

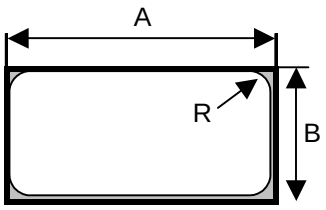
$D = \frac{81{,}4}{3{,}14} = 25{,}92cm$ I.e. a Furanflex tube of 260mm is needed

3. Furanflex in a "rectangular " shape

If we want to approach the cross-section of a rectangular chimney opening as much as possible, Furanflex is to be laid against all the four walls of the chimney. That is impossible only in the corners where a proper arch (rounding, radius) is to be given to the material of Furanflex. The radius of that arch is minimum R=50mm. In the case of smaller sizes (e.g.

140x140mm) it may be 40mm. With this formation it may be achieved that the largest possible Furanflex cross-section should be inserted into a rectangular chimney.

To do so, first it is necessary to calculate the perimeter of Furanflex in a rectangular chimney and then the diameter of the Furanflex tube starting from it.



The perimeter of Furanflex:

$$C = 2 \cdot R \cdot \pi + 2 \cdot (A - 2R) + 2 \cdot (B - 2R)$$

Numerical example:

A= 400mm B= 200mm R= 50mm

$$C = 2 \cdot 5 \cdot 3{,}14 + 2 \cdot (40 - 10) + 2 \cdot (20 - 10) = 111{,}4cm$$

The perimeter of the rectangular chimney is a bit bigger than that (120cm)

The diameter of the Furanflex to be inserted

$$D = \frac{C}{\pi} = \frac{111{,}4}{3{,}14} = 35{,}47cm$$ I.e. 350mm

The cross-section of the rectangular chimney is $A \cdot B = 800cm^2$

The cross-section of the inserted Furanflex can be determined as follows. The areas "excluded" by the roundings are to be deducted from the original cross-section.

q=area outside the roundings at one corner

To calculate that, first the area of the quarter circle under R is to be determined

Area under the rounded arch $\frac{R^2 \cdot \pi}{4}$

(Area of the complete circle with radius R $4 \cdot \frac{R^2 \cdot \pi}{4}$

This area is to be deducted from the area of the rectangle formulated by radius R

$$q = R^2 - \frac{R^2 \cdot \pi}{4} = R^2 \cdot \left[1 - \frac{\pi}{4}\right] = R^2 (1 - 0{,}785) = 0{,}215 \cdot R^2$$

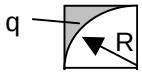
Thus the area outside the rounding is 21.5 % of the quadrate of the radius of the rounding

Numerical example:

With a rounding of R=5cm, the total cross-section to be excluded at the four corners of the rectangular chimney is

$$4 \cdot q = 4 \cdot 0{,}215 \cdot 5^2 = 21{,}5cm^2$$

Thus the cross-section of Furanflex of the largest size that may be inserted into a chimney with a cross-section of 800cm^2 is 788.5cm^2 in opposition to the original 800cm^2.



In summary, the following can be said about the "rectangular"-shaped Furanflex:

- A maximum Furanflex cross-section can be achieved in a rectangular chimney if the perimeter of Furanflex is in contact with all the four walls except the rounding with a 5cm radius at the corners
- In this case, the cross-section of Furanflex will be smaller than that of the rectangular chimney by 21.5 cm
- This "reduction" in cross-section is identical in all sizes, only depending on the radius of the rounding

