K A C H E L G R U N D Ö F E N

(CERAMIC STOVES)

A GUIDE FOR THE PRACTITIONER

by

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I N D E X

Introduction

The recent increased interest in Kachelöfen makes it desirable to Offer a review of the pertinent construction practices.

For the design and construction of Convection Kachelöfen, the applicable document is "Technischen Richtlinien fur Warmluftheizungen (TR Warmluftheizung)".

This guide addresses Kachelgrundöfen, in other words, solid-fueled, site-built storage-type stoves with hand built fireboxes that are constructed mainly of chamotte (firebricks) and Kacheln.

This guide is a compilation of extracts from "Reichsgrundsätzen für Kachelofen- und Kachelherdbau', Sept. 1942, and DIN 18 899 "Kachelgrundöfen - Begriffe, Bau, Gute und Leistung", Aug. 1955, supplemented with other relevant references.

This guide is not a textbook. but rather an illustration aimed at the professional stove-builder and the architect.

Calculations and Construction

Fig. 1 gives a flowchart illustrating the order Of calculations as well as the construction sequence. It is valid for all types Of Kachelgrundofen.

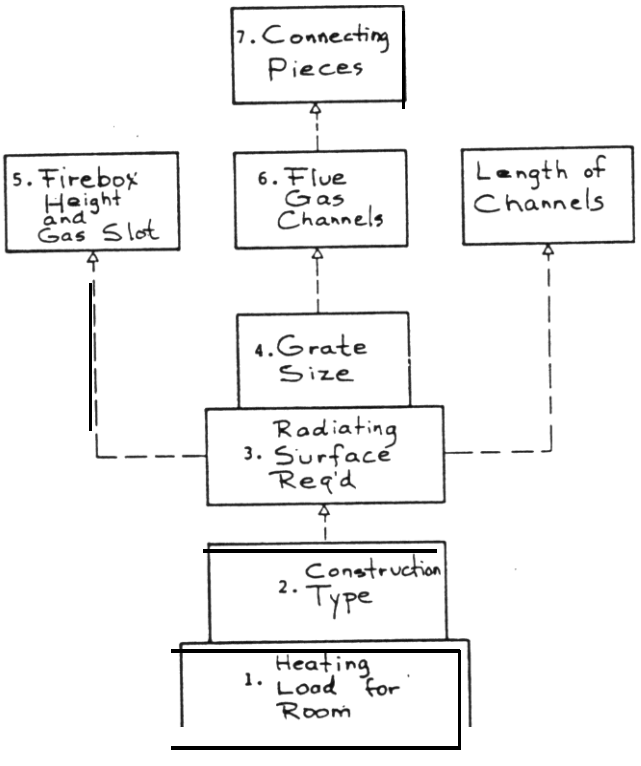


Fig. 1 Sequence of Construction

1. Heating Requirements

The Kachelgrundofen must meet the heating requirements of the room(s) with the most efficient use of the fuel, yet without being over-fired.

The heating requirements of a room are calculated according to DIN 4781.

2.) Construction Styles

The style of construction chosen depends on the local climate, the type of room to be heated, and the firing method chosen.
Table 1 gives the characteristic differences among the three types of construction. These are in no way to be interpreted as differences in quality.

