Masonry Heater Association Of North America

Heater Plan Portfolio

www.mha-net.org

Revised 2/11

The MHA Heater Plan Portfolio

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Revised: Nov. 2008

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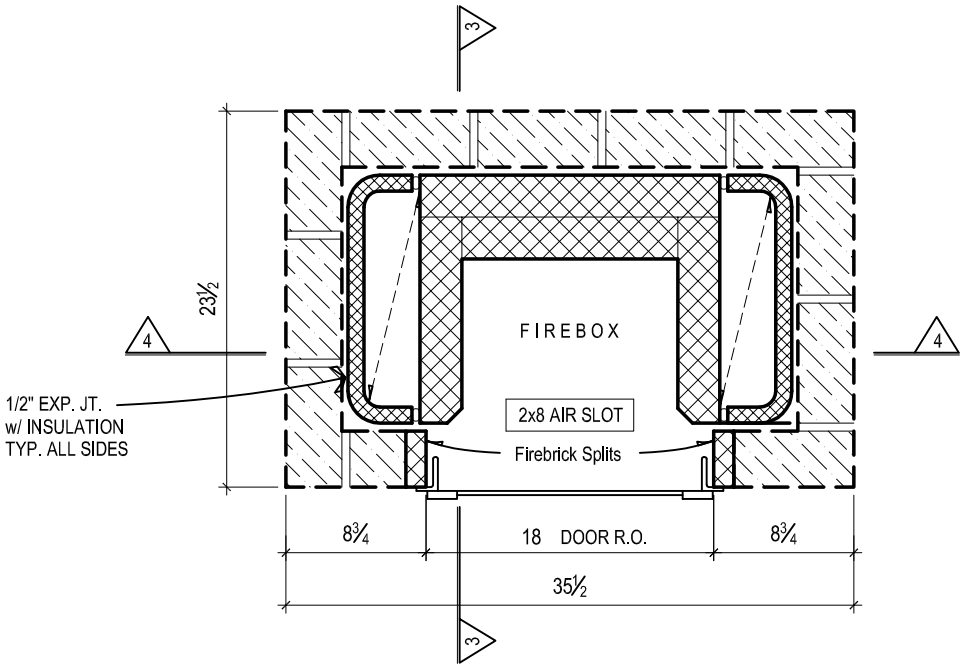
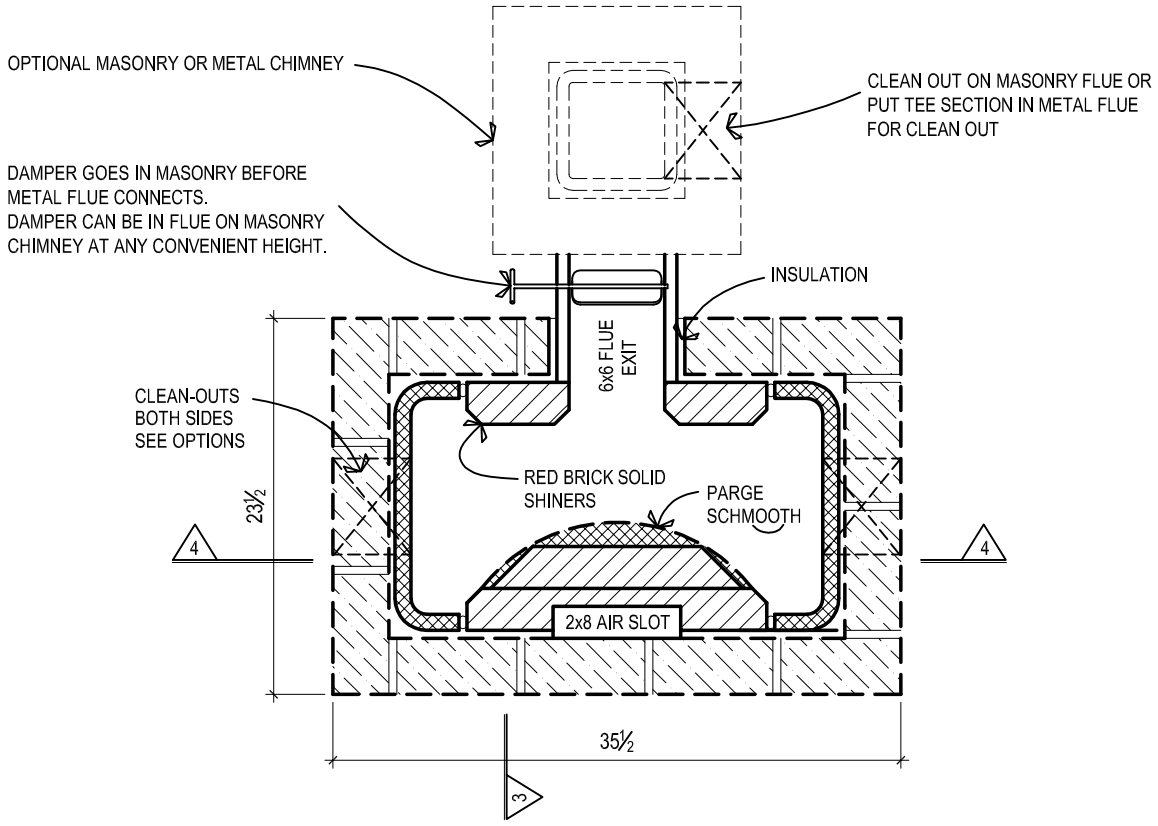
Drawing Not to Scale



1b. PLAN at FIREBOX

24x36 CONTRAFLOW 1" = 1'-0"

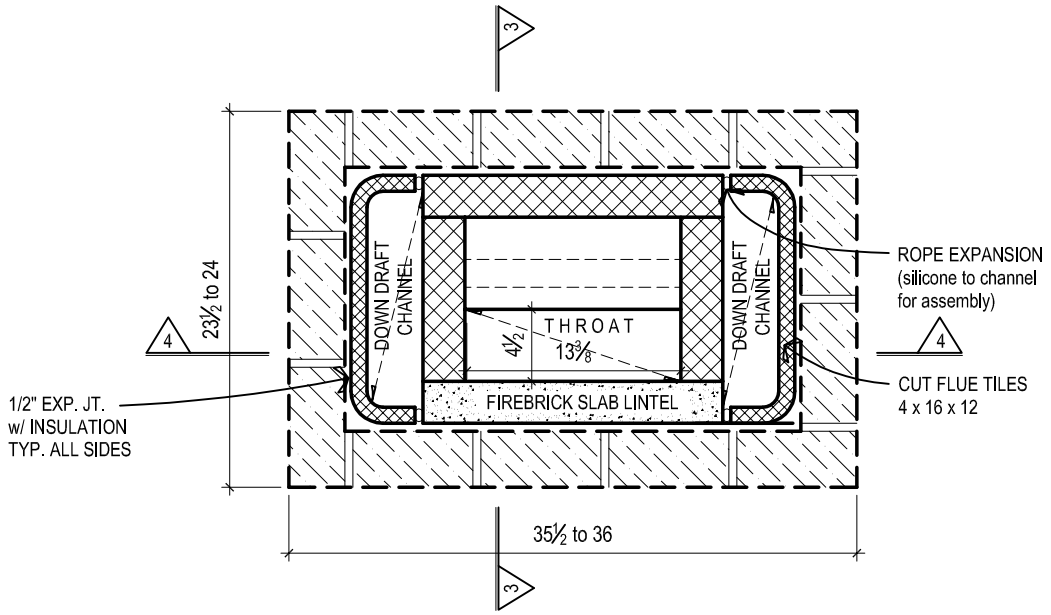


1a. PLAN at BASE HORIZONTAL CHANNEL

24x36 CONTRAFLOW 1" = 1'-0"

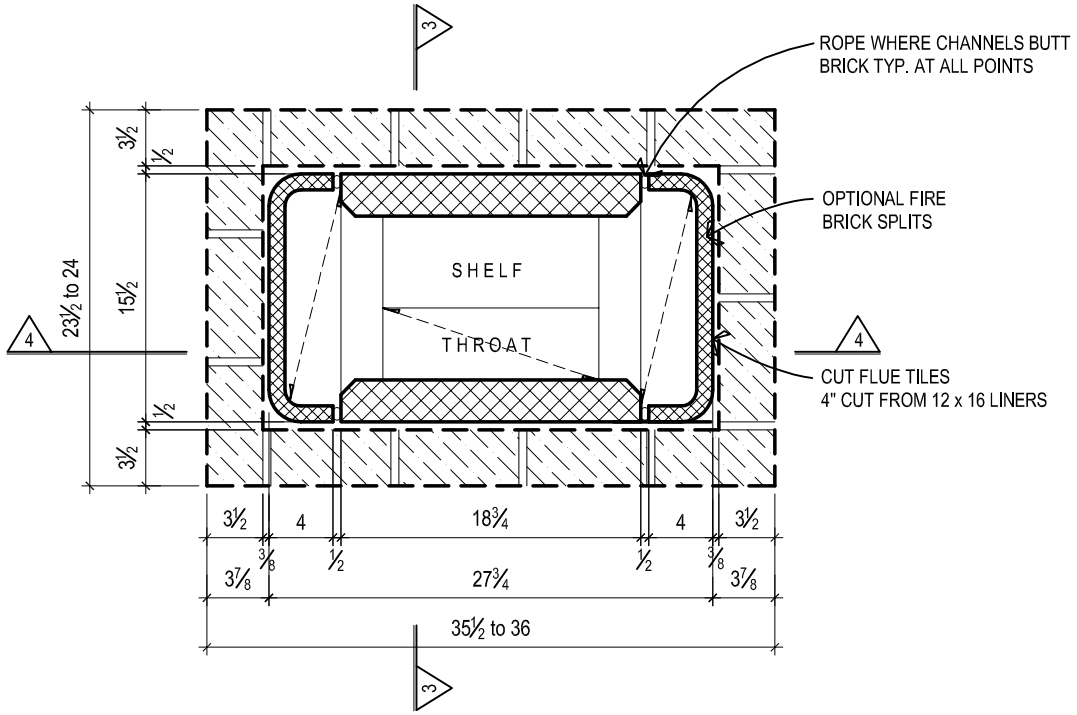
NOTE

OUTSIDE DIMENSIONS ARE NOMINAL - EXACT
LAYOUT TO BE DETERMINED BY LOCAL BRICK SIZES
AND 12 x16 FLUE LINERS



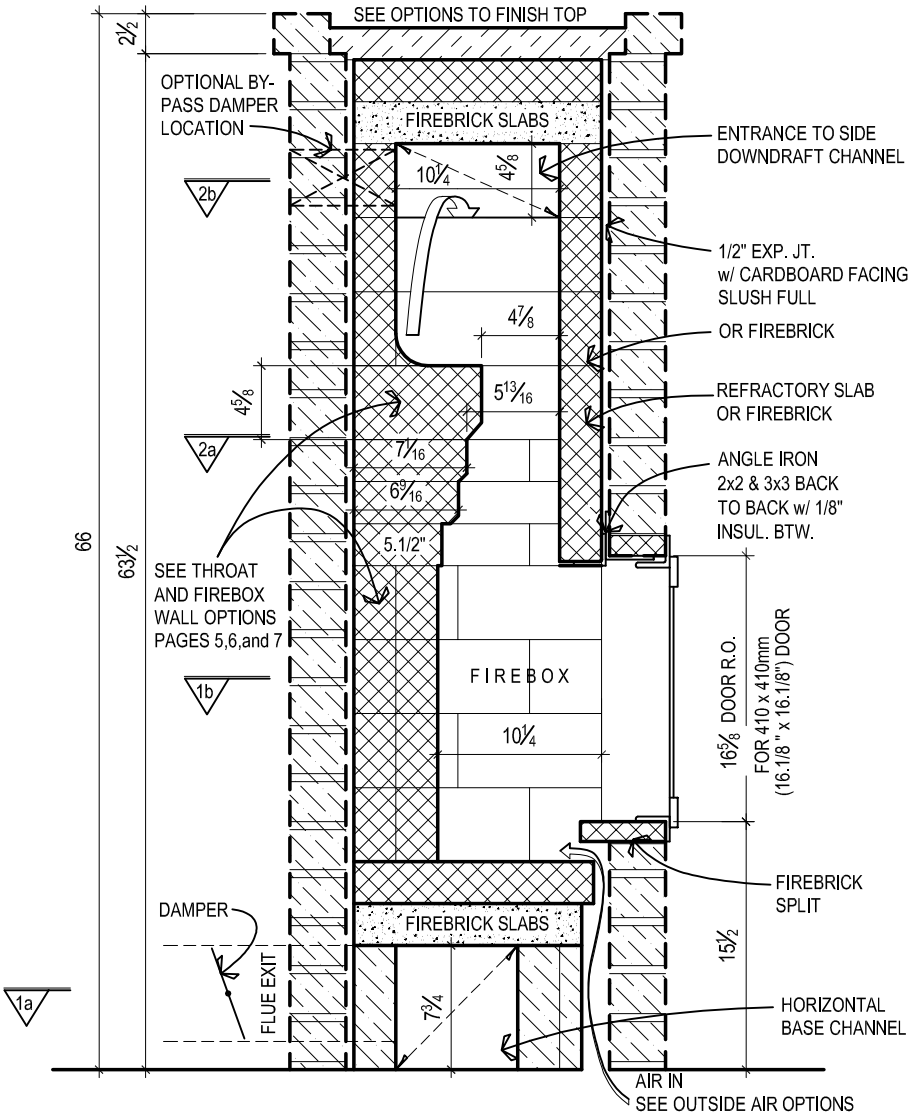
2b. PLAN at UPPER COMBUSTION CHAMBER

24x36 CONTRAFLOW 1" = 1'-0"



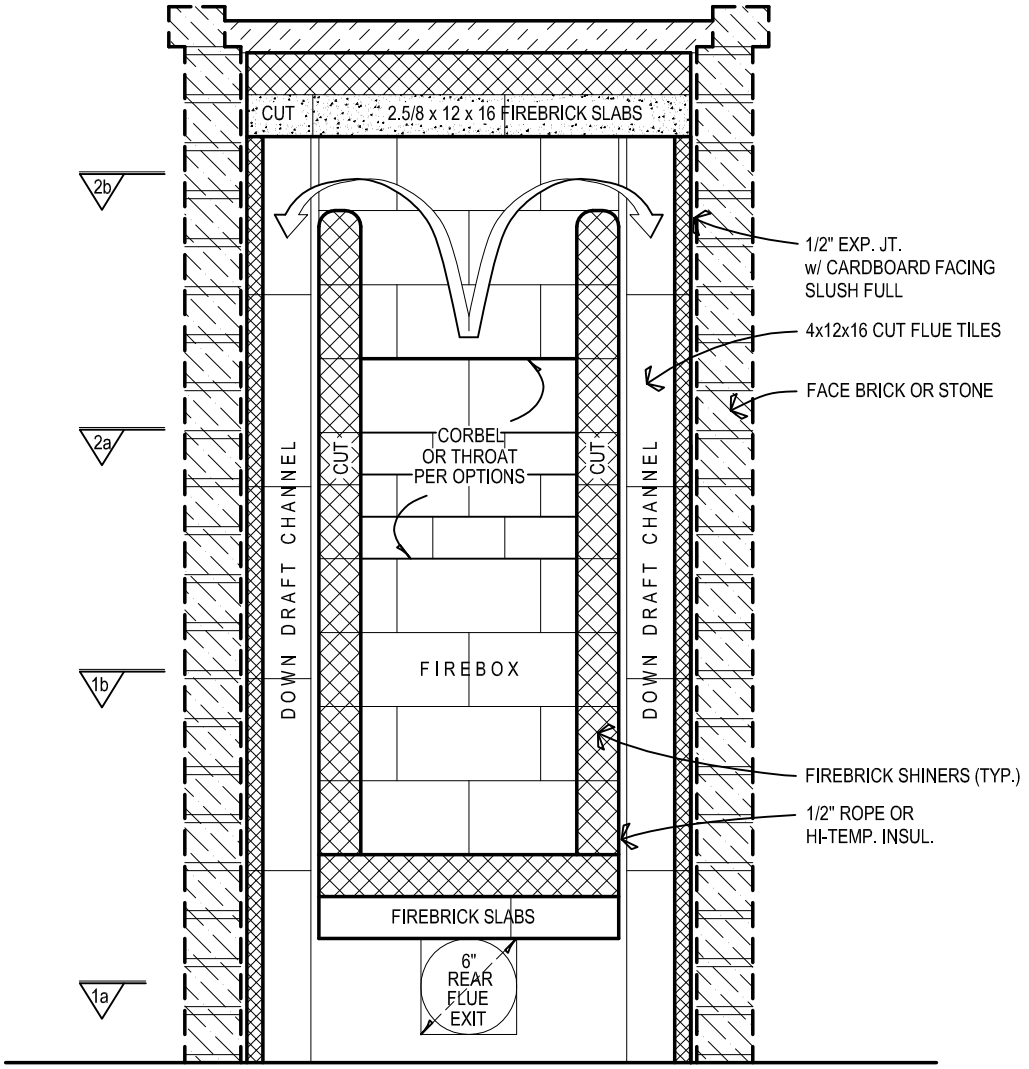
2a. PLAN at THROAT

24x36 CONTRAFLOW 1" = 1'-0"