General remarks

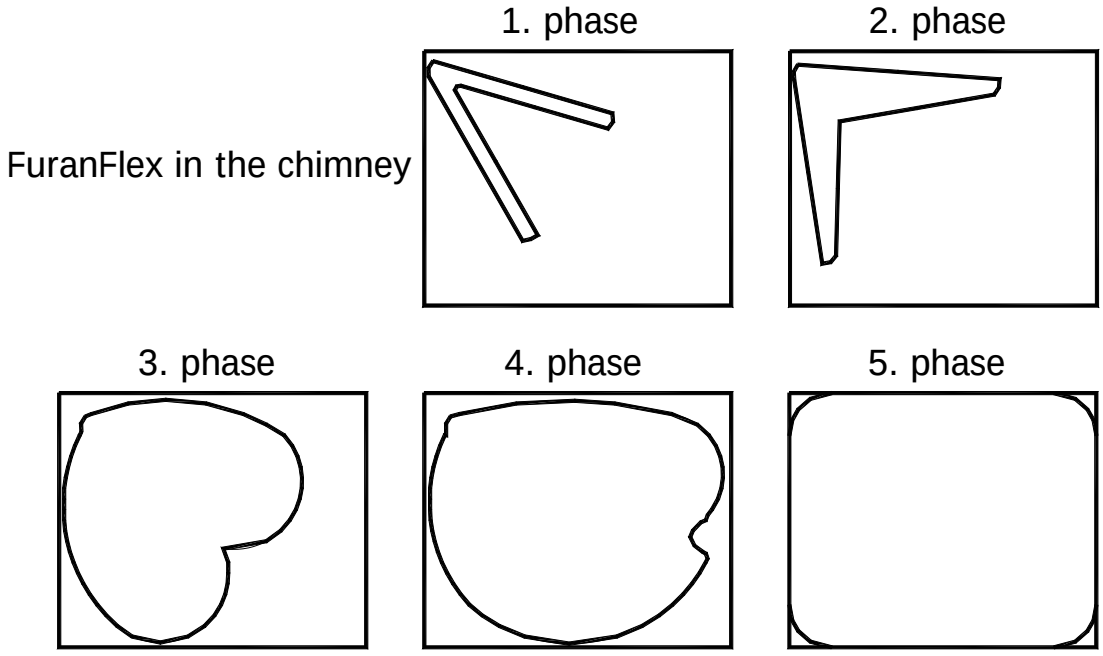
The above calculations are "school examples". In practical applications a few other factors are to be taken into account:

- An increase in the Furanflex diameter as a result of inflation
- The wall thickness of Furanflex
- Compared to the calculated perimeter or diameter, a somewhat smaller Furanflex size is necessary. In an opposite case, the material will "wrinkle".

Furanflex shapes in the cross section while blowing up

See phases indicated on the sketch below how FuranFlex can shapes in the rectangular cross section while blowing up:

- 1. Phase: Furanflex in the form of being introduced in the chimney (Please notice to pull the tube in the corner to have enough room for inflation.)
- 2. Phase: Furanflex is opens as it is blown up.
- 3. Phase: Furanflex starts to fill out the cross section while first touched the chimney wall at several points.
- 4-5. Phase: The Furanflex tube fills out the whole cross section without wrinkles. (To see the inner surface use a camera while blowing up with air to see how the tube is situated in the sensitive areas of the chimney.



24. Lining of rain pipes

Furanflex technology can be applied for lining vertical rain pipes and there have been several successful applications already.
Before discussing the details, it is necessary to explain the word "vertical" a bit more extensively.

Rain water, the sewage water flowing in the canals contain a diversity of substances, in the case of sewage water acids, alkaline solutions and in all cases solid particles, e.g. sand. Furanflex resists all the chemicals to be found in sewage water but solid, hard, even powderous particles cause damage to it.

The hard, solid powderous particles do not float in the flowing liquid but deposit and "slide" together with the water at the bottom of the canal. That represents a continuous abrasive effect.

It is well known that to the wear effect of hard particles resist or a harder surface, e.g. diamond or soft, or flexible surfaces like rubber, thermoplastic plastics, PVC, polyethylene. Furanflex does not belong to either of the above categories, i.e. it is not too hard and not too soft.

Thermosetting, so-called cross-linking resins do not resist the impacts of wear. (It is an exception if the resin contains special and expensive additives.) It means that the resin layer of a thickness of a few tenth of a millimeter on the surface of the glass fibers is worn off and only bare glass fibers can be seen on the surface. It is known that glass fibers are not completely resistant to corrosion and such a "canal pipe" that has been worn off may become completely damaged in 5-10 years. It is independent from the type of the resin, e.g. polyester, epoxy, etc.