Table 1 — Type of Construction

Type:	Heavy	Medium-Heavy	Light
Prevailing Climate Usual for this Type of Construction	heating intervals particularly long, very low temps.	heating intervals of medium length, low temperatures	short heating periods, mild temperatures
Heat Storage Capacity	Highest mass Highest storage capacity	Medium-heavy construction, good storage capacity	Light construction, adequate storage
Usual Mode of Operation	One large burn daily	One burn daily with one reloading	One burn daily with several reloadings
Type of Heating Cycle	A relatively long-warm-up time is followed by very long, steady heat output	A normal warm-up time is followed by a a long heat output	Room is warm after short warm up, but cools quicker unless stove is reloaded
Wall thickness Firebox and) downdraft flue)	4.9- 5.5 in 3.1- 3.9 in 2.7- 3.3 in	4.1- 4.7 in - 2.9 in - 2.7 in	3.1- 3.7 in - 2.5 in - 1.95in*
Mass per 1000 kcal/h rated output (per 1000 BTU/hr	300 kg (approx) 166 lb	200 kg (approx) 110 lb	150 kg (approx) 83 lb)
Middle Surface Temperature (F)	147 F	176 F	194 F
Specific Rated Output (BTU)	240 BTU per hr per sq ft	320 BTU per hr per sq ft	400 BTU per hr per sq ft

Stove Types

The Coal or Coke Fired Kachelofen is outfitted with a two or three piece firebox door and frame system. The addition of a shaker grate results in a continuous burn stove.

The Wood Fired Kachelofen has separate burn and heating modes. The ceramic • ass of this stove absorbs the large amount of heat that is rapidly produced by a quick burn of the wood charge. After completion of the burn, this heat is slowly released into the room. During the heating mode, air entry <draft) is blocked by the tight closure of the firebox door. Wood fired Kachelöfen are usually constructed without a grate or ashbox.

The Reiswellenkachelofen is similar in function to the Wood Fired. Kachelofen. The firebox differs in that is designed to burn fagots(bundles) or coarse slabwood. Correspondingly it is made larger and deeper. It formed using arched brickwork or castable.

The firebox floor without grate can also be utilized as a baking oven. A sliding damper is then used at the chimney connection, and prevents stray drafts during the heating or baking phase (when closed).

3. Heating Surfaces

The total outside surface area of the Kachelgrundofen is used to calculate the heating surface. The stove floor is only counted if it is raised up by means of feet or an arch.

3.1 Heating Capacity

The Specific Rated Output varies with the three construction types as well as with the method of firing.

Table 2
Specific Rated Output

Type	Firing Method	Storage * Tine (hrs)	Specific Rated Output kcal/sq.m-h
Heavy	Fast burn (or continuous)	up to 10	600
Medium-Heavy	Fast burn (or continuous)	up to 8	800
Light	Continuous (or Fast Burn	up to 5	1000

* Storage time is defined as the time required to reach an average outside surface temperature of 50 C.

3.2 Calculation of Heating Surfaces

The required area of heating surfaces is calculated by dividing the required output (from a heat loss calculation for the room) by the Specific Heating Capacity (for the specific construction type).

Table 3. below, gives the heating surface areas for various traditional stove sizes.

Table 3 Heating surface areas of some traditional stove sizes (sq m)

Kachelofen Width (tiles)	Depth	Height of Stove in Courses 22x22 Kachel + 10 cm cap 4	5	6	7
2	2 1/2	2.42	2.86	3.29	3.73
	3	2.73	3.22	3.69	4.17
	3 1/2	3.04	3.58	4.11	4.64
	4	3.36	3.94	4.52	5.10
	4 1/2	3.67	4.38	4.92	5.55
2 1/2	3	3.18	3.63	4.16	4.62
	3 1/2	3.43	4.02	4.60	5.18
	4	3.77	4.40	5.03	5.66
	4 1/2	4.11	4.79	5.47	6.15
	5	4.44	5.17	5.98	6.62
	5 1/2	4.78	5.55	6.32	7.89
3	4		4.86	5.54	6.22
	4 1/2		5.27	6.00	6.73
	5		5.68	6.45	7.23
	5 1/2		6.89	6.91	7.73
	6		6.49	7.36	8.23

Tables 4 - 6 (on pages 12 - 14) give the calculated values for Kachelgrundöfen of the three construction types for Specific Heat Ouptputs of 2000 - 4500 kcal/h.

These tables are theoretical values. Values for the size of the first and last channel in particular should be determined from the actual type of fuel to be burned!