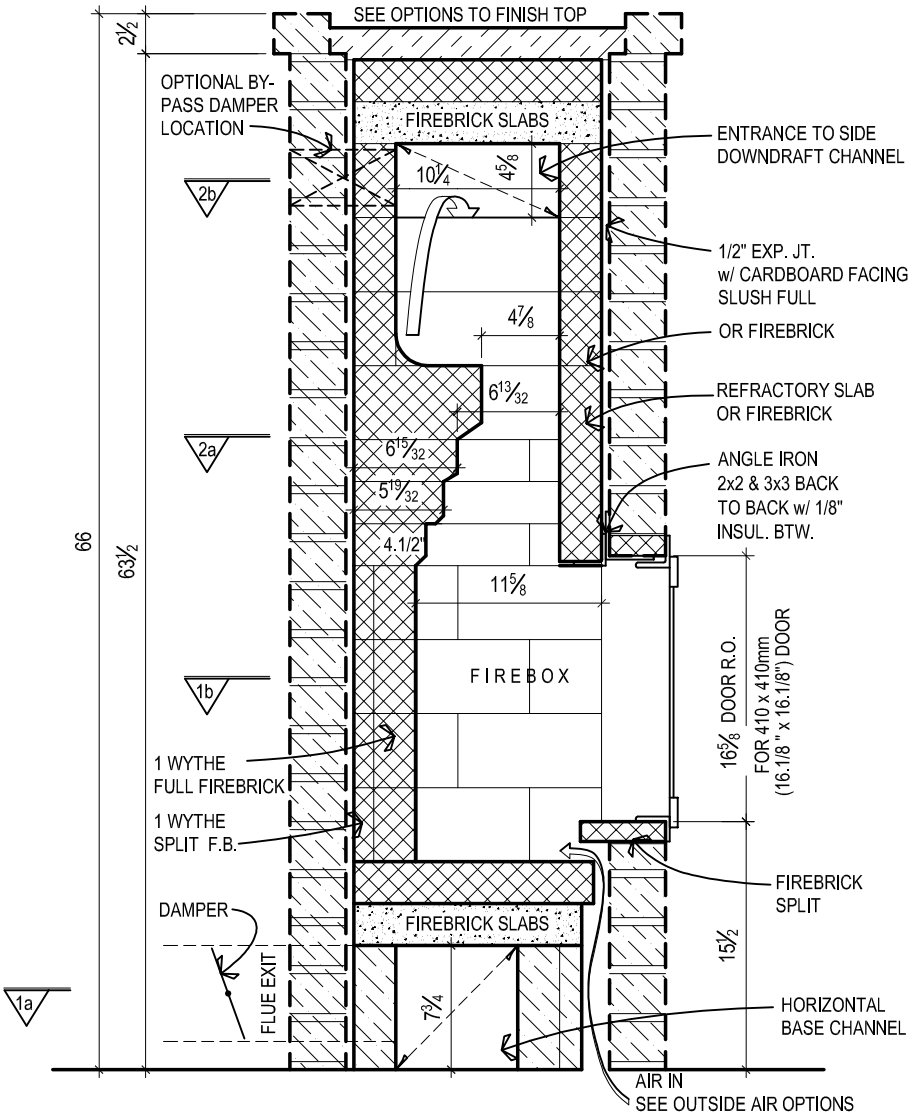
3. CROSS SECTION thru FIREBOX

24x36 CONTRAFLOW 1" = 1'-0"



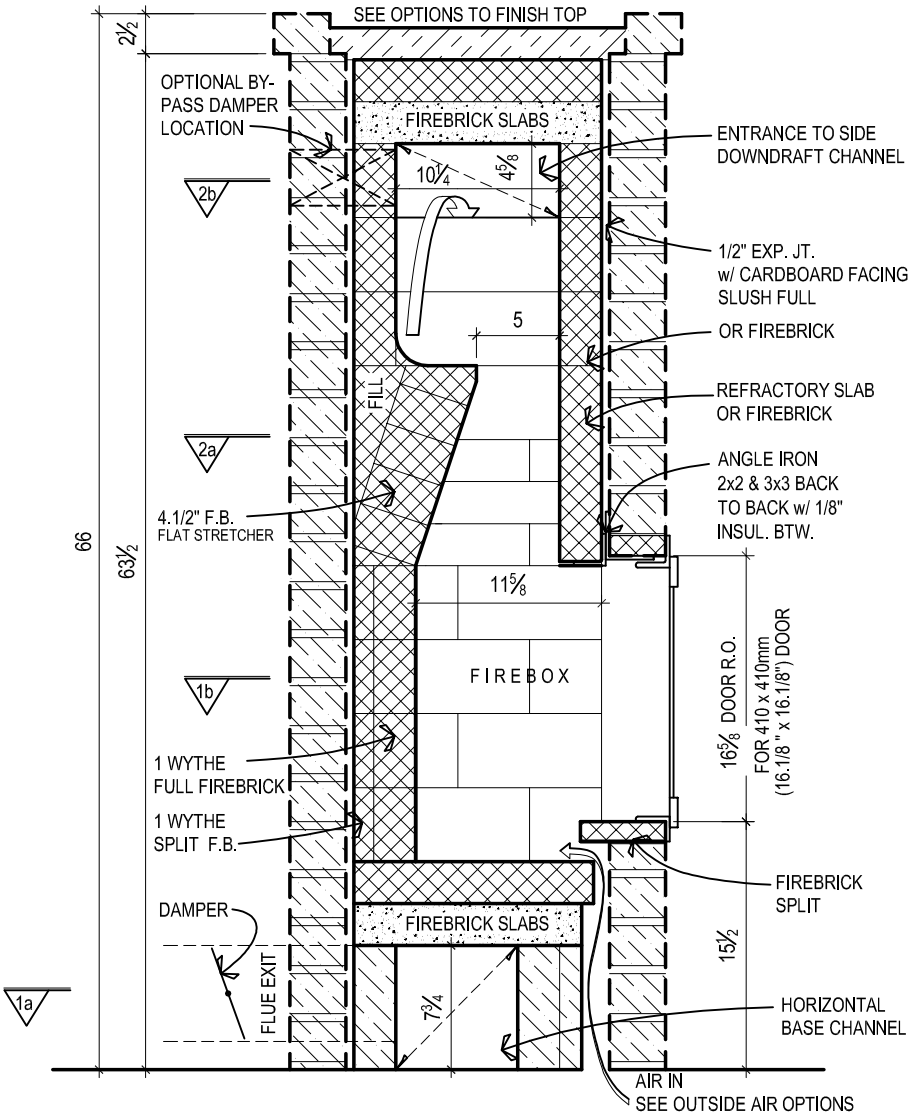
4. LONGITUDINAL SECTION thru FIREBOX

24x36 CONTRAFLOW 1" = 1'-0"



5. DEEPER FIREBOX OPTION

24x36 CONTRAFLOW 1" = 1'-0"



6. DEEPER FIREBOX w/ FLAT STRETCHER THROAT OPT.

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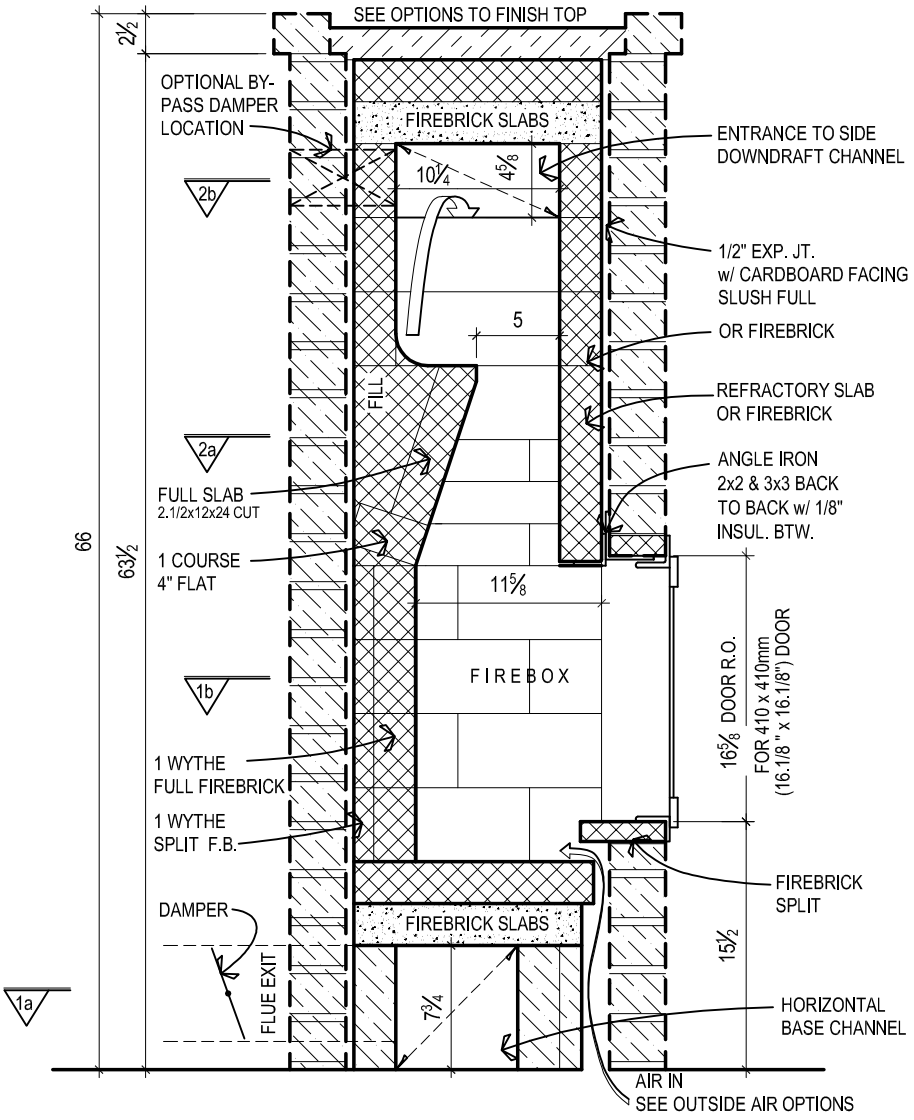

7. DEEPER FIREBOX w/ 1 PC. SLAB THROAT OPT.

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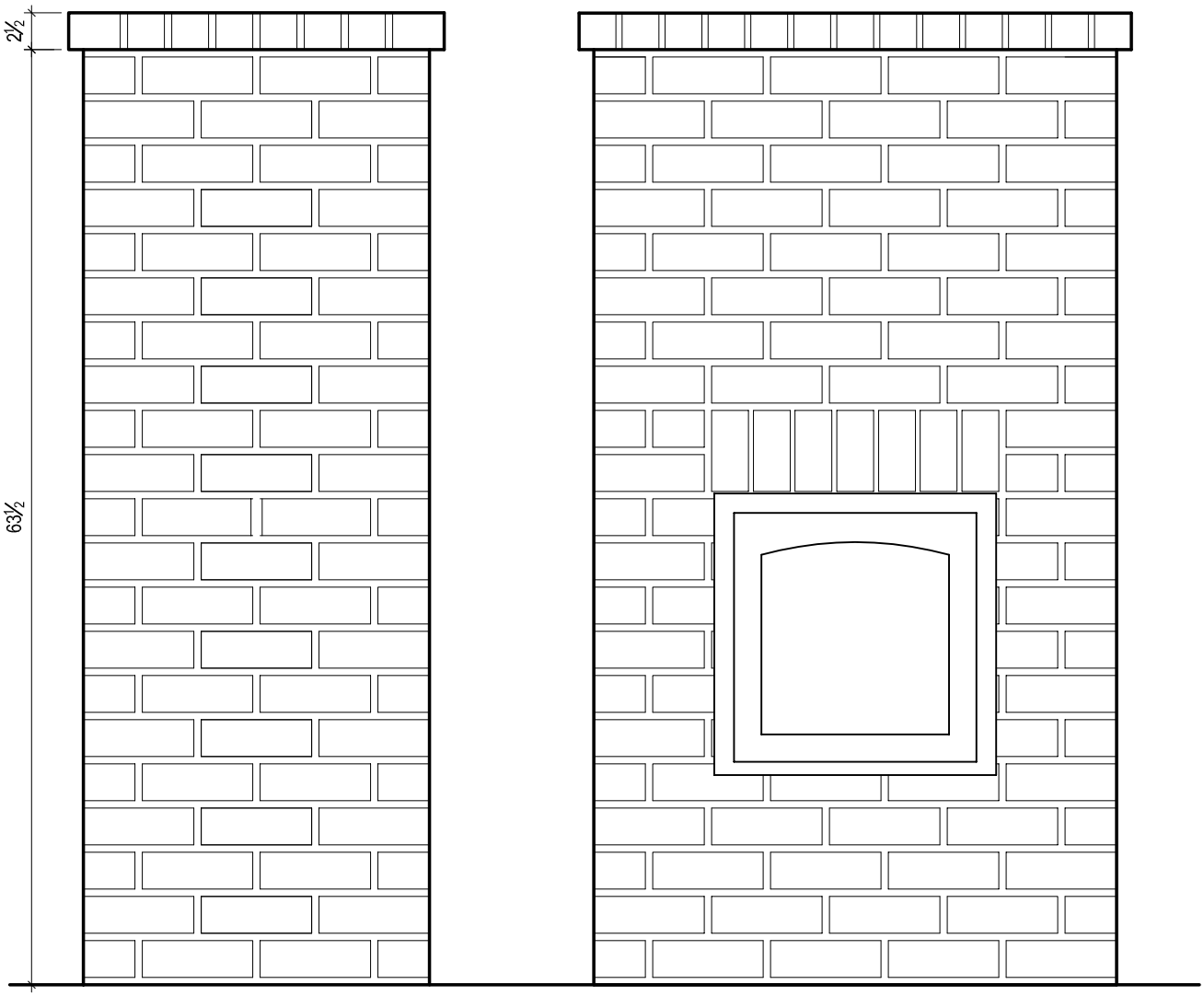


8b. SIDE ELEVATION
24x36 CONTRAFLOW 1" = 1'-0"

8a. FRONT ELEVATION
24x36 CONTRAFLOW 1" = 1'-0"

2' x 3' Small Brick Heater

Materials List

320 - 2 5/8 x 3 5/8 x 7 5/8 Standard Face Brick
10 - 80 lb. bags Type "S" Premixed Mortar (if you use Type "N" add 20 % Portland Cement)
80 - Standard 2 5/8 x 4 ½ x 9" Fire Brick
1 - 50 lb. Refractory Mortar (Premixed)
(i.e. Sair/set - Tennex - Heat/stop) or Equal
5 - 2 ½ x 12" x 24" Refractory Slabs (Straights) Cut to 2 ½ x 12 x 16"
1 - Chimney Damper (For 8 x 8 Masonry Chimney or 6" ID Class "A" Metal Flue
1 - 2 x 4" Outside Air Damper
2 - Cleanout Doors, 2 Flue Channels
2 sq. ft. ½" Ceramic Blanket Insulation (4 lb. Density)
1 - Door for 18" w x 19" hi opening
1 - 24" - 3 x 3 x 3/16 Angle Iron (Lintel)
1 - Air Supply Baffle
45 sq. ft. ¼" Mineral Wool Insulation (or Cardboard)
50 - 2 5/8 x 3 5/8 x 7 5/8 Standard Solid Brick (Commons) for Base below firebrick
+ Footing
+ Hearth and 8 x 8 Masonry Chimney or 6" Class "A" Metal Flue

Revised, November 14, 2008

Corrections:

On page 1, Figure 1b:

Change: ½” expansion joint w. insulation typical all sides

to:

Core is wrapped with 1/8” cardboard to provide slip joint. Fill with mortar slush between facing bricks and slip joint. Refer to photo assembly sequence, below.

Photo Sequence:

There is an online photo assembly sequence available for the 24” x 36” Contraflow heater on the MHA website at”

http://tinyurl.com/6mfvn5

Revised, November 25, 2010

Contraflow Heater Core

22” firebox with replaceable liner
Front White Bake Oven

Assembly Drawings

Material List for core

Masonry:

170	1.25” x 4.5” x 9” firebrick splits
250	2.5” x 4.5” X 9” firebricks
4	55# bags of castable refractory for bake oven castings (3 piece set)
4	55# bags of castable refractory for core capping slabs (2 piece set)
2	55# bags of castable refractory for firebox floor casting

Castable refractory: KS-4 or MC-25 from Harbison Walker, or equivalent

Insulating base slab: one bag vermiculite plus one 80# bag of mortar premix.

2 pails Sairset or other refractory mortar

1/8” ceramic paper for the bakeoven gaskets and side channel gaskets (available from Northstone Heat Supply northstoneheat.com)

6 ft. piece of “Truss Wire Mesh Reinforcement for 8” concrete blocks”
http://wirebond.com/?page_id=882
available from a masonry supply yard (used to reinforce bake oven slabs)

Hardware:

1 base slab butterfly damper 5”x5” (custom made), or 1 UPO ash box/air intake door

1 5.5” x 11” firebox floor grate (1B from Northstone Heat Supply (below), or equivalent)

1 chimney shut off damper for either 8” round or 8”x12” rectangular flue

1 steel angle iron ¼” x 4” x 4” – weld on small angle iron brackets to hold firebrick split “heat shields” as in Figure 21.

Firebox door, cleanout doors.

Hardware sources:

http://mha-net.org/html/hardware.htm

Foundation

Instructions for the foundation are beyond the scope of this heater core plan. This document:
http://heatkit.com/docs/foundation.PDF

describes a foundation suitable for this heater, if there is a basement underneath. The foundation described in the above document requires, in addition, a 2” clearance to combustibles in order to

meet current IRC or IBC building codes. This foundation provides an ashpit in the basement. Please note that it also requires a 6” air inlet, near the basement ceiling.

For slab on grade construction, ashes will be cleaned out immediately below the firebox door, via an ashbox door with air control (available from the hardware suppliers listed above). Combustion air in this case will enter through the ashbox door.

If you are building slab on grade and your local code still requires an outside air supply, please refer to this document:

http://heatkit.com/docs/assembly/grade.PDF

Please note that many of the construction documents, such as finishing instructions, for the Heat Kit core, also apply to this handbuilt core

http://heatkit.com/html/assy-hk.htm

However, please note that Heatkit does not provide support for this handbuilt core.