It follows from all that that there is no such danger in the case of vertical pipes thus here Furanflex lining can be applied. However, a few important considerations have to be taken into account.

- The curve at the bottom of the vertical pipe turning into horizontal cannot be made from Furanflex either.
- It is recommended to build a section of 400-600 mm above the curve from some other material in order to fend off the wear effect of the water drops, containing particles, that might be splashed up
- The materials to be used for the above purpose may be plastic pipe profiles available on the market
- Attention is to be paid to the statical arrangement and heat expansion of the Furanflex liner tube

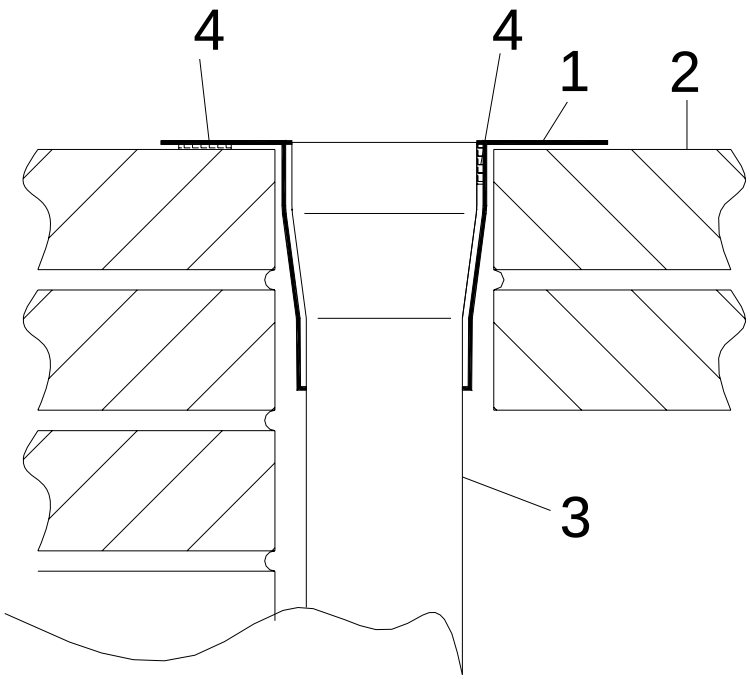
The latter point is to be discussed in greater detail. The Furanflex liner tube may be placed in the vertical rain pipe in two ways.

In one case, a Furanflex tube of such a size is to be applied which is pressed against the wall of the rain pipe following inflation. That means sufficient mechanical fixation, it will not

move either as a result of its own mass or under the influence of heat expansion. We recommend the choice of this solution.

There may be cases where, for some reason, a Furanflex tube with a markedly smaller diameter is to be inserted into an existing canal pipe. In such cases, the hardened Furanflex needs to be "caught" somewhere. And that task is not so easy at all.

At the upper point of the pipe Furanflex can be fixed in accordance with the figure attached. A stainless steel holding sheath, widening upwards, having a rim is to be placed at the upper point of the rain pipe. (1) Its rim lies on the roof (2). Siloplast sealer is to be placed beneath the rim and along the internal perimeter of the holding sheath (4). Following that, we insert the Furanflex tube (3), being mindful of the sealing. It is recommended to place another structure element on the upper input opening in order to slow down the flow of the rainwater falling down.



For experience has demonstrated that in the case of very heavy rainfalls the mass of water hit the curve conducting away the water with such a force that the curve was pushed off the Furanflex tube.
In the case of rain pipes, the vertical movement of the Furanflex tube is minimal. Its heat expansion co-efficient is close to that of aluminium. That means that a pipe of 1 meter expands approximately 2.5 mm at a temperature rise of 100^{o}C. In our case, however, we cannot talk about heat expansion of that dimension. Summer heat and winter cold cause heat expansion to the structure of buildings as well which partially compensates the expansion of Furanflex. In the case of rain pipes, a shift of 0.2-0.3 mm per meter may be reckoned with in Furanflex tubes.