4. Grate and Ashbox

Ashbox

The floor of the ashbox must be flush uith the bottom of the ashbox door frame. The minimum distance from the floor Of the ashbox to the bottom of the grate is 13 cm. (Fig. 2).

The floor of the ashbox must be built safely and in accordance with applicable local building and fire codes. It must have a minimum thickness of 15 cm. firebrick.

An Ashbox shall receive the daily accumulation of ash; its capacity shall be a minimum of 8.9 liter per 1000 kcal/h Of rated heat output.

The lenght of the ashbox must be equal to the depth Of the ashchamber. The height of the front of the ashbox must be calculated to allow for the free passage of combustion air, and must leave unobstructed an area at least twice the area of the combustion air inlet in the door.

Angled ashguides are to be installed underneath the grate to ensure the safe passage of the ashes into the ashbox.

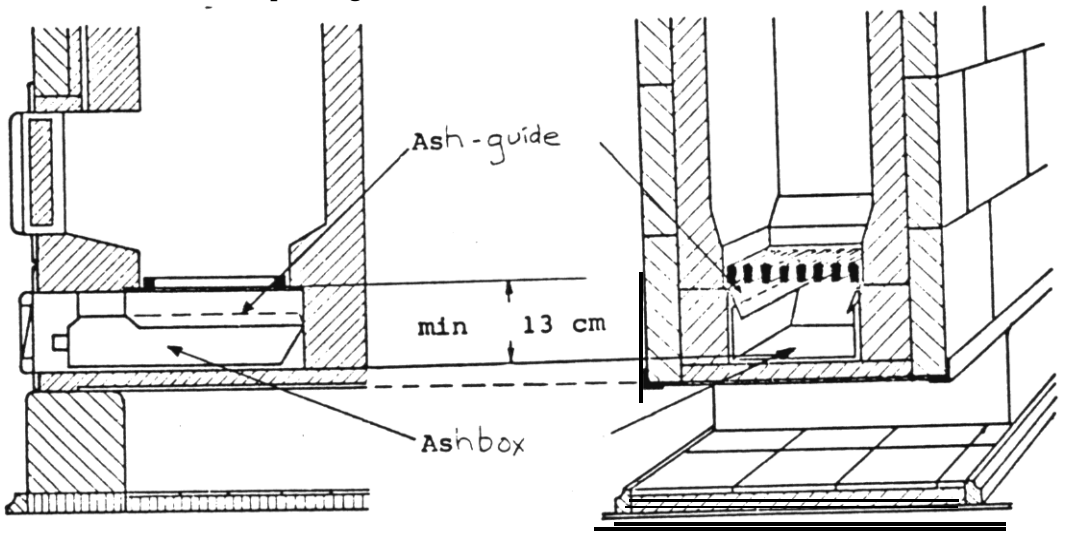


Figure 2 Ash Chamber

Grate

The grate area R for combination Kachelgrundofen for wood or coal firing, per 1000 kcal/hr, must be:

Heavy const. type ——— 140 - 150 sq.cm.
Med.-heavy type ——— 120 - 130 sq.cm.
Light const. type ——— approx. 100 sq.cm.

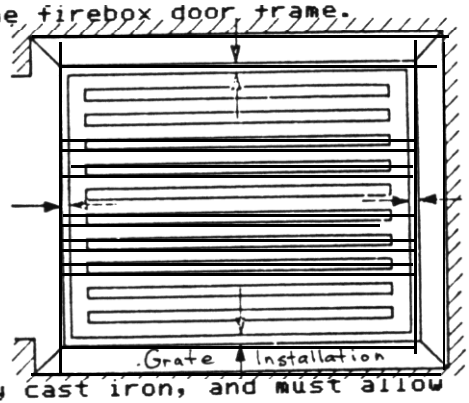
If the Kachelgrundofen is for wood firing only, and a grate is installed, then a larger grate size must be chosen.
Normally one-piece grates (cookstove grates) - Table 4 - are used. In case the calculated grate size is larger (for example, with a wood fired stove) than available stove grates, individual grate bars arc then used.