Setting Firebricks

Firebricks are laid up with clay air setting refractory mortar (“Sairset”, or fire cement) with thin joints. Only enough clay needs to be used to completely fill the joint. No joint thickness needs to be built up - you are only filling in gaps and irregularities between the bricks. Although masons are used to trowelling firebricks, the best joints are obtained by dipping the bricks into mortar that has been thinned to the right consistency. It looks messy, but the cleanup is easy later with a sponge.

Refractory mortar normally comes in the bucket at trowelling consistency. For dipping, you will need to thin it with water. A drill powered drywall mud mixer works well for this. You can tell if the refractory mortar has the right consistency by floating a firebrick in it. It will sink about half way.

The firebox is laid up from standard firebricks. Standard firebricks are 4 ½” wide by 9” long by 2 1/2” thick. The thickness will vary between 2 ¼” and 2 ½” depending on the supplier. The dimensions given in these drawings assume a 4.5” firebrick module, and may need to be modified for non-standard firebricks.

Slabs Required

The base slab (Figure 1) is cast from a 1:3 mix of vermiculite (or perlite) and portland cement. The remaining slabs are cast from castable refractory, available from refractory suppliers such as RHI or Harbison Walker.

It is very important to take certain precautions when casting refractory slabs under on-site conditions. These techniques are beyond the scope of these instructions. However, you will find and excellent article explaining them by Marcus Flynn, a very experienced heater mason from Montreal, here:

http://www.pyromasse.com/castable_e.html

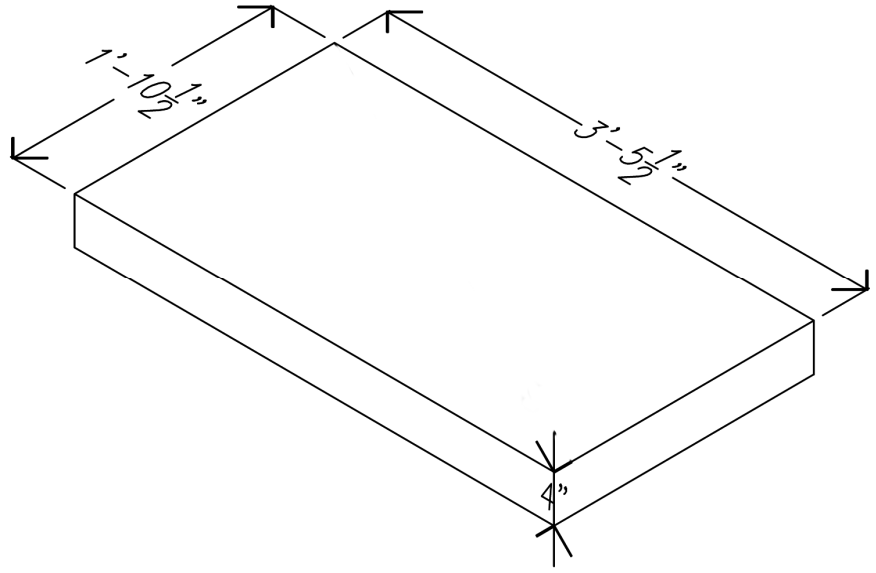


Figure 1 Base slab.

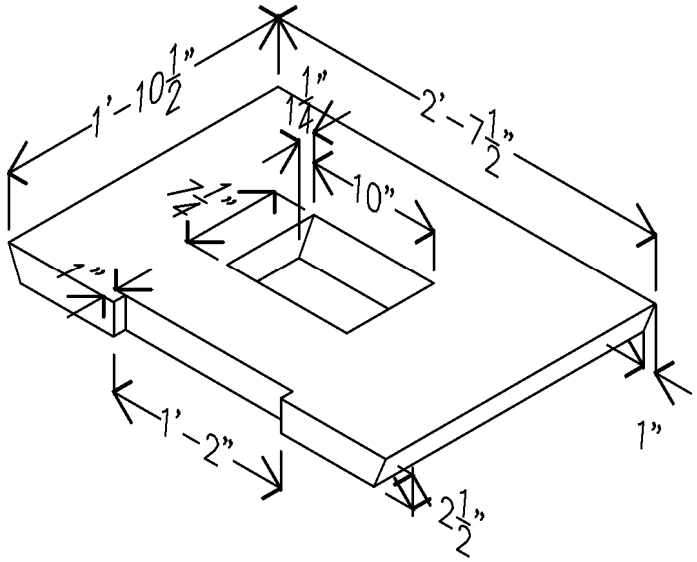


Figure 2 Firebox floor slab. Note the angle at the back of the hole.

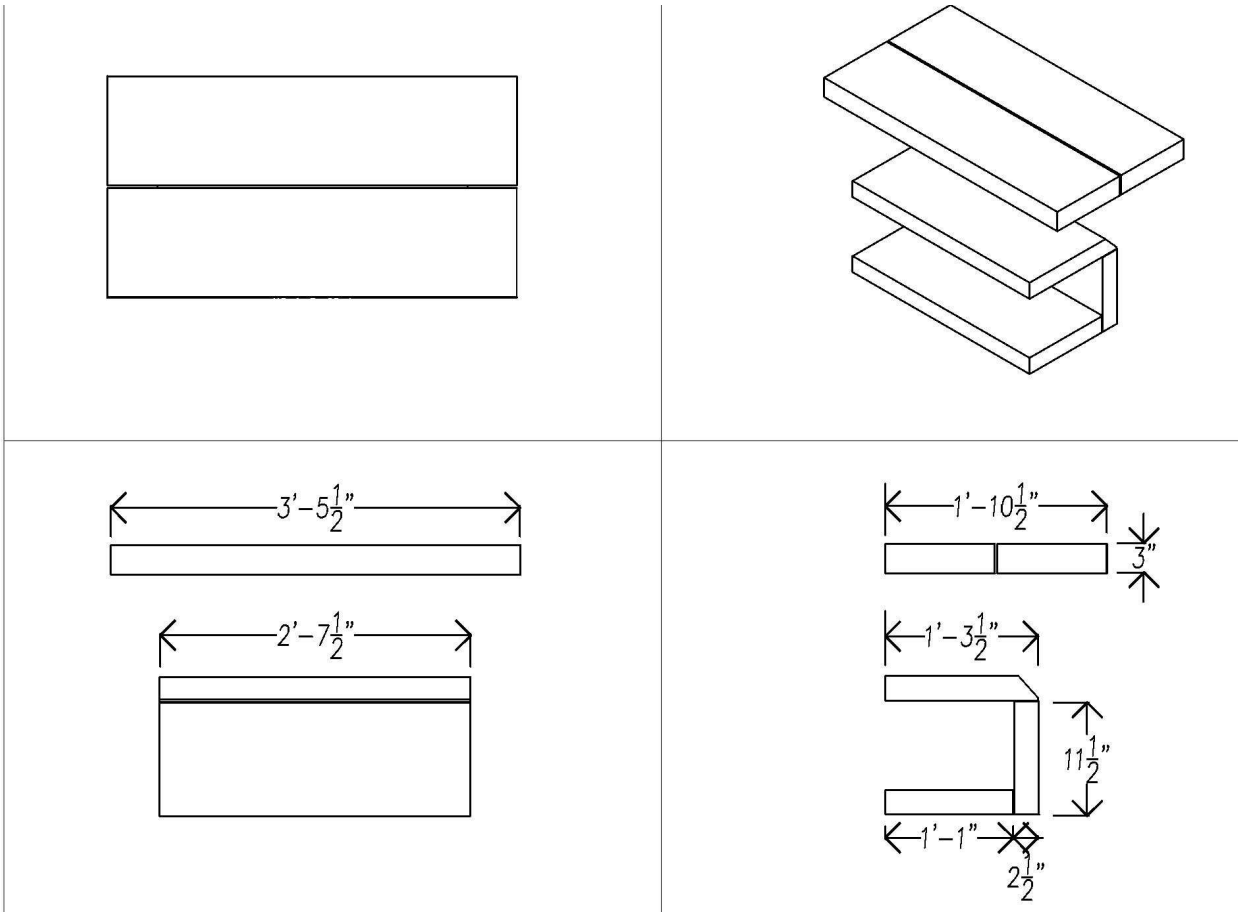
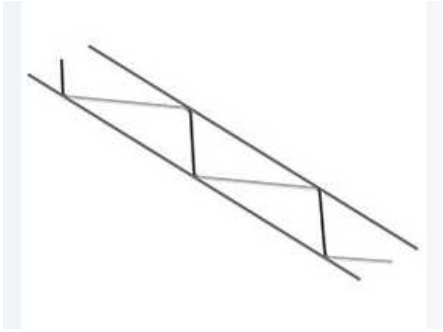


Figure 3 – the 3 bake oven slabs and the 2 piece ceiling slab



Reinforce the bake oven floor and back castings with a piece of
"Truss Wire Mesh Reinforcement for 8" concrete blocks"
http://wirebond.com/?page_id=882
available from a masonry supply yard

Place the reinforcing midway in the slabs. Bend the straight wire ends down 1.25", to create support during vibration and prevent the reinforcing from sinking in the form

Assembling the Bottom End

The bottom end of a contraflow heater is the most complicated part of the whole job. The two downdraft channels connect here, underneath the firebox. As well, the chimney connection and the cleanout openings for the particular installation need to be determined and located here.

This plan shows a rear exit chimney, and front cleanouts. The chimney can be connected anywhere along the rear or sides. The cleanouts location can also vary, and should allow adequate access to remove fly ash that drops off at the bottom of the channels over the years.

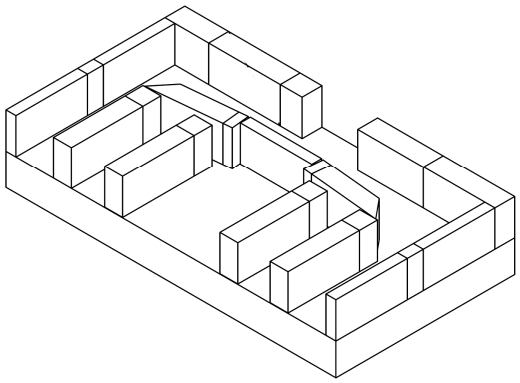


Figure 4

First course. Note the cleanout openings in the front, and the chimney opening in the rear.

A rear connecting channel joins the two downdrafting side channels.

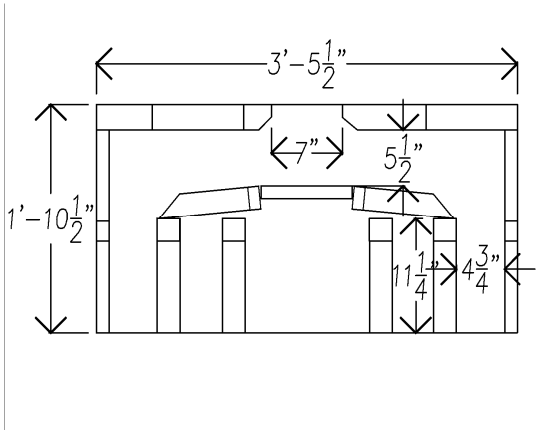


Figure 5

Layout diagram. Note the firebrick split to allow clearance for the grate over the connecting channel.

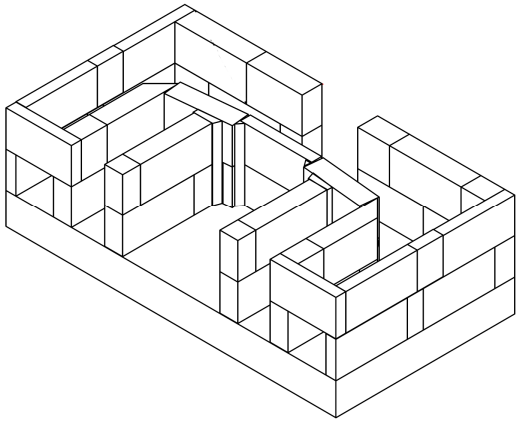


Figure 6

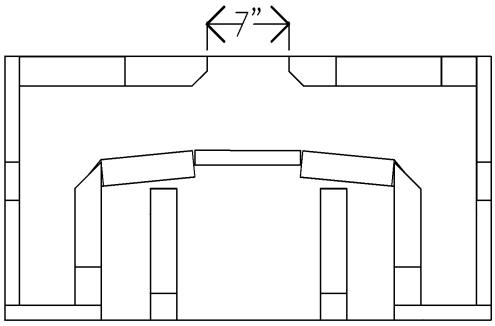


Figure 7

Firebox and Heat Exchange Channels

Install the firebrick floor slab onto a bed of refractory mortar.

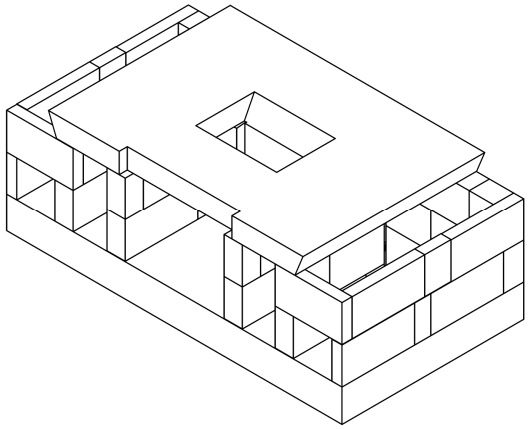


Figure 8

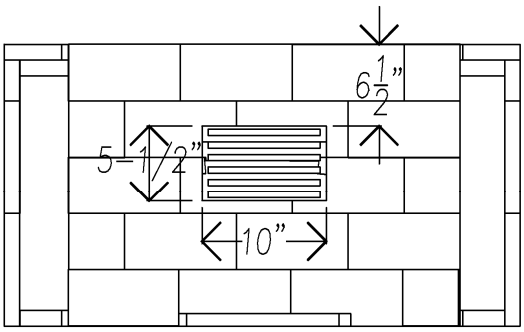


Figure 9

Firebrick lining for the floor.

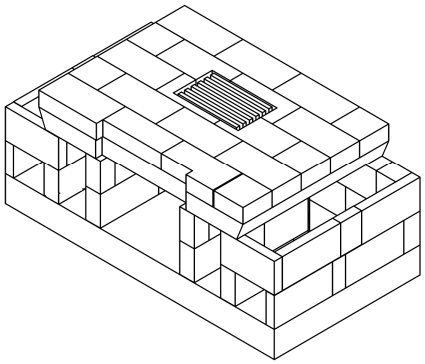


Figure 10

Note the 1” notch in the front for a comubstion air channel

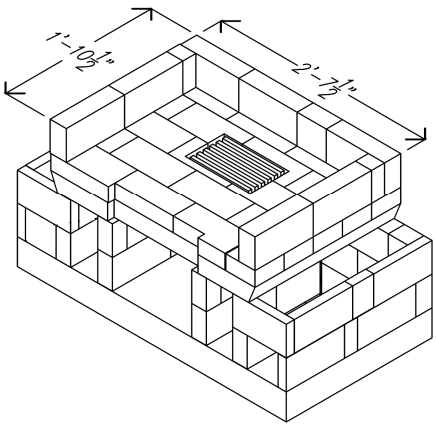


Figure 11

Firebox is built with an inner and outer shell. Layout for outer shell. Short sidewall cut piece is 2”. Cut in rear wall is 4.25”

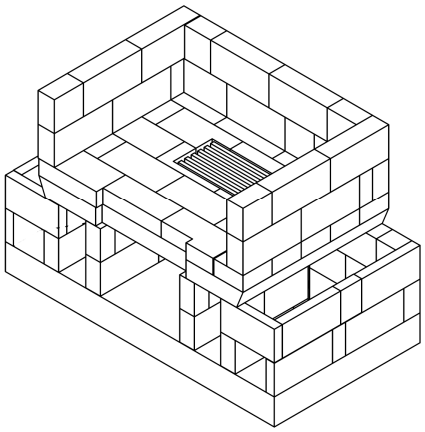


Figure 12

Second course of firebox. Each sidewall has a half brick. Rear has a half and a 4.25”

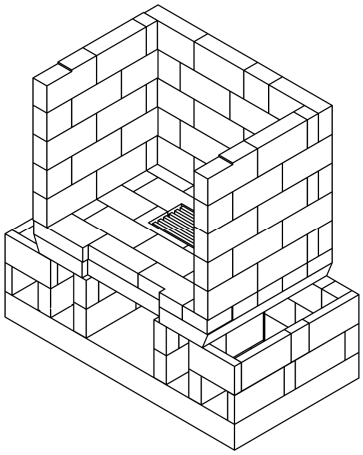


Figure 13

Firebox is five courses. Note ¼” notch in top front bricks, to allow for angle iron firebox lintel.

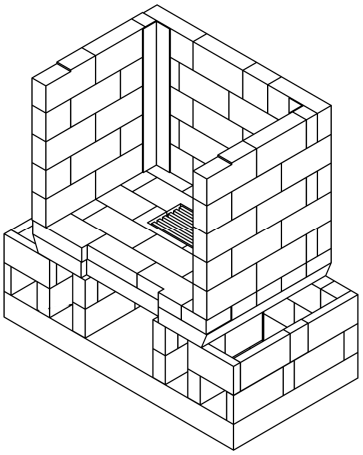


Figure 14

Inner firebox is laid up dry against the outer. Use cardboard strips or ceramic paper to create and expansion joint in the rear corners as shown.

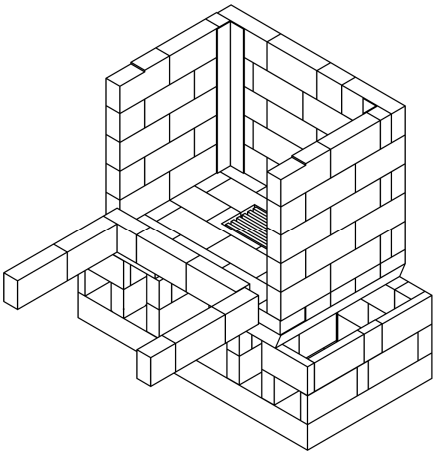


Figure 15

Inner layout starts with a half brick on the right.