25. Insertion Furanflex in cold weather

There are times when chimneys have to be lined in cold weather as well. Temperature below 15°C is considered cold weather.
But Furanflex, cooled beneath the above temperature in the cellar or cold storage room is considered cold too. In such cases the Furanflex liner tube is to be handled with enhanced care.

The resin constituting Furanflex becomes increasingly inflexible, rigid with a decrease in temperature. Heating up may reverse that process. Resin in a cold state, if bent, deformed, is able to break the glass fibers in it and the fibers of the external textile fabric. In a similar manner as e.g. a straw frozen in an ice cube breaks together with the ice.

The strongly bent parts of the Furanflex liner tube are especially sensitive, as demonstrated in the figure below:

Therefore it is a dangerous operation when the tube folded up is torn open with high force on the spot. In this case, when the bending is "straightened out" significant forces are generated in the curve of a small radius, able to tear the external textile fabric.
Breaks in a cross direction have also occurred, though less frequently.

Similarly critical is the first period of inflation when the flat tube folded in half wants to adopt a circular cross-section. In such cases, the longitudinal folding open up and may cause longitudinal breaks in the external textile.

The right technology is the following. Prior to installation, the Furanflex liner tube is to be stored in a room of 20-22°C for 1-2 days. By covering it up, it may be hindered from cooling down on the spot again.

TECHNIMO, the French representative of Furanflex has elaborated an incubator-type instrument. It consists of a simple plate with heating cables placed on its lower surface. The package of Furanflex is placed on that tray and then a coating covers it. The heating cable is attached to a 220 V source of electricity and the material is warmed up to approximately 25°C prior to insertion.

It is very important that the cold Furanflex must not be inflated with cold air and fast. It can be avoided with different methods. One method is to blow a little steam and a little air alternately into the liner tube. The other method is to place the Fastblower in a way that it should suck in lukewarm air from the beginning.

Foil tube sizes

While inserting the Furanflex chimney liner tube, the internal foil tube may become damaged. It may originate from material defects or external impact. This phenomenon, occurring extremely rarely, may cause serious problems. The adapter heads closing the pipe supplied by Kompozitor Ltd. make it possible to insert an new foil tube into the liner tube built in already, in case of foil breakage. That operation can be carried out in 10 minutes.

It is necessary to have a reserve tube of the proper length and diameter on the spot whenever a Furanflex tube is inserted. The tube made of thermoplastic plastics is classified according to the diameter but the so-called spread out width. The spread out width is actually half of the perimeter. In the case of FuranFlex, however, the diameter of the internal foil tube is always a bit smaller than the diameter of the liner tube. Therefore in the above table the row of Furanflex liner tube diameters as well as the spread out width size of the internal foil tube belonging to them are presented. When ordering the reserve foil tubes, the spread out width data can be found in chapter 4.

The influence of sun radiation

Inside chimneys the radiation of the sun is not the characteristic meteorological situation. However, the tubes sticking out from the chimneys are constantly subjected to sun radiation. With few exceptions, all plastics are damaged by the rays of the sun to a smaller or greater extent.

In the case of Furanflex, this means that the surface of the tube in the open air, radiated by the sun, will "wear" a bit, becoming mat in 5-8 years. This damage of a depth of one thousandth of a millimeter is only an esthetical issue. The external surface of Furanflex is not homogeneous anyway, so this phenomenon may be neglected. But it will provide a more attractive and lasting appearance if the parts of Furanflex in the open air are painted with the suitable material.

For that purpose, Furansil paint may be recommended, marketed by Kompozitor Ltd. in black and silver colours. The paint, consisting of one component, needing no primary coating, being heat resistant up to 400^{o}C, provides perfect protection in the open air.

26. Furanflex according to the EN 1443 standard

This European Standard can be used as a basis for the specifications of chimney products. Furanflex is a single-wall chimney where the flue liner is the chimney. Though Furanflex is used for relining in practice which means a process of restoring or replacing the flue liner of a chimney.