With normal and strong chimney draft conditions, the grate closest in sire to the calculated size is employed. In cases of unusually low draft, the next size larger grate is to be chosen.

Table 4 **Standard Cookstove Grate Sizes**

Grate Size cm x cm		Grate Area sq cm	Grate Size cm x cm		Grate Area sq cm
12 x 18	=	216	18 x 26	=	468
14 x 28	=	280	18 x 28	=	504
14 x 22	=	308	26 x 28	=	560
16 x 22	=	352	20 x 32	=	640
16 x 24	=	384	28 x 36	=	720
18 x 24	=	432			

The grate must have room for expansion on all sides. An expansion allowance of 5 mm. is sufficient (Fig. 3). For coke firing, the grate should be level with the bottom of the firebox door frame. For coal firing, it should be 6 cm. below the level of the frame. For wood firing, the grate can be ommitted.



5. Firebox Construction

The firebox door, the firebox, and the flue gas channels must in all cases be of airtight construction.

Firebox Door and Frame

Firebox door and frame must be made of grey cast iron, and must allow for tight closure. In addition to air tightness, however, it is also important to allow for expansion (Figs. 4 & 5). Otherwise, the difference in thermal expansion coefficients between Cast iron and masonry will result in cracking of the tile facing.

The door hardware (Figs. 6 & 7) can consist of one or more doors. Behind the outer firebox door, there must be a plate or screen that fits tight to the door frame.

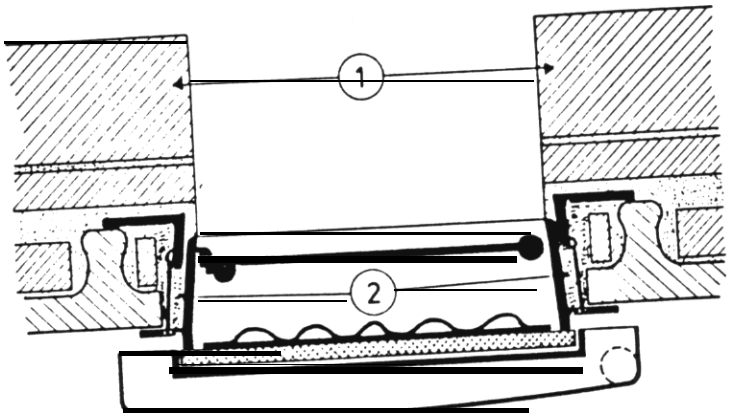
For coke firing, the door hardware consists of a firebox door and an ashdoor. Both doors can be fitted into one unit.

For coal firing, the door hardware consists of a firebox door and an ashdoor.

For wood firing, only one door (firebox door) is required.

Installation

The firebox door and/or the ashdoor must have an adjustable air control designed to allow for easy reading of the air adjustment. The air opening must be adjustable to give a minimum opening Of 5 sq. cm. per 1000 kcal/h rated heat output.

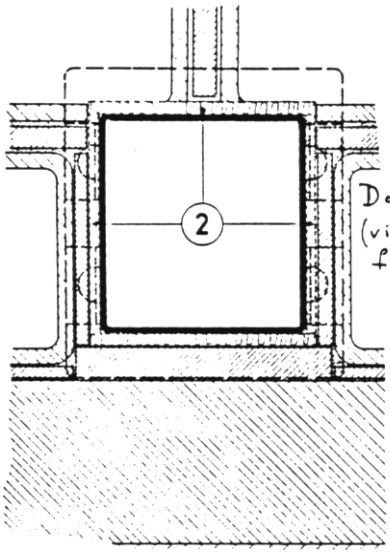


1 = Firebrick protection for door frame

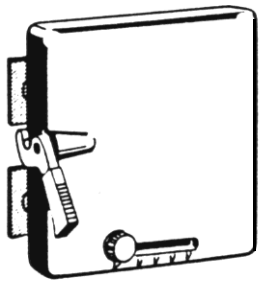
2 = flexible material, eg. mineral wool

3 = Expansion

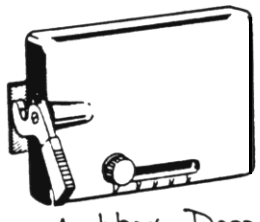
Figure 4 – Door Installation Detail



Door Installation (viewed from firebox)