Each course has two 6” cuts. Cut end is always buried in a blind corner.

This is the part of the core that will show. Select firebricks to avoid cracked bricks, and to avoid chips showing on the front face.

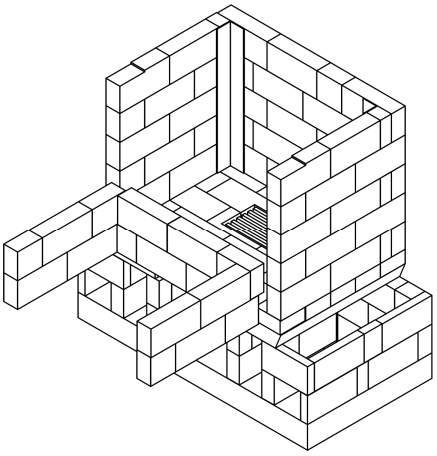


Figure 16

Second course is reverse of the first, starting with the half brick on the left.

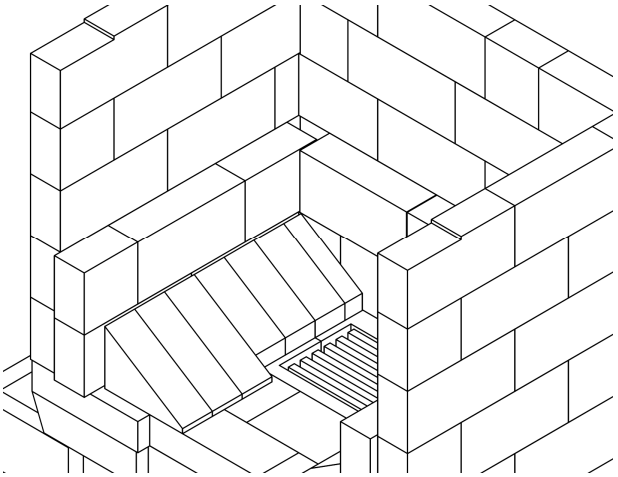


Figure 17

Detail showing angled cuts to create a floor slope. This detail can be added later in the construction sequence

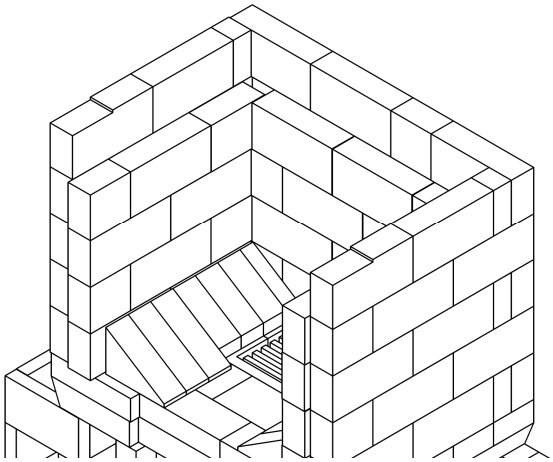


Figure 18

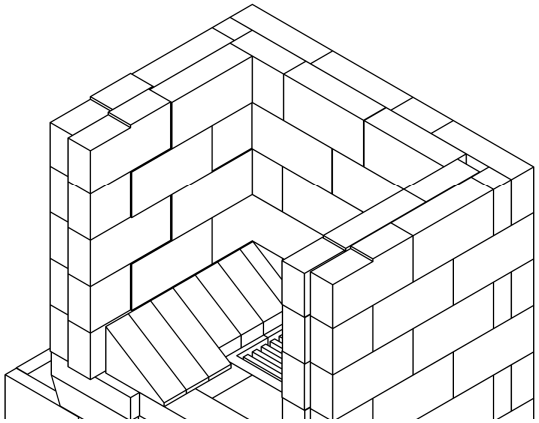


Figure 19

Note the ¼" notches to receive the angle iron

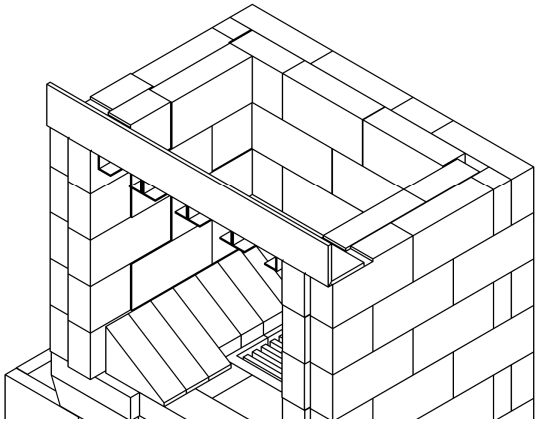


Figure 20

Angle iron lintel is 4"x4"x1/4" and is 31.5" long. Angle iron brackets are welded to the bottom to allow firebrick splits to be slid in, to act as heat shields for the lintel.

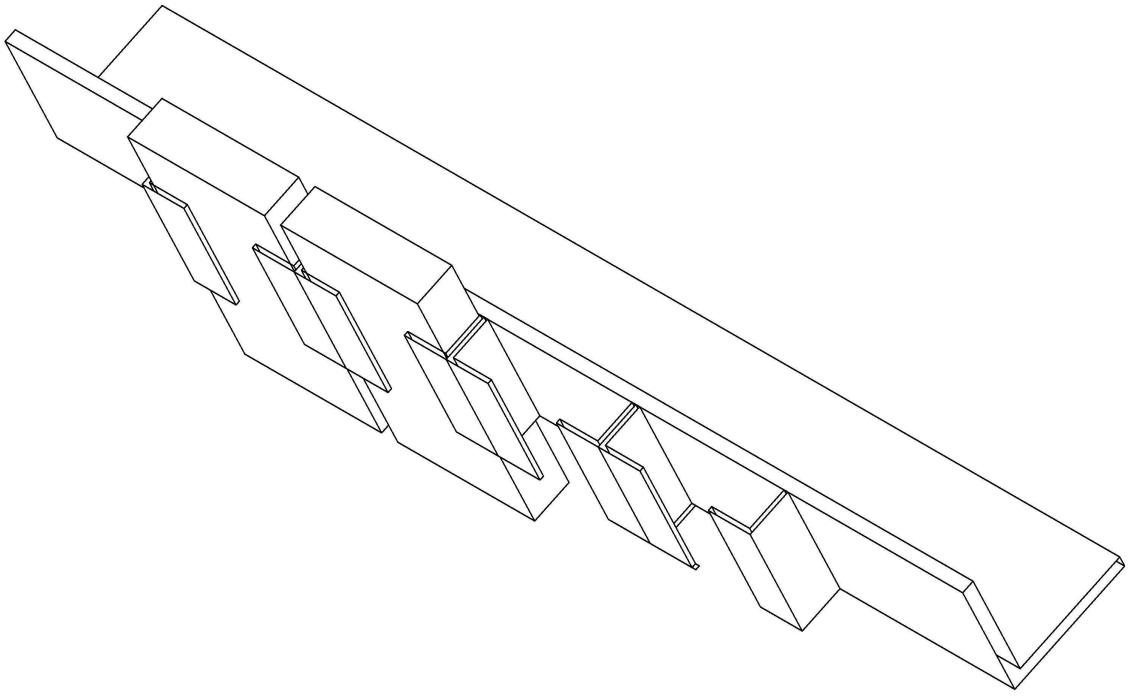


Figure 21

View of firebox lintel from below, showing welded on brackets

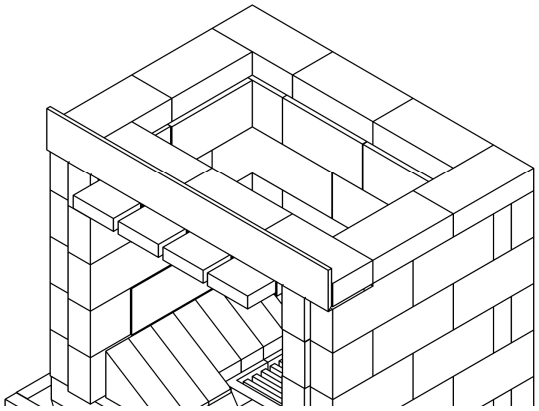


Figure 22

The heat shields are slid forward to also protect the facing lintel later.

Next course is full bricks laid as stretchers.

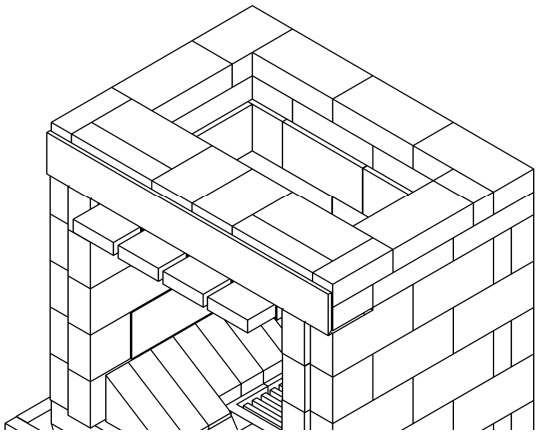


Figure 23

Cuts shown are soaps (bricks ripped lengthwise), and ¾ bricks (= 6.75” long)

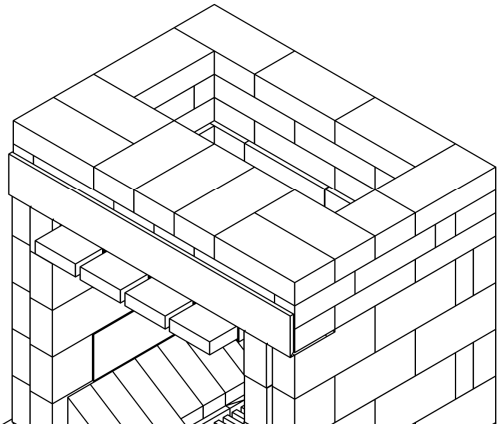


Figure 24

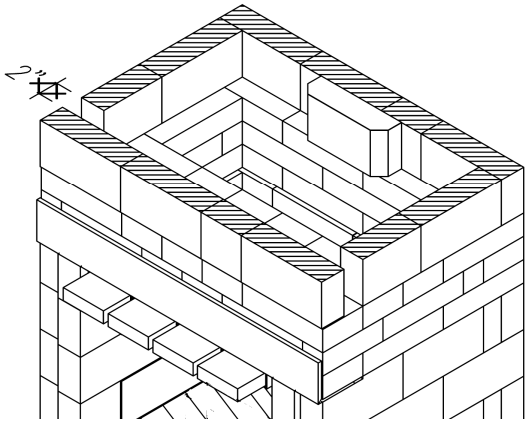


Figure 25

Base for oven. Two 2” bypass slots are left to boost oven floor heat.

Hatching is shown for clarity.

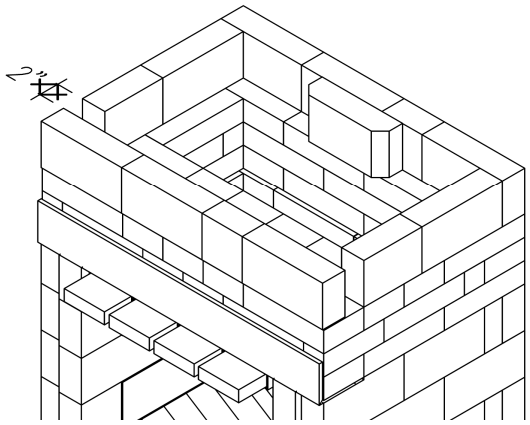


Figure 26

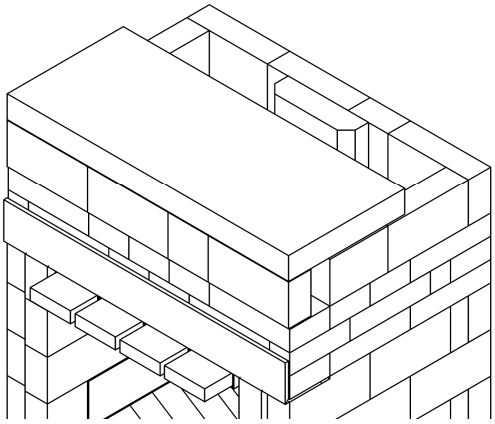


Figure 27

Oven floor slab is installed in a bed of refractory mortar and levelled. Clean up mortar squeeze out under slab.

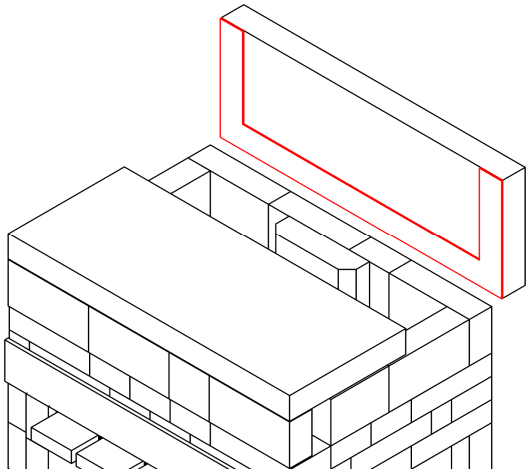


Figure 28

Gaskets are cut from 1/8” ceramic paper and adhered to slabs with dabs of refractory mortar or silicone

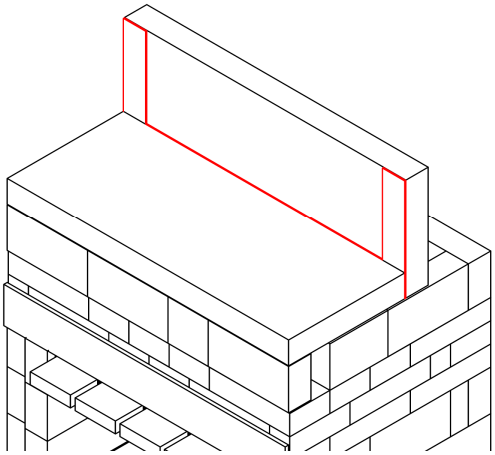


Figure 29

Slide oven back in place. It sits dry.

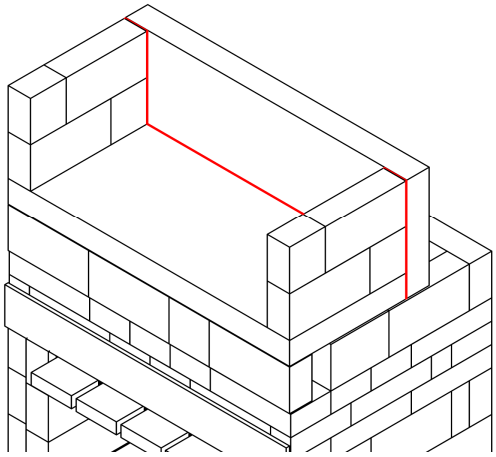


Figure 30

Side walls are brick. Use a dry joint against the gasket.

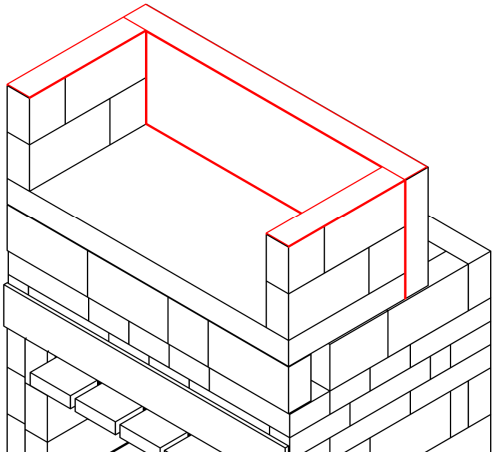


Figure 31

Gasket on top.

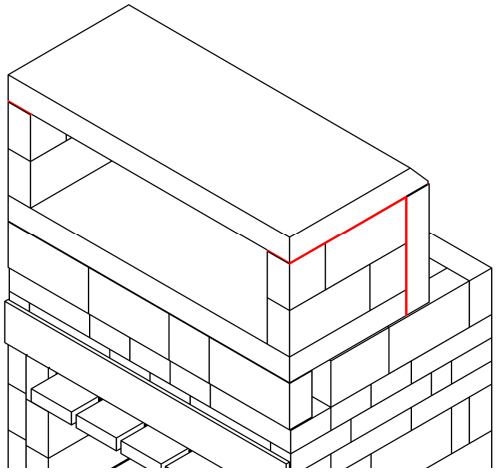


Figure 32

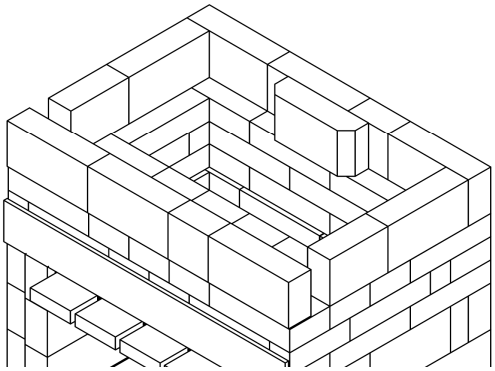


Figure 33

Oven is not shown, for clarity.

Continue building up around the back as shown.