In general the chimneys shall be mainly classified in accordance with the following performance characteristics:

- Temperature
- Pressure
- Condense resistance
- Corrosion resistance
- Soot fire resistance and distance to combustibles

For Furanflex the designation consist of the follows:

EN 1443– T250 H2 O W 3 R6 C50

Let us see the indicators:

- **EN 1443**: **Number of the corresponding standard**

- **T250**: **Temperature classes**
  Temperature classes are existing from T080-T600. The T250 means that Furanflex has a nominal working temperature, which is equals or lower than 250^{o}C.

- **H2**: **Gas tightness classes**
  This means that according to a standardised test the leakage rate in litres/seconds per square meters of flue surface area shall not exceed the values given in the following table (before and after exposure to heat).

Class	Leakage rate ($l*s^{-1}*m^{-2}$)	Test pressure (Pa)
N1	2,0	40 for negative pressure chimneys
N2	3,0	20 for negative pressure chimneys
P1	0,006	200 for positive pressure chimneys
P2	0,120	200 for positive pressure chimneys
H1	0,006	5000 for high positive pressure chimneys
H2	0,120	5000 for high positive pressure chimneys

According to the gas tightness test of CSTB France Furanflex has a leakage rate of 0,074 $l*s^{-1}*m^{-2}$under the test pressure of 5000 Pa. According to this H2 class can be accepted.

- **O**: **Soot fire resistance classes** (S or O)
  O for chimneys without soot fire resistance
  G for chimneys with soot fire resistance
  Furanflex is not resists to soot fire according to the standardised tests made in most European institutes e.g. Hungary, Italy, France etc.

- **W**: **Condensate resistance classes**
  W for chimneys operating under wet conditions
  D for chimneys operating under dry conditions
  Furanflex is can be operated under wet conditions.

- **3**: **Corrosion resistance classes**
  Corrosion resistance classes for chimneys, which convey products of combustion from various fuels, can be seen in the following tablet:

Corrosion resistance class	1 Possible fuel types	2 Possible fuel types	3 Possible fuel types
- Gas	Gas: sulphur-content ≤ 50 mg/m^3. Natural gas L + H	Gas Natural gas L + H	Gas Natural gas L + H
- Liquid	Kerosene: sulphur content ≤ 50 mg/m^3	Oil: sulphur-content ≤0,2 mass% Kerosene: sulphur content ≥ 50 mg/m^3	Oil: sulphur-content >0,2 mass% Kerosene: sulphur content ≥ 50 mg/m^3
- Wood	-	Wood in open fire places	Wood in open fire places Wood in closed stoves
- Coal	-	-	Coal
- Peat	-	-	Peat

  Under the temperature class of Furanflex it resists allow ft the possible flue types listed above in column 3.

- **R6:** **Thermal resistance**
  Thermal resistance is R = 0,06 m^{2}K/W. The R6 value is resulted from the multiplication of R by hundred. The value of R is derived from the thermal conductivity coefficient (l=0,4w/m, K) given by Kompozitor Ltd.

- **C50:** **Distance to combustible materials**
  The designation of distance of the outer surface of the chimney to combustible material is given in milimeters as: C = 50mm

27. Furanflex label

Furanflex chimney lining tube is delivered in a folded form packed in carton boxes. See picture below:

Each package is labelled with the following label to give you a visual guidance.