Firebox Door (Loading Door)



Ashbox Door

Firebox

In Kachelgrundofen construction the firebox must be built in such a way that the firebricks can expand without displacing or exerting pressure on the inside of the Kacheln.

For stoves of the light and medium-heavy construction types, the individual chamotte slabs are to be installed with expansion joints in between.

For stoves of the heavy construction type, it is highly recommended that the entire firebox be freestanding with an airspace around all sides (Fig. 8). It is also recommended that the celling slab (Fig. 9) be free floating.

The height of the firebox – measured from the top of the grate to the bottom of the celling slab – should be as great as possible. Minimum heights are:

heavy type	68 cm
medium-heavy type	60 cm
light type	70 cm

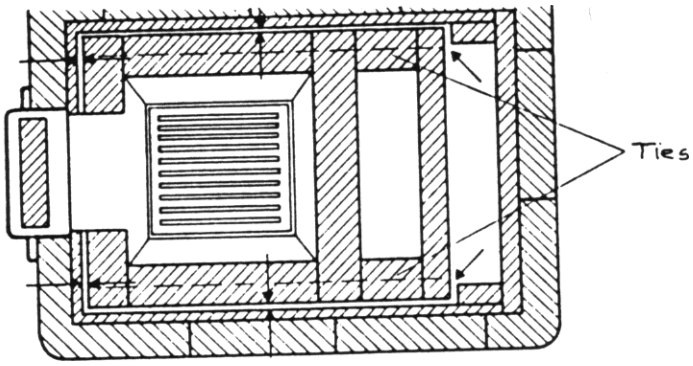


Figure 8 - Freestanding Firebox With Expansion Joints

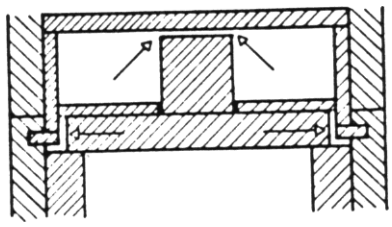


Figure 9 - Free Floating F.B. Ceiling

Gas Slit

A Kachelgrundofen must have a gas slit (short circuit between firebox and flue gas channel) in the firebox ceiling. This is to prevent explosions (back-puffing). The cross-sectional area of the gas slit (Fig. 10) must be 3 sq cm per sq m of heating surface, and must be a minimum of 8 sq. cm.

6. Flue Gas Channels

The flue gases of the Kachelgrundofen are to be channelled in such a way that they give off their heat through Intimate contact with the outer walls. Depending on their function, they are referred to as downdraft (Sturz-), updraft (Steige-) and horizontal (liegenden) channels (Zuge).

The type and length of the channels are determined by fuel type, stove shape, and available chimney draft.

Shorter channels, capable Of extracting heat from smaller fires with some increase in exit temperature, are absolutely preferable over longer channels that, with large fuel loads and low exit temperatures, might prevent complete combustion.

It isnecessary for the outside surfaces of the stove to heat up as evenly as possible, in order to prevent unequal expansion and possible cracking of the joints and spalling of the Kacheln.