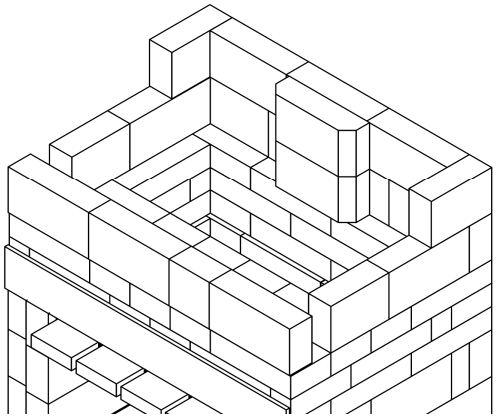


Figure 34

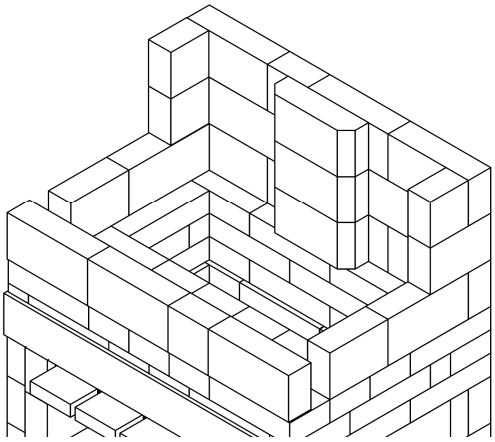


Figure 35

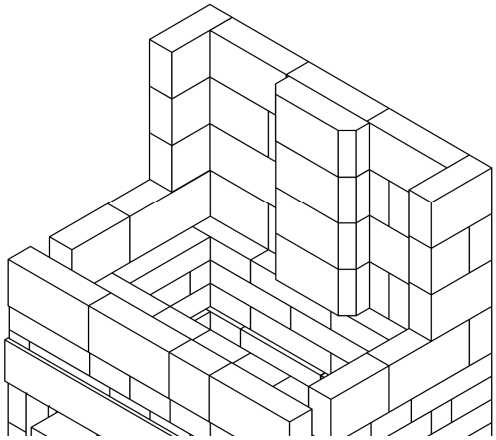


Figure 36

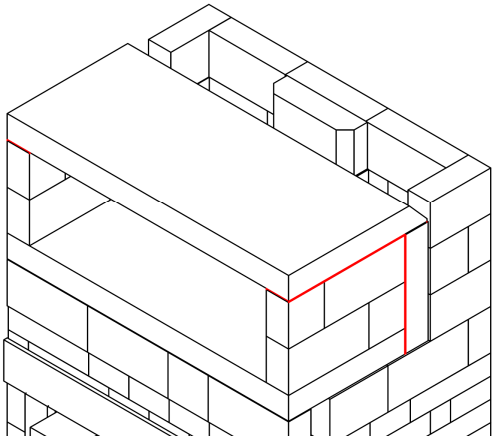


Figure 37

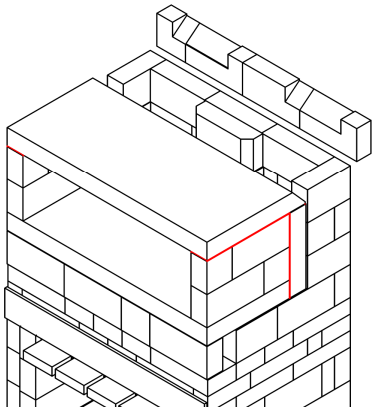


Figure 38

Transition bricks to cap off flared out rear side channels. Show tilted up for clarity.

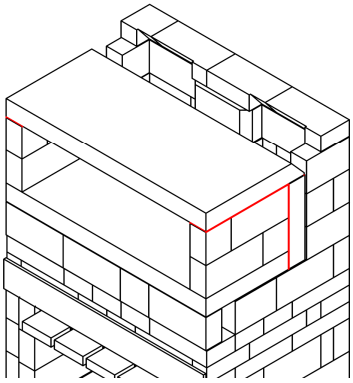


Figure 39

Same as Figure 38, bricks in place.

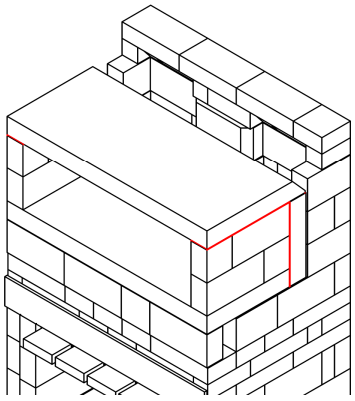


Figure 40

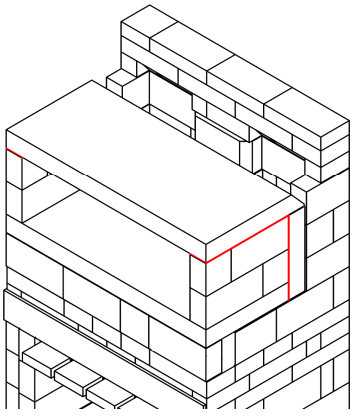


Figure 41

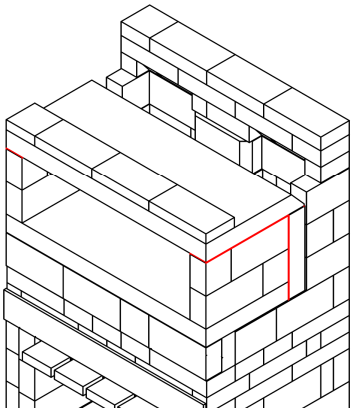


Figure 42

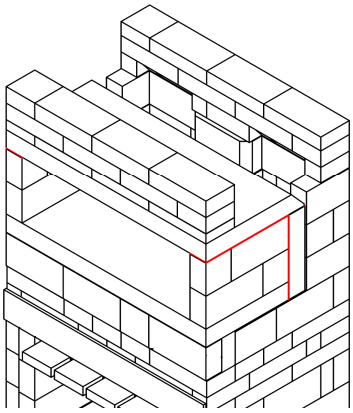


Figure 43

Adjust height so that front and rear coursing is level. Splits are shown here.

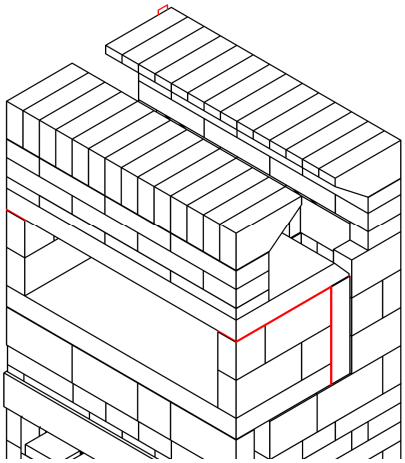


Figure 44

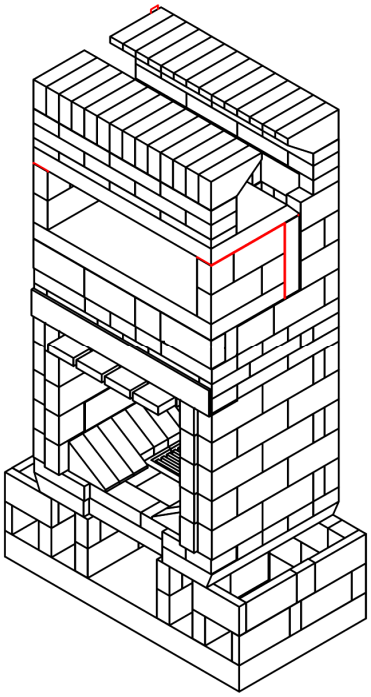


Figure 45

Angled transition header course to carry ceiling slabs.

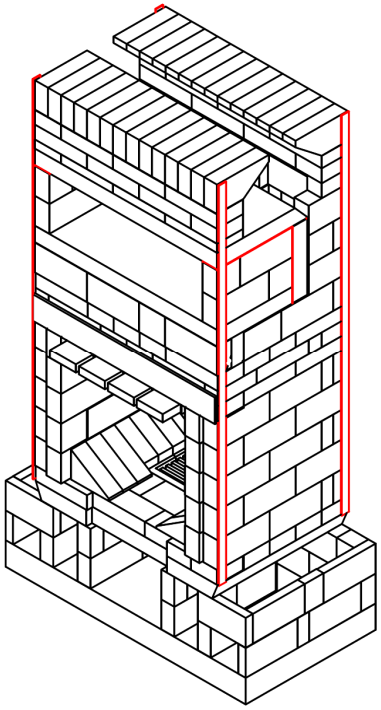


Figure 46

Glue on a ¼” thick strip of ceramic paper, or ceramic fibre to provide an expansion joint where the side channels will meet the firebox

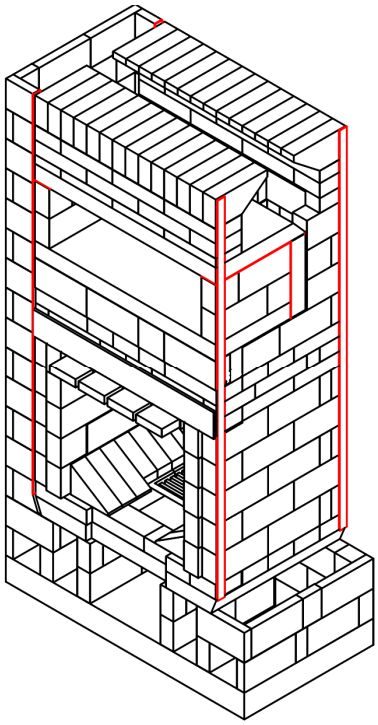


Figure 47

Left side channel is shown completed

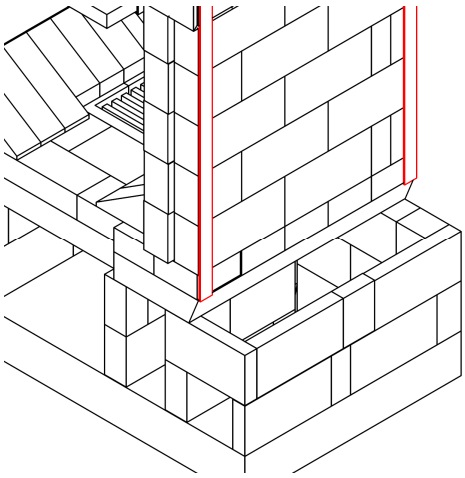


Figure 48

Build up side channels with firebrick splits.

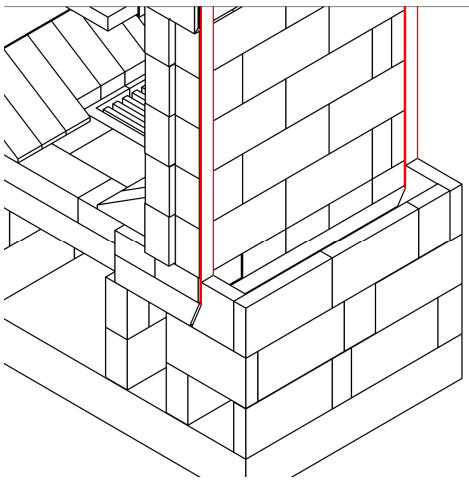


Figure 49

Use the bond pattern shown.

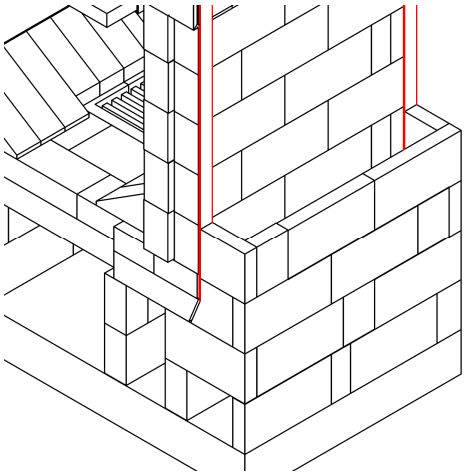


Figure 50

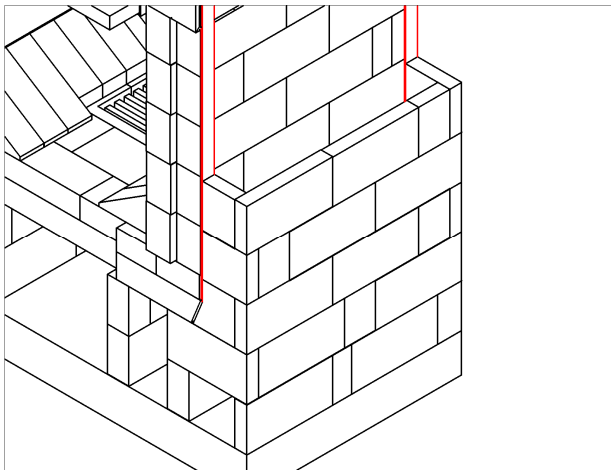


Figure 51

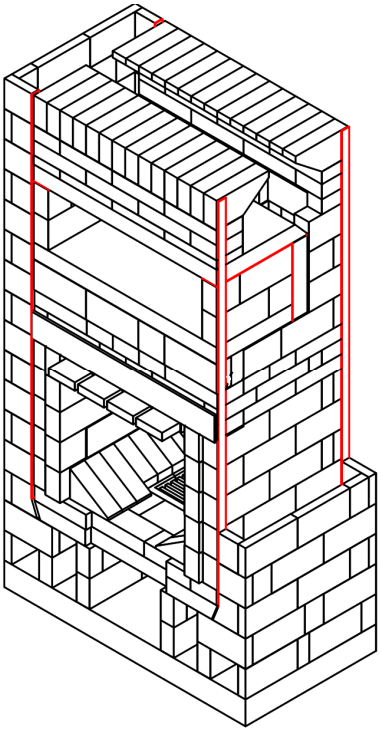


Figure 52

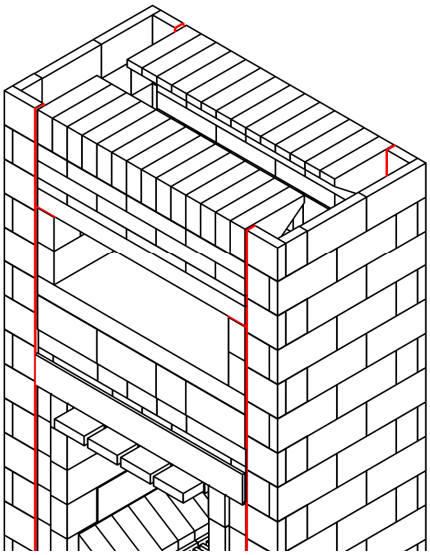


Figure 53

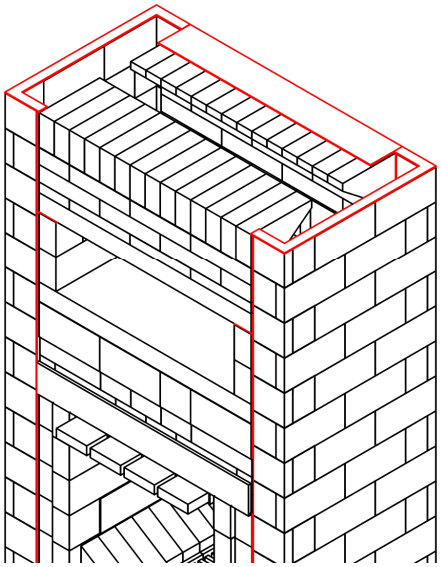


Figure 54

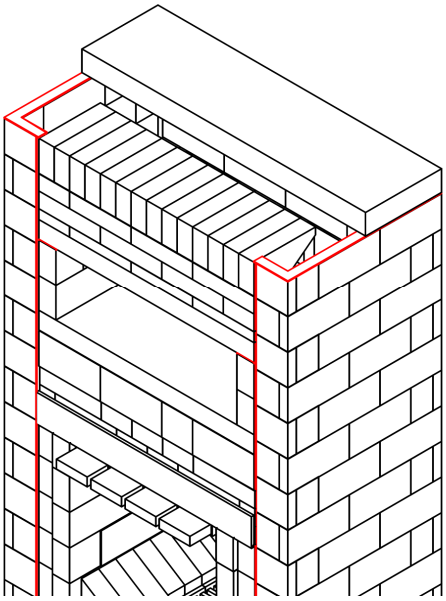


Figure 55

Lay down ceramic paper gasketing as shown to receive the ceiling slabs, which sit dry.

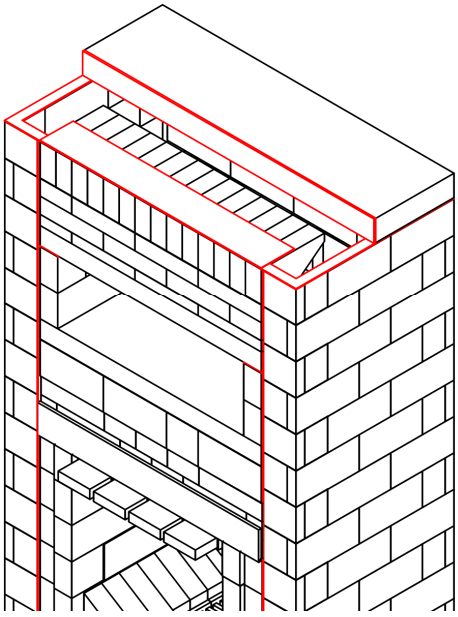


Figure 56

Use a gasket between the two ceiling slabs as shown.

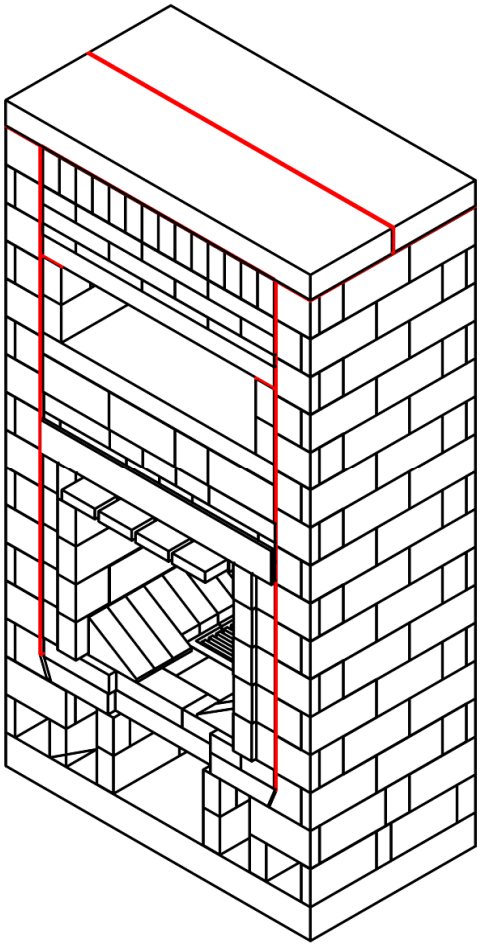


Figure 57 Completed core.