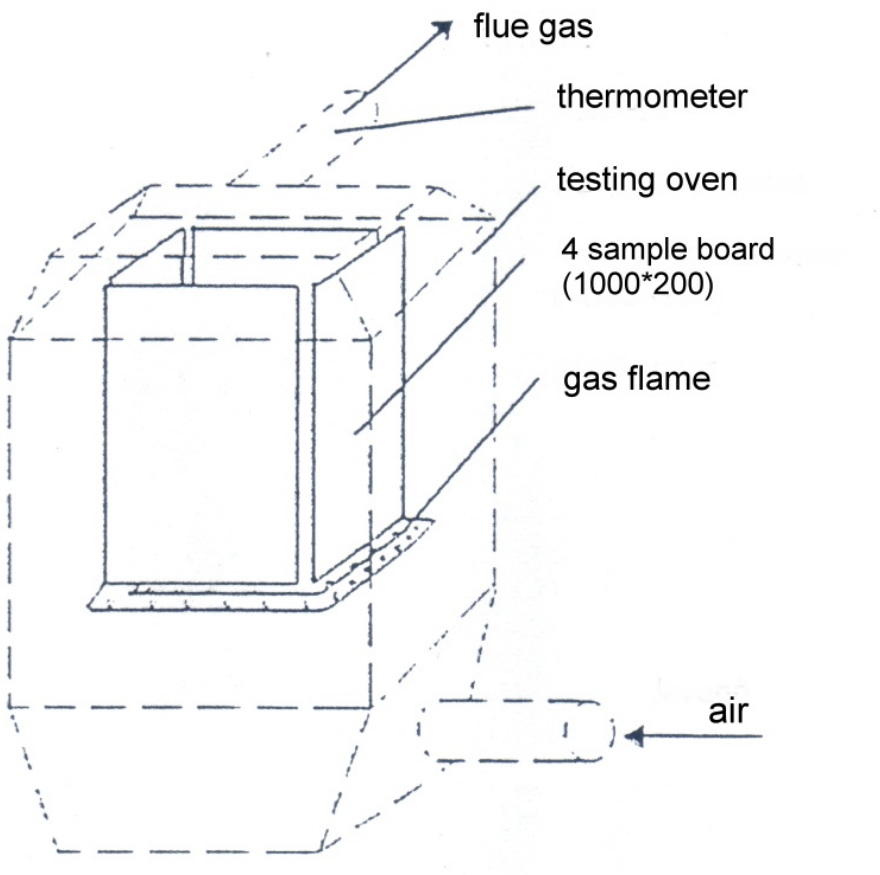
Skorstensfolket Sverige AB Box 22316 104 22 Stockholm Telefon +46(0)8 651 79 00 Fax +46(0)8 651 75 01		
FuranFlex		
Approvel	SWEDCERT, S, TG nr 0249	
Manufacturer	Kompozitor KFT H-1147 Budapest Gyarmat u. 71.	
Controller	CSTB, Frankrike	
Dimensions	Date of production	Production No
150	04.03.2004	xx

28. The inflammability properties of Furanflex

According to the Hungarian standard MSZ 14800-3 and the German standard DIN 4102, there are non-inflammable and inflammable materials.
Non-inflammable materials are inorganic materials, e.g. metals, rocks, bricks, concrete, etc.
Inflammable materials are organic materials, e.g. wood, plastics, plants, and living beings.
The two standards mentioned above classify the inflammable materials into three groups:

- Inflammable
- Moderately inflammable
- Hardly inflammable

According to the prescriptions of ÉMI (M-726-3), only hardly inflammable materials may be applied for chimneys. Therefore the tests in accordance with the above standard have been carried out.
The test is carried out on the appliance in the drawing as follows:



4 sample plates (1000x200mm) of the material to be tested are suspended (1) in a closed chamber (2). A gas burner is placed rectangular beneath the plates (3). Following the lightening of the burner, the temperature of the flue gas leaving the upper point of the chamber is measured continuously. (4) The higher the temperature of flue gas, the more the specimens burn. Following the elapse of the time stipulated in the standard, the appliance is cooled down and the specimens are lifted out.

The following aspects are examined:

- The weight loss of the specimens
- The surface damage of the specimens
- The independent time of burning following the turning off of the gas burner

The conditions of the category "hardly inflammable" and the results of the test of the material of Furanflex are presented below:

	Flue gas temperature	Damage of length %	Loss of mass %	Independent burning time
Permitted values	235°C	85	80	30 sec.
The values of Furanflex	98°C	33	3.5	0 sec.