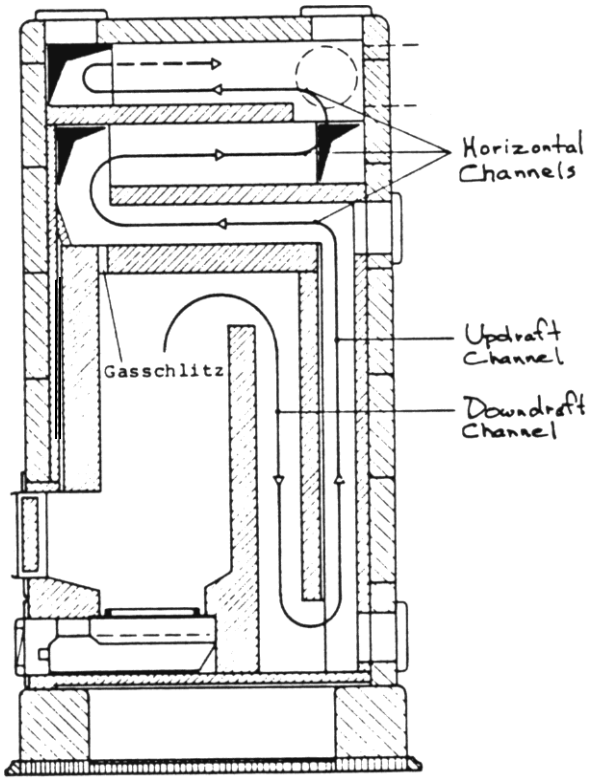


Figure 10 - Flue Gas Channels

On their way from the firebox to the chimney, the flue gases are continually gluing off heat. Accordingly. the last channels must let through more heat in order to achieve even surface temperatures.

For coal and coke firing:

Cross-sectional area of first channel (usually doun-draft) grate area	2/3
Cross-sectional area of last channel grate area	1/3

For wood firing:

Cross sectional area of first channel, per 1000kcal/h rated output

heavy construction type
200 sq cm

medium-heavy construction type
180 sq cm

light construction type
150 sq cm

Cross sectional area of last channel is approximately 2/3 that of the first channel.

In between, the decrease in size should be as even as Possible. Sudden changes in size, as well as constrictions, are to be carefully avoided.

Bends in the channels should be as smooth as possible. The channel should be opened up by around 28% at these points.

Kachelgrundöfen with long flue gas channels should be Provided with a by-pass channel for start up that incorporates a tight fitting damper.

In cases of unfavourable chimney draft, a by-pass channel must be provided to enable the downdraft channel to be short circuited.

In the case of large firebox doors (Fig. 11), which cannot be made tight fitting without the use of asbestos gaskets, a pivoting or sliding shut-off damper must be installed

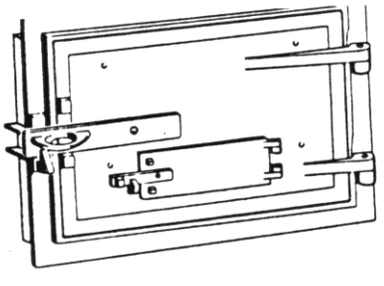


Figure 11 - Large Firebox Door

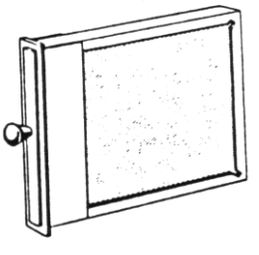


Figure 12 - Sliding Damper

7. Connecting Pieces

Connecting pieces between the Kachelgrundofen and the chimney should be as short as possible. Cross sectional area of the connecting piece (smoke pipe) should be about the same as that of the last flue gas channel.

The longest permissible length of the connecting pieces depends on the "effective chimney height"; for each foot of connector there must be at least four feet of extra 'effective chimney height..

The previous discussion regarding leak free (tight) construction applies as well to the connecting pieces, their heat shields, and their clean-outs; see DIN 18 168, page 2.

8. Clean-Out Openings

Enough clean-out openings are to be provided so that each flue-gas channel may be easily cleaned. Clean-out doors must be fully tight fitting (air tight).

Construction Techniques

Layout

For a freestanding Kachelofen the clearance to walls must be a minimum of 12 cm.