Facing

For information on doing the facing, refer to the photo sequence from the 2008 Wildacres workshop, which is located here:

http://mha-net.org/docs/v8n2/wildac08c.htm

The finishing instruction for the 22” Heat-Kit heater also apply to this core, and are located here:

http://heatkit.com/docs/assembly/Finish.PDF (English)

http://heatkit.com/docs/finish/Finish.F.pdf (French)

Tempcast also publishes some finishing information specific to their door and air system:

http://www.tempcast.com

Revised on July 10, 2008

Double Bell Heater

Designed by Igor Kuznetsov and Alex Chernov
Built at 2008 Wildacres Workshop

Material List

Core:

1. Firebrick 2.5x4.5 x9 - 600pc
2. Firebrick tile 12x24x2.5 3 to 6pc
3. Refractory mortar 55lbs (25kg) pails - 3pails

Facing:

1. Clay brick (8x3.5x2.25) - 850pc
2. Mortar mix according to quantity of brick
3. 24 iron angle 3.5x3.5 1pc
4. 36 iron angle 3.5x3.5 1pc
5. Pieces of 3x4 aluminum or galvanized steel flashing 8ft
6. Stone for capping the firebox shelf
7. Optional stone for capping heater top, or
8. 1 bag of coarse vermiculite and bag of Portland cement for sealing mix.
9. Strips of mineral or ceramic wool.
10. 100 sq ft of mineral wool or cardboard for expansion joint

Hardware:

1. Cast-iron firebox door 1pc
2. Ash-box door of some sort 1pc
3. Clean-out doors of some sort 3pc
4. Grate 2.25x 15
5. Shut-off chimney damper 1pc
6. Ceramic or mineral wool for door gaskets