In can be seen from the table that Furanflex demonstrates significantly better properties than requested by the Hungarian and the German standards in respect to the category "hardly inflammable".
Unfortunately, the standards have failed to follow the rate of development of plastics. An upper category is missing, e.g. "barely inflammable". The French system is better because it differentiates more steps. In it the material of Furanflex meets the requirements of category M1, called "non-ignitable".

29. List of Furanflex certificates

List of Furanflex certificates

Hungary

All certificates for Furanflex were given by:

ÉMI (ÉPÍTÉSÜGYI MINŐSÉGELENŐRZŐ INNOVÁCIÓS KHT)

NON-PROFIT COMPANY FOR QUALITY CONTROL AND INNOVATION IN BUILDING (Notified body in the EU committee under the No 1415)

1996	A-42	200°C	T-piece: Stainless steel		
1998	A-42/a	200/220°C	T-piece: Stainless steel or composite		
1999	M-214/ 1999	Test report:			
			350°C	5 hours	O.K
			500°C	6 hours	O.K
2001	A-225/2001	200/250°C			
2002	A-84/2001	Multikamin-Furanflex (Special type of chimney, existing only in east Europe)			

Austria

INSTITUT FÜR BRANDSCHUTZTECHNIK UND SICHERETFORSCHUNG

PRÜFERZEUGNIS
BV-Zahl: 4011/00 26.o7.2000

(FURANFLEX under the name of „ AHRENS-FLEX Reliner")

Czech Republic

TECHNICKY A ZKUSEBNI USTAV STAVEBENI PRAHA, s.p.

ZPRAVA c.03-13 109 Plzen 1.zari.2000

CERTIFIKÁT STAVEBENI TECHNICKÉ OSVEDCENI

CERTIFICAT c.03-13 111 Plzen 1.zari 2000

CERTIFICAT c.03-14379 Plzen 14.zari.2000

PROTOKOL c.03-13110 Plzen 14.zari.2000

France

CSTB	2000	Avis Technique	14/02-727	Chemisage
CSTB	2000	Avis Technique	14/02-727 *01 Add	Tubage

Lithuania

FIRE PREVETION AND RESCUING DEPARTEMENT AT THE MINISTRY OF INNER AFFAIRS OF THE REPULIC OF LITHUANIA

October 4, 2000 No. 9/4-1143

Norway

SINTEF Bygg og miljoteknikk
Norges branntekniske Laboratorium

PRODUKTDOKUMENTASJON: SINTEF 128-080

21. 08. 2000

Italy

INSTITUTO GIORDANO

RAPPORTO DI PROVA NM. 149006 13-06-2001

Switzerland

VEREINIGUNG KANTONALER FEUERSICHERUNGEN
Brandschutz-Zertificat No. 11262 Bern 12.04.2000

SCHWEIERISCHE BRANDSCHUTZ-ZULASSUNG
No. 11262 Bern, 12.04.2000

Sweden

SWEDCERT

TYPGODKANNANDEBEVIS 0235 20. 03. 2000. renewed (21. 05. 2002)

TYPGODKANNANDEBEVIS 0249 28. 03. 2000 renewed (21. 05. 2002)

Health and safety

DTC Dansk Toxicologi Center
- Evaluation of FuranFlex/Fix (27.Jul. 2001)

GSF Institut für Ökologische Chemie (Germany)
- Untersuchungsbericht Thermolyseprodukte von Furanflex (6.Juli.2001)

Control of the production

-IFU-CERT

Kompozitor Ltd has the following certificates:

- DIN EN 9001 (2000)
- DIN EN ISO 14001 (1996)

Yearly one audit and control by:

IFU_CERT Zertifizierungsgesellschaft für Managementsysteme mbH
Lange Laube 28, 30159 Hannover

-CSTB (Paris)

The expert of CSTB visit and controls two times yearly the production of Furanflex in site.

-QUALITY MANUAL OF ICOPREG AND FURANFFLEX

Kompozitor has this manual, which is controlled and modified yearly.