For a built-in Kachelgrundofen, a solid foundation is of particular importance, in order to prevent loosening of tiled surfaces that are continuous with room walls.

Wire Reinforcing

All Kachelpieces are to be properly reinforced with Kachel reinforcing wire, in accordance with workmanlike practice; in Kachel courses that are broken up by openings, such as doors, the opening shall be spanned by a reinforcing wire anchor.

Layup of the Stove

All interior construction of the stove is to be carried out in such a manner that thermal expansion can be accommodated without exerting pressure on the outer walls.

Since the ability to store heat is a natural and desirable advantage of the Kachelgrundofen, it is important to recognize this and to place a high value on storage capacity. The amount of heat that can be stored depends on temperature and on the weight of the heat-storing mass, as well as on its type of constructron.

Accordingly, only materials with a high capacity to store heat (specific heat) are to be used; Chamotte (firebrick) material (Quality B 3) is the only material that should be used in the interior construction and for filling the Kacheln.

Installation of Warm Air Pipes

A warm air pipe can be either a See-Through, a Heating Pipe, a Warming Nook. or a Warming Chamber. When one is included. usually above the firebox, its bottom must be protected by a firebrick slab with a 1 cm. overhang.

If the bottom of the pipe (Fig. 13) is made of cast iron. then the firebrick underlay may be ommitted.

Operating Instructions for Kachelgrundofen

Newly constructed stoves must be cured <dried out) with small fires, according to the following instructions. However, the stove must not be used for the purpose of drying out the new construction of the house Itself.

Curing (Heating to Dryness)

For trouble-free results, it is important to observe the following: during construction, the masonry materials become soaked with water; also, the clay and fireclay mortars have a very high water Content. To dry the stove out properly, one must begin firing it right away with small loads, driving moisture up the chimney as well as Out through the walls.

For this slow drying process only small fires are to be lit. Fuel should only be added after the previous load is almost out. Wood shavings, sawdust, or other scraps that either burn hot or are smoky are not to be used under any circumstances.

Drying Time

With two daily fires, the drying time varies from 8 – 14 days, depending on stove size. During this period. all controls (eg., sliding dampers, pivoting dampers. air controls on firebox or ashbox door) are to be left open, even after the fire has gone out!

Wood Fired Kachelgrundofen that are to be used for baking should be particularly well dried out. Before baking for the first tine. it is recommended that the stove be pre-fired. This uill pre-warm the oven as well as driving out any last remnants of moisture.

Danger of Frost

Due to the high moisture content, a new Kachelofen can receive frost damage even after it has been fired several times. If the curing of the stove occurs during the coldest time of year, then it is Imperative that the 14 day drying cycle is used.

Fuels

Only fuels that are compatible with the particular stove design are to be used:

Wood Firing:

All types of firewood, including slabwood, cut to proper length. Sawdust and wood shavings are not to be used.

Coal Firing:

Coal, browncoal briquettes and anthracite briquettes. Coal and briquette dust is not to be used.

Coke Firing:

(Only stoves with loading chutes>: Ruhrbrech Coke Gr. III and anthracite briquettes.

Operation

For coal and coke fired stoves, all doors are to be closed during operation. Only the combustion air control - precisely adjusted - is to be open.

For wood fired stoves, the firebox door is closed after the fire, and the sliding (chimney) damper is closed.

Before reloading, ashes should be cleared from the firebox. The ashbox should be emptied daily.