3-D Views and Sections

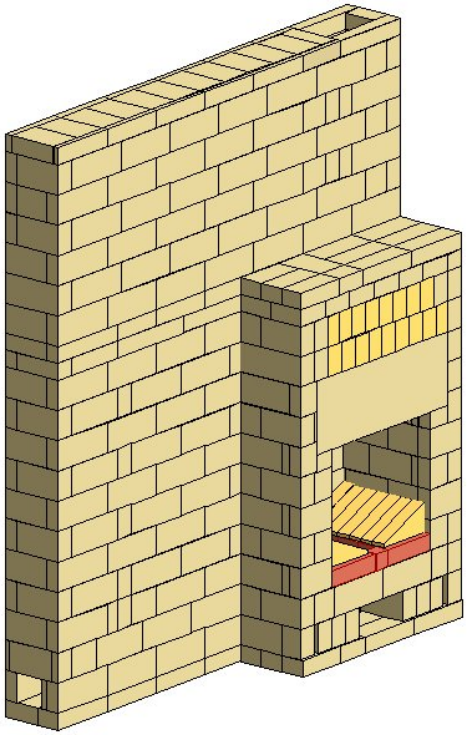


Figure 1 – full view, front

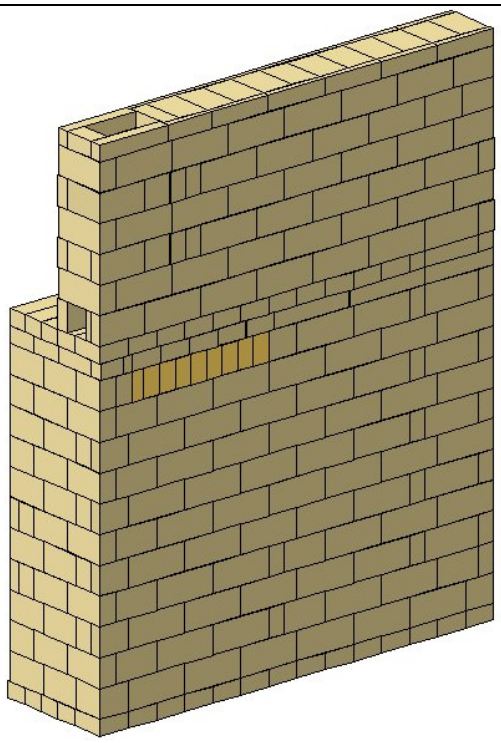


Figure 2 – full view, back

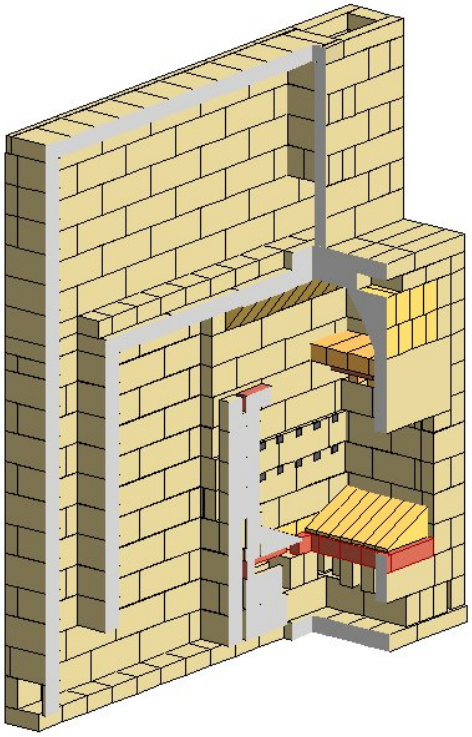


Figure 3 – front section

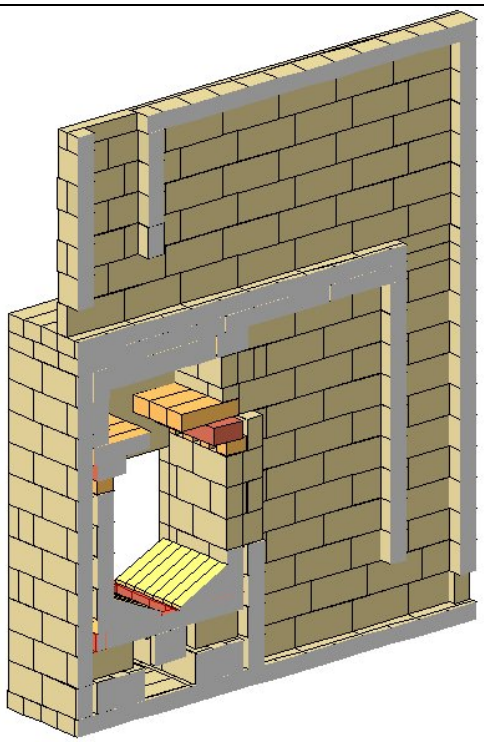


Figure 4 – rear section

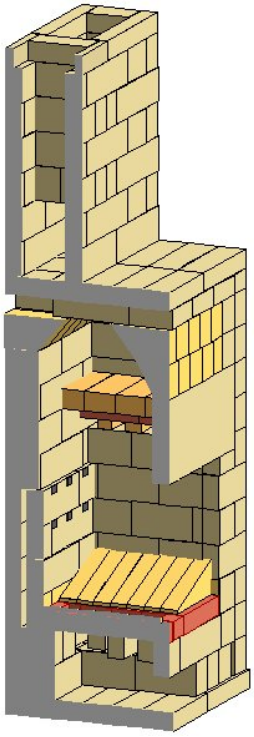


Figure 5 – left section

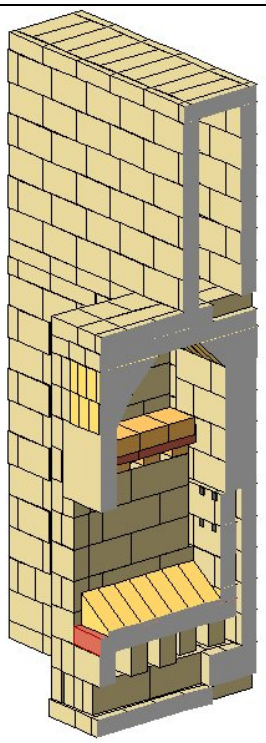


Figure 6 – right section

3-D Assembly Sequence

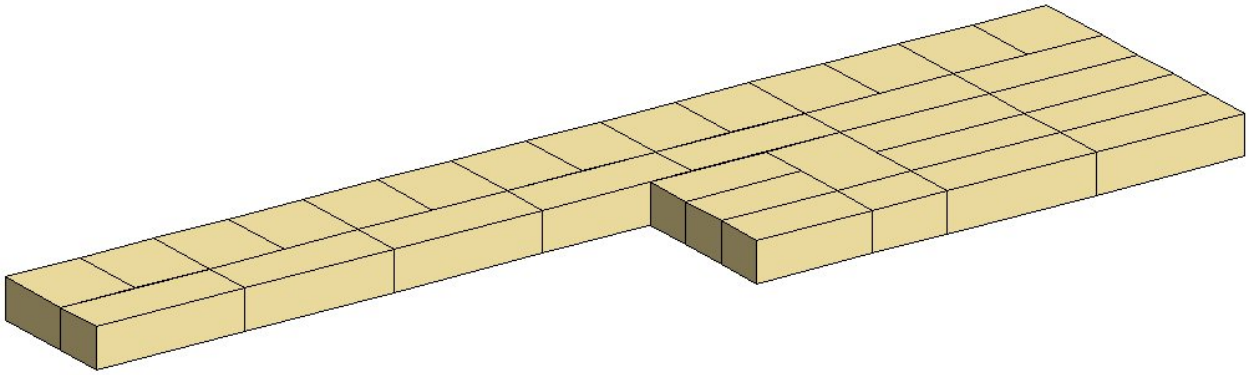


Figure 7 – course 1

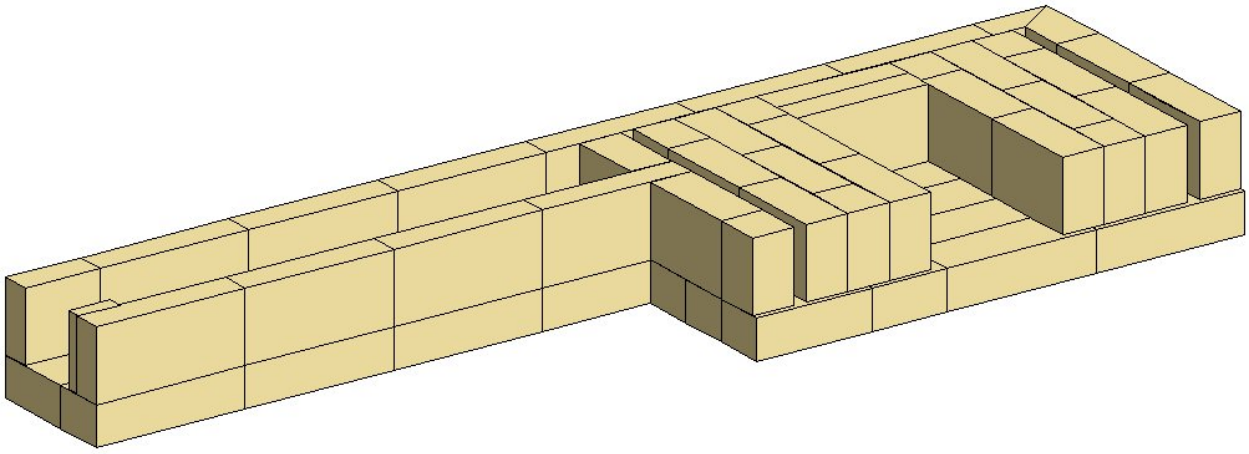


Figure 8 – course 2

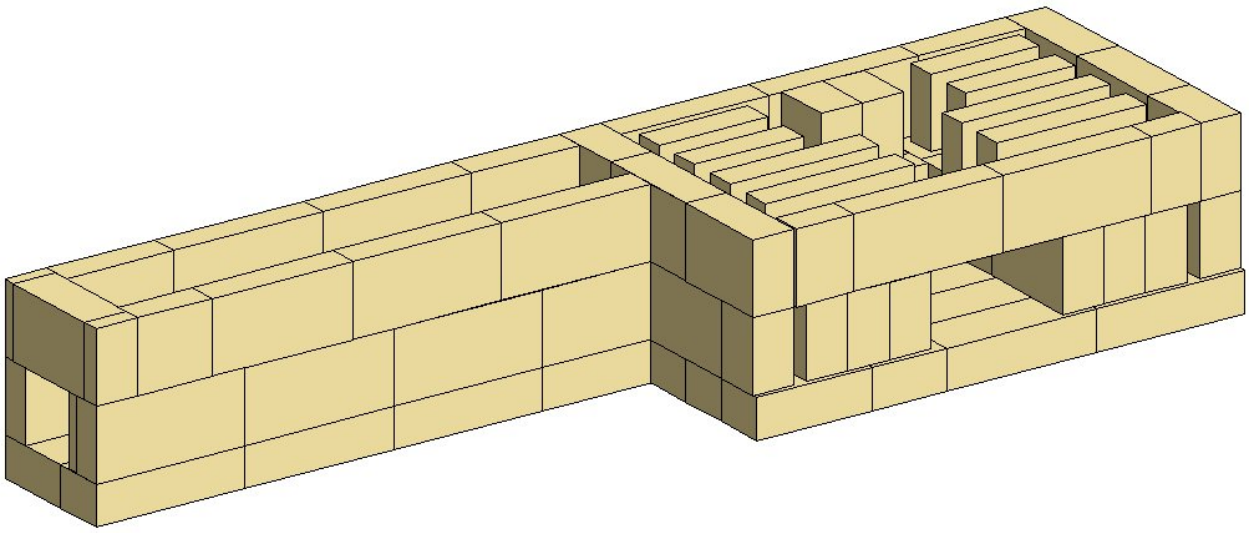


Figure 9 - course 3

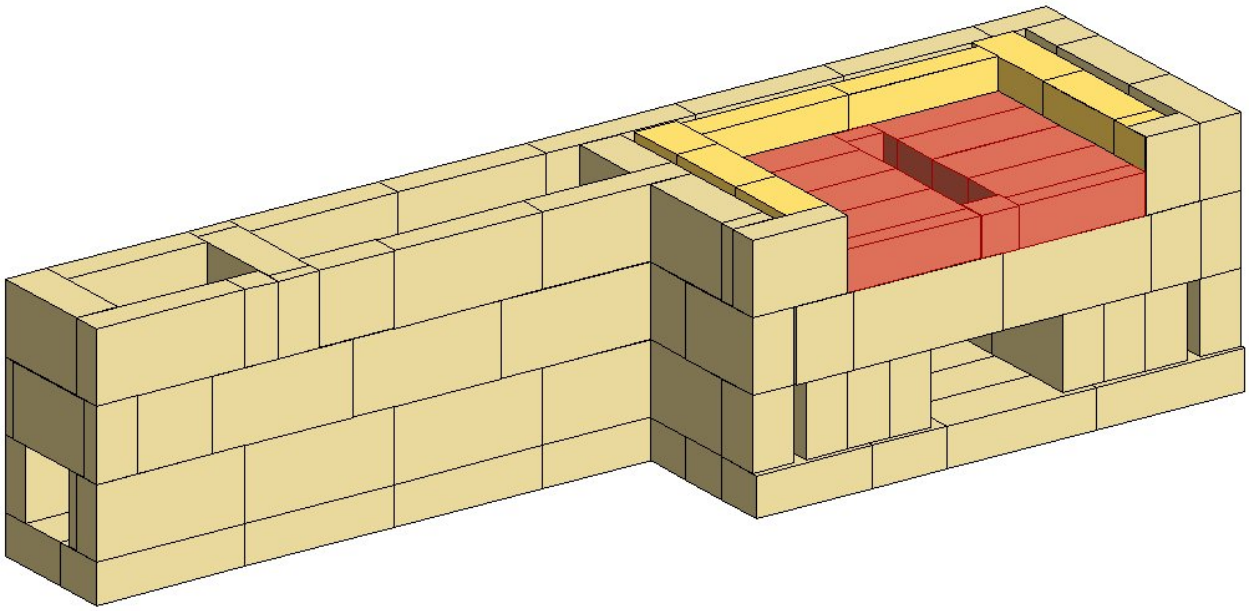


Figure 10 – course 4

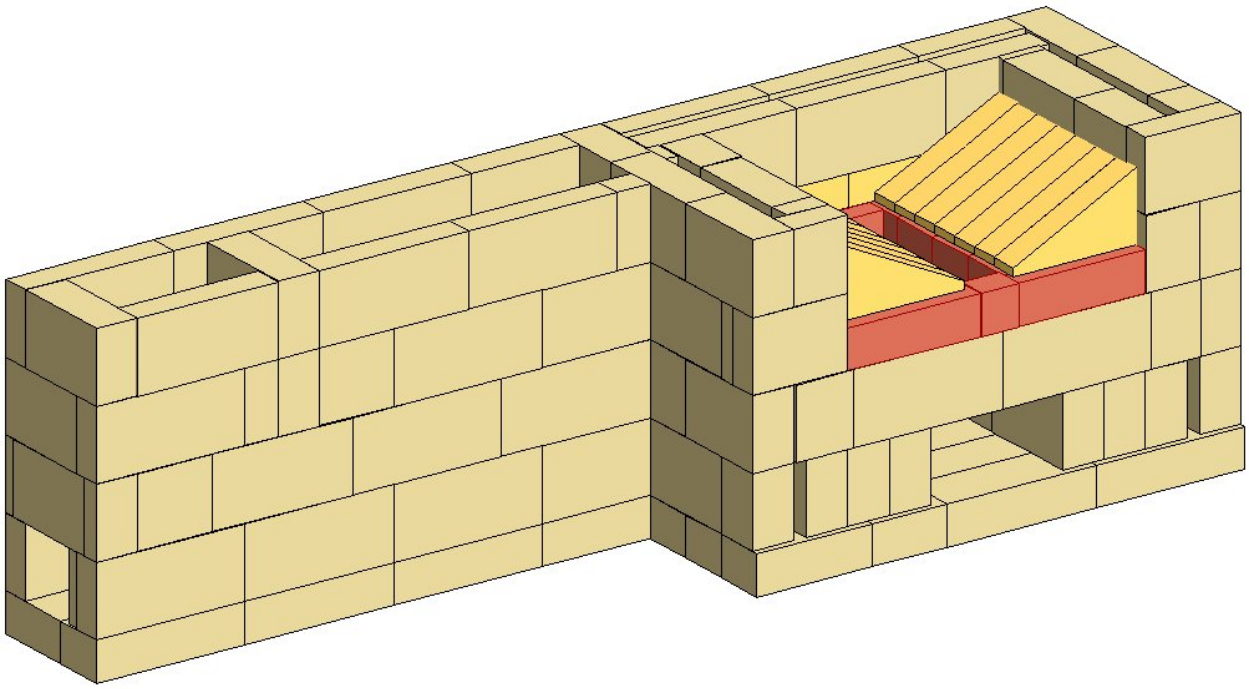


Figure 11 – course 5

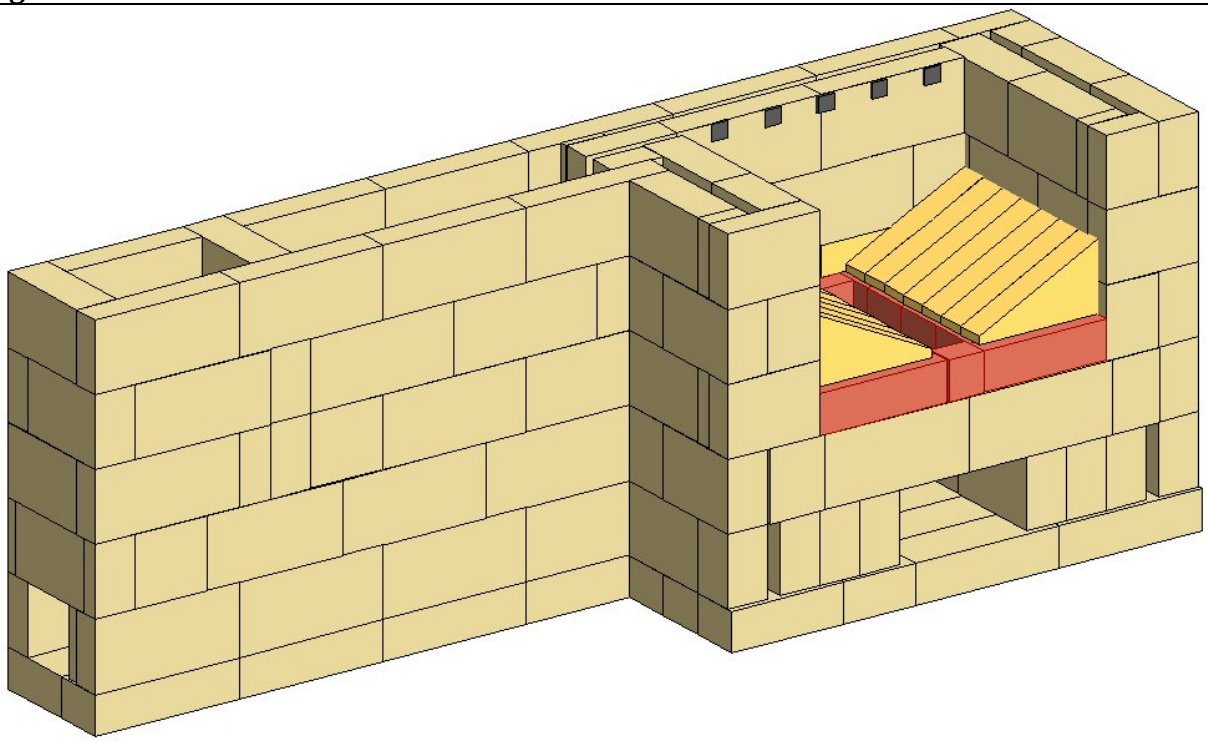


Figure 12 – course 6

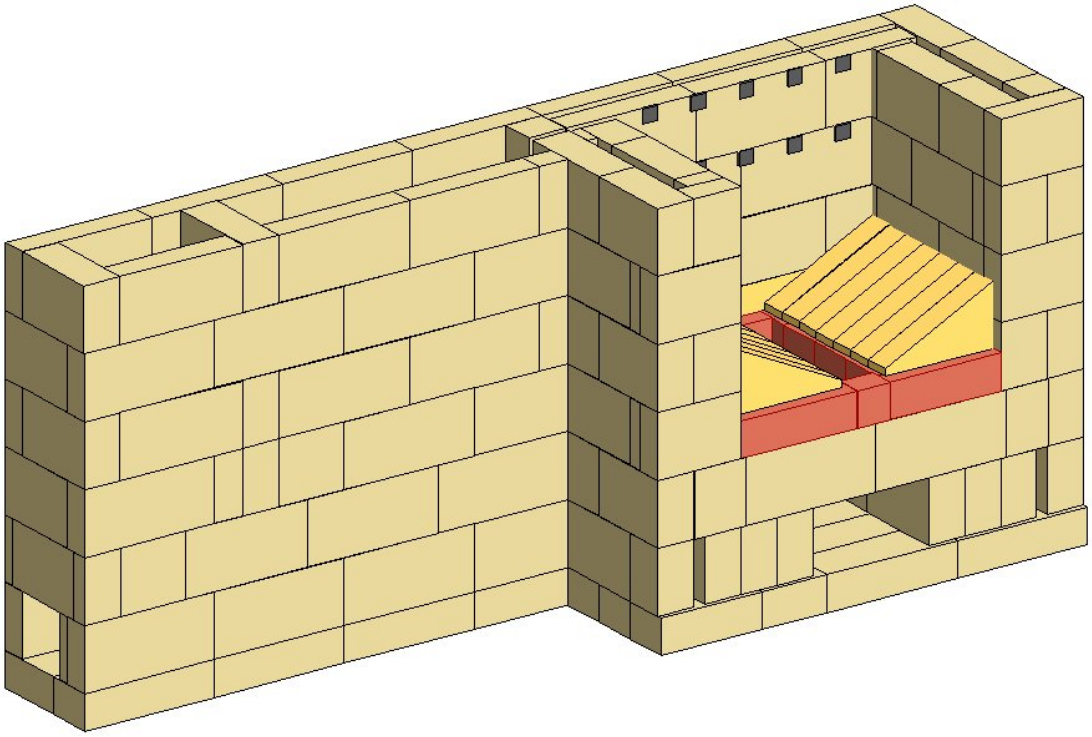


Figure 13 – course 7

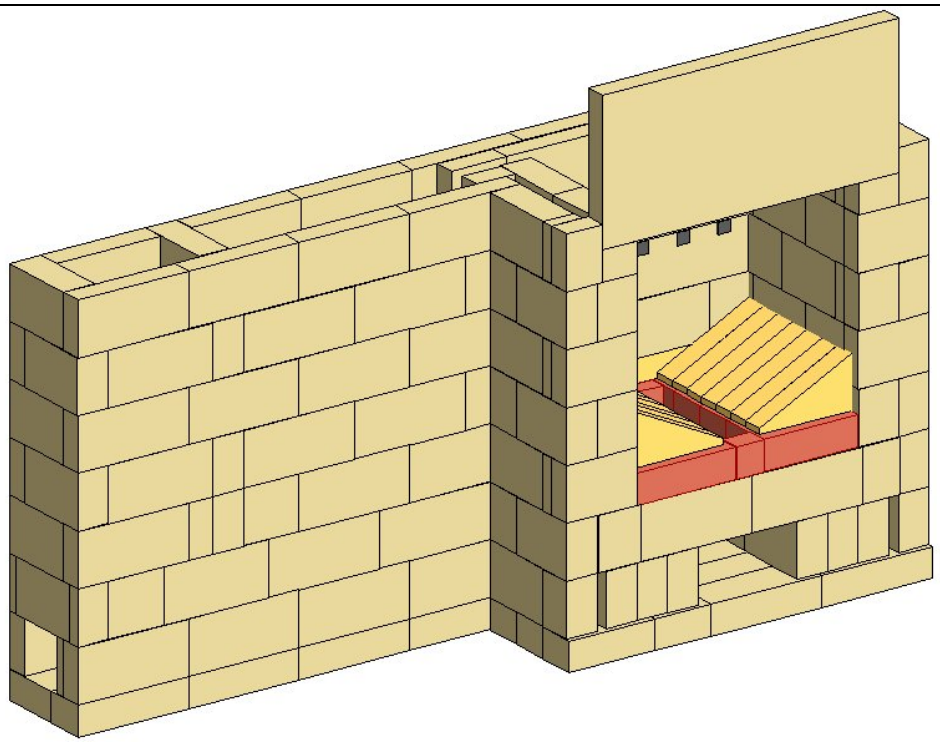


Figure 14 – course 8

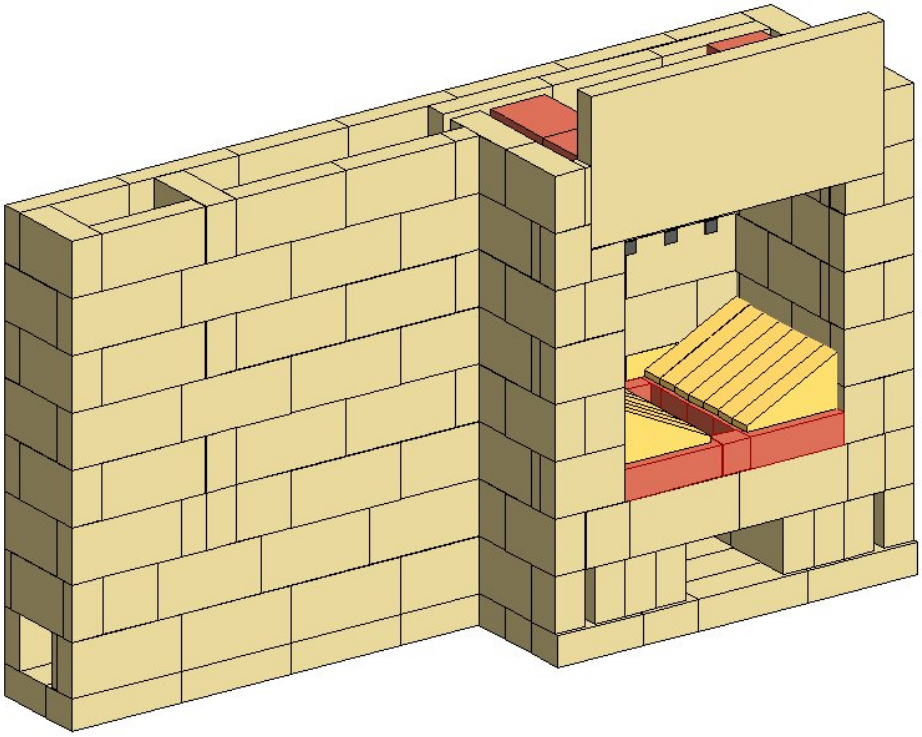


Figure 15 – course 9