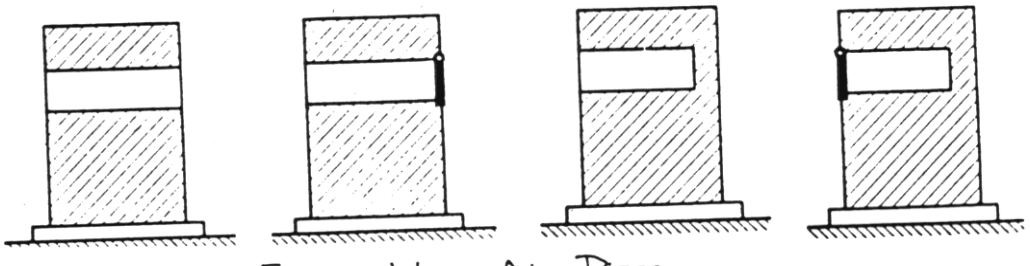


Fig. 13 Warm Air Pipes

Table 4 Kachelgrundöfen / Heavy Construction

Heat Output Capacity (DIN 4701) kcal/h	2000	2500	3000	3500	4000	4500
Recommended heating surface area sq m	3.4	4.2	5.0	5.8	6.7	7.5
Recommended firebox height cm	60	60	60-70	70	70	70
Gas slit size sq cm	11	13	15	18	20	23
Grate area *(1) Calculated sq cm	290	363	435	508	580	653
Selected size cm x cm	14x20	16x24	18x24	18x28	18x32	20x32
*(2) Selected area sq cm	280	384	432	504	576	640
Flue gas channels for coal firing						
Cross section of first run sq cm	187	256	298	336	384	426
last run sq cm	100	128	144	168	192	213
Flue gas channels wood firing *(3)						
Cross section of first run sq cm	approx. 400	approx. see	approx 600	approx. 700	approx. 800	approx. 900
last run sq cm	270	340	400	470	540	600

1) valid only for coal and coke firing

2) with weak chimney draft. choose next larger size

3) cross sectional area depends also on type of firewood, and is smaller, for example, with hardwoods

Table 5 Kachelgrundöfen / Medium Construction

Heat Output Capacity (DIN 4701) kcal/h	2000	2500	3000	3500	4000	4500
Recommended heating surface area sq m	2.5	3.1	3.8	4.4	5.0	5.6
Recommended firebox height cm	60	60	60	60-70	70	70
Gas slit size sq cm	8	10	12	14	15	17
Grate area *(1) Calculated sq cm	250	310	380	440	500	560
Selected size Cm x cm *(2)	14x21	14x22	16x24	18x2'4	18x24	20x28
Selected area sq cm	280	308	384	432	504	560
Flue gas channels for coal firing						
Cross section of first run sq cm	187	205	256	288	336	373
last run sq cm	100	103	128	144	168	187
Flue gas channels wood firing *(3)						
Cross section of first run sq cm	approx. 360	approx. 450	approx. 540	approx. 630	approx. 720	approx. 810
last run sq cm	240	300	360	420	480	540

1) valid only for coal and coke firing

2) with weak chimney draft, choose next larger size

3) cross sectional area depends also on type of firewood. and is smaller, for example. with hardwoods

Table 6 Kachelgrundöfen /Light Construction

Heat Output Capacity (DIN 4701) kcal/h	2000	2500	3000	3500	4000	4500
Recommended heating surface area sq m	2.0	2.5	3.0	3.5	4.e	4.5
Recommended firebox height cm	70	70	70	70	70	70-80
Gas slit size sq cm	8	8	9	11	12	14
Grate area *(1) Calculated sq cm	200	250	300	350	400	450
Selected size cm x cm	12x1	14x2	14x2;	16x2:	18x2	18x26
*(2) Selected area sq cm	216	280	308	352	432	468
Flue gas channels for coal firing						
Cross section of first run sq cm	145	187	205	235	288	312
last run sq cm	100	100	103	117	144	156
Flue gas channels wood firing *(3)						
Cross section of first run sq cm	apprx. 300	apprx. 375	apprx. 450	apprx. 525	apprx. 600	apprx. 675
last run sq cm	200	250	300	350	400	450

1) valid only for coal and coke firing

2) uith weak chimney draft, choose next larger size

3) cross sectional area depends also on type of firewood. and is smaller, for example. with hardwoods