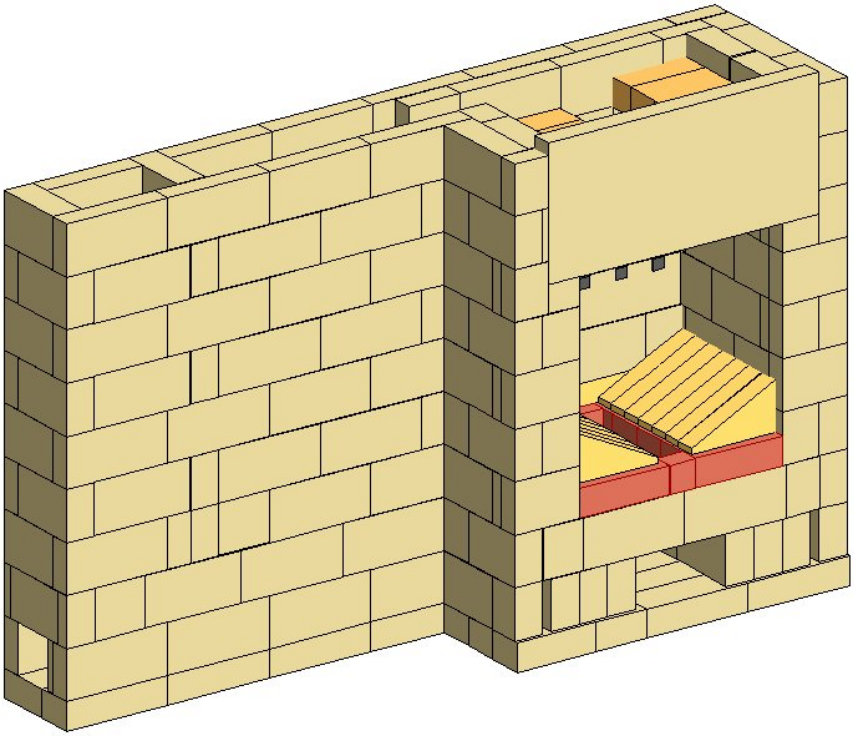


Figure 16 – course 10

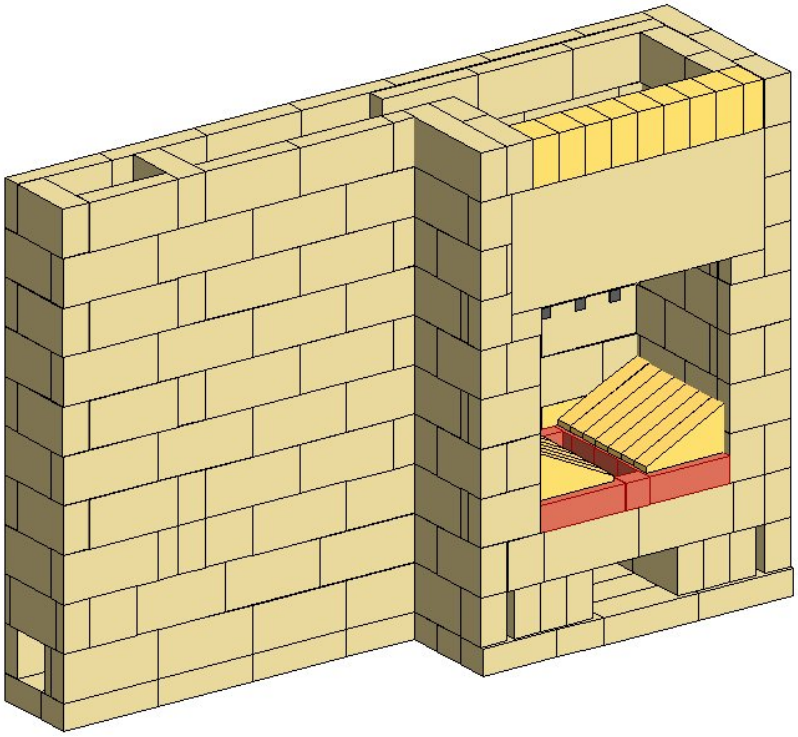


Figure 17 – course 11

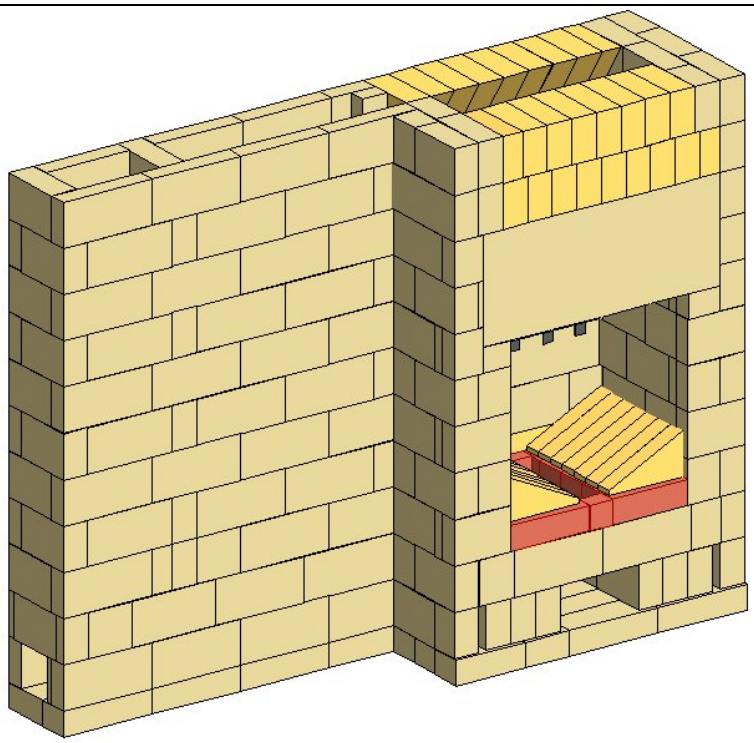


Figure 18 – course 12

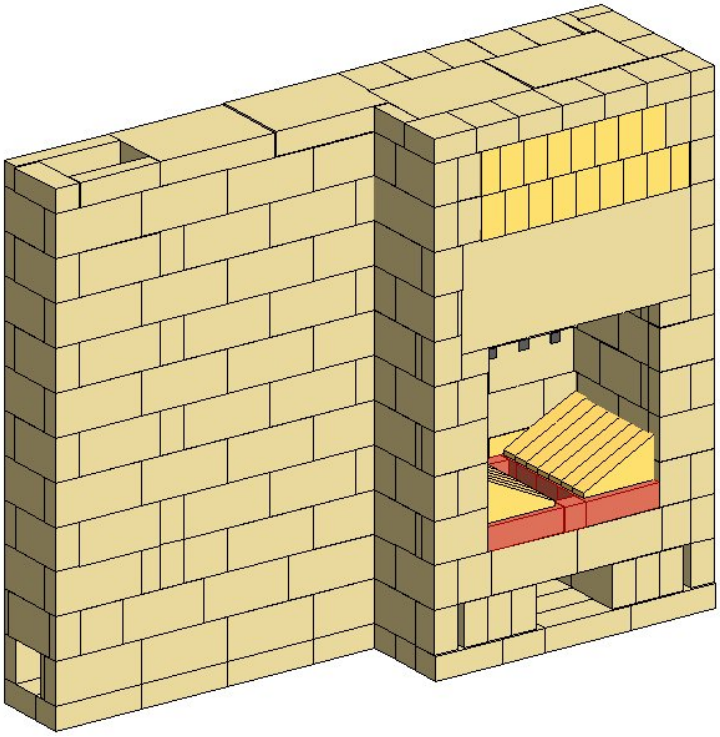


Figure 19 – course 13

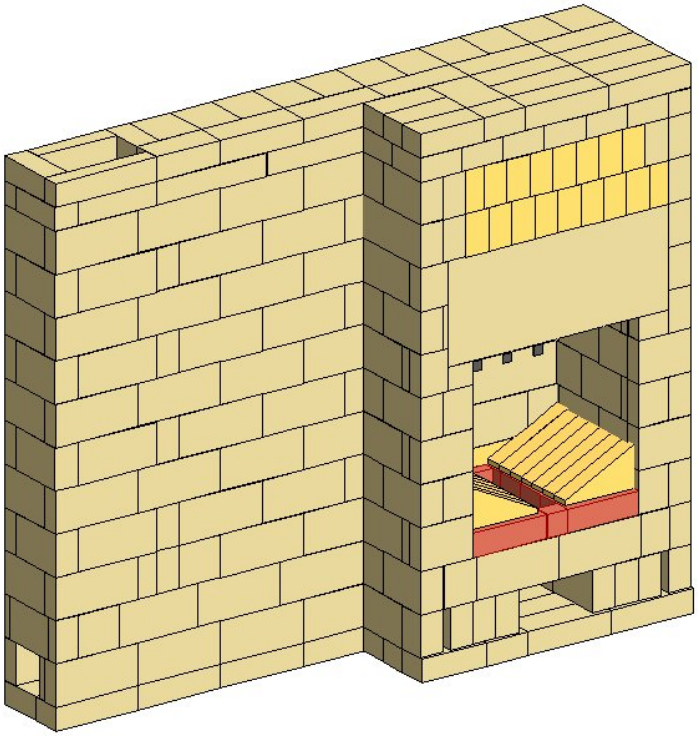


Figure 20 – course 14

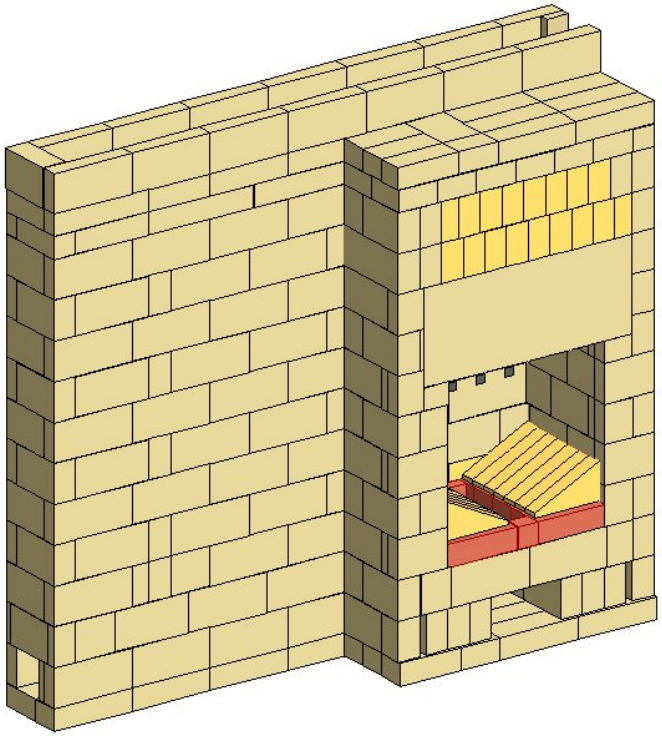


Figure 21 – course 15

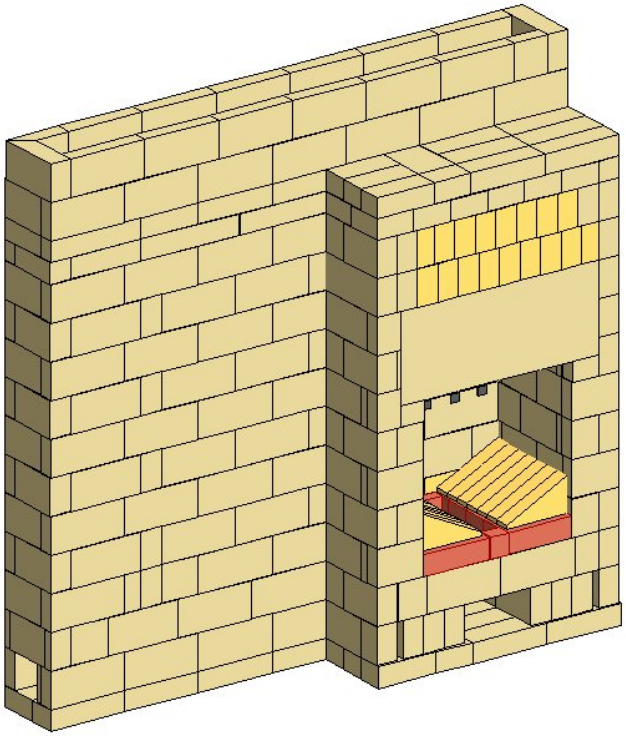


Figure 22 – course 16

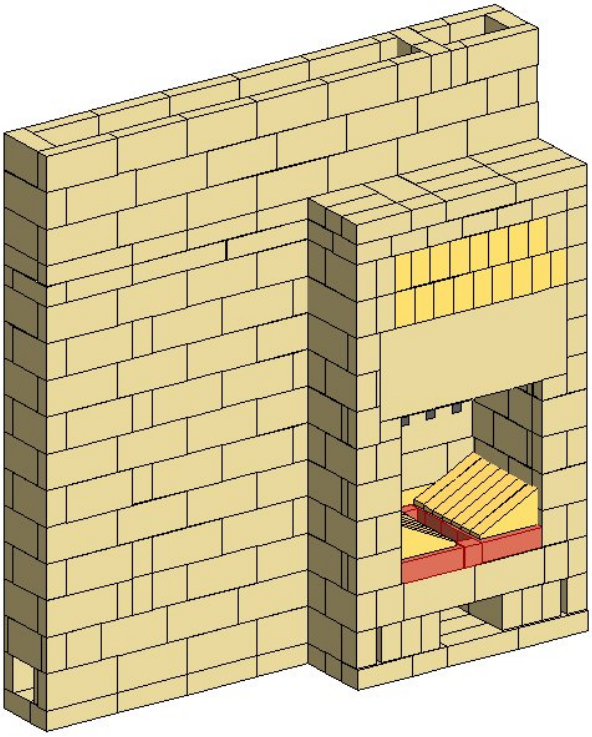


Figure 23 – course 17

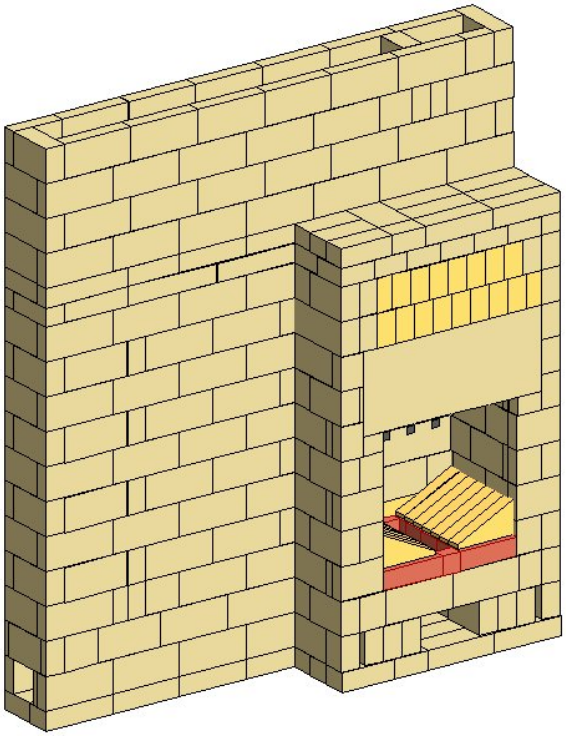


Figure 24 – course 18

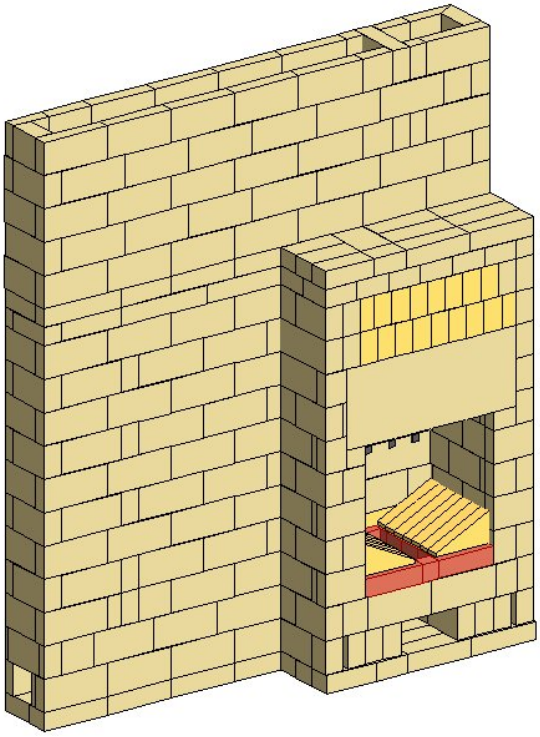


Figure 25 – course 19

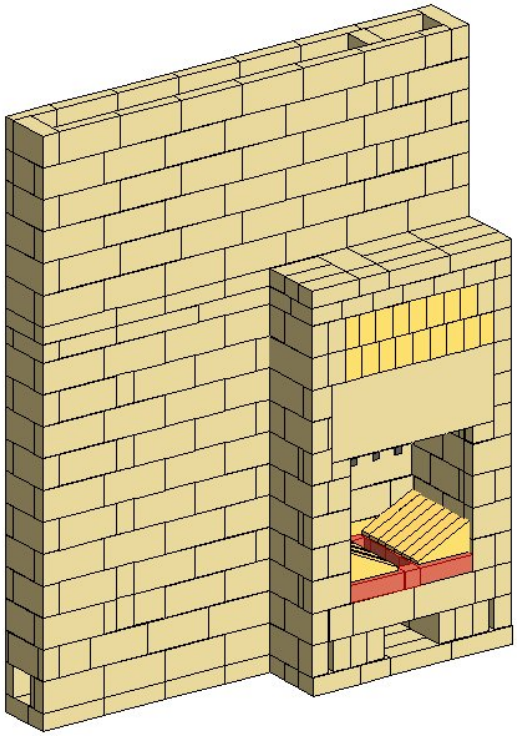


Figure 26 – course 20

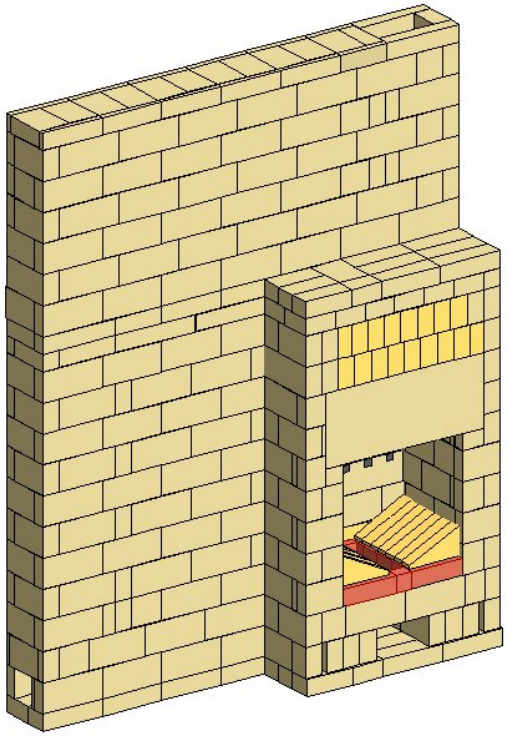


Figure 27 – course 21

3-D By Individual Course

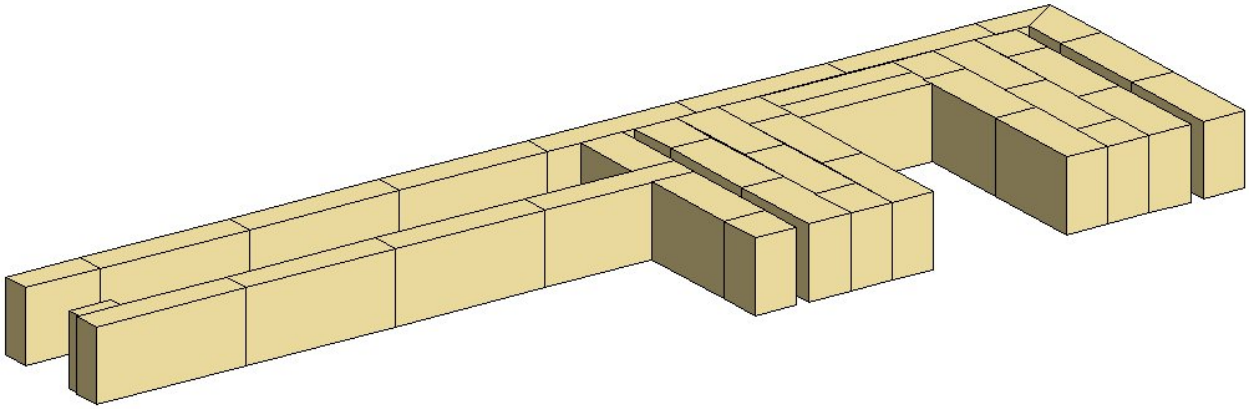


Figure 28 – course 2 (see Figure 7 – course 1for course 1)

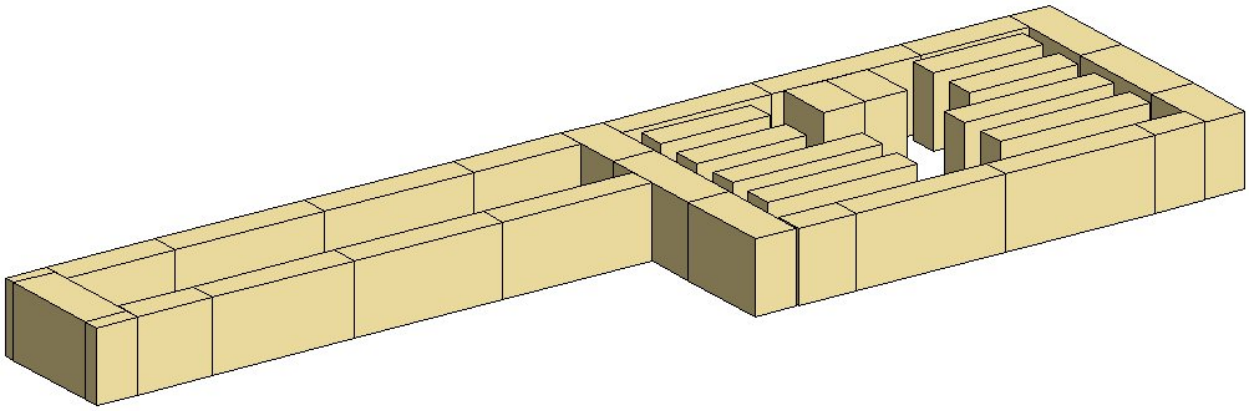


Figure 29 – course 3

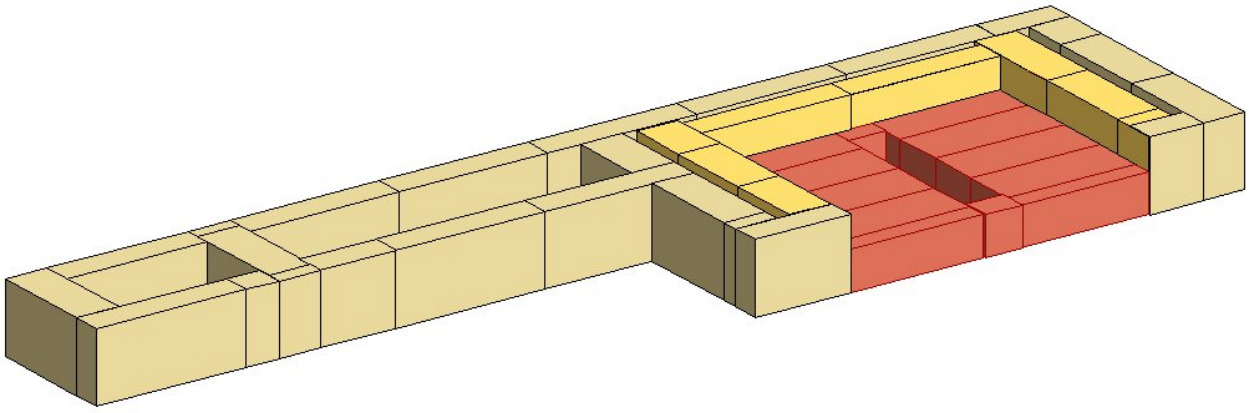


Figure 30 – course 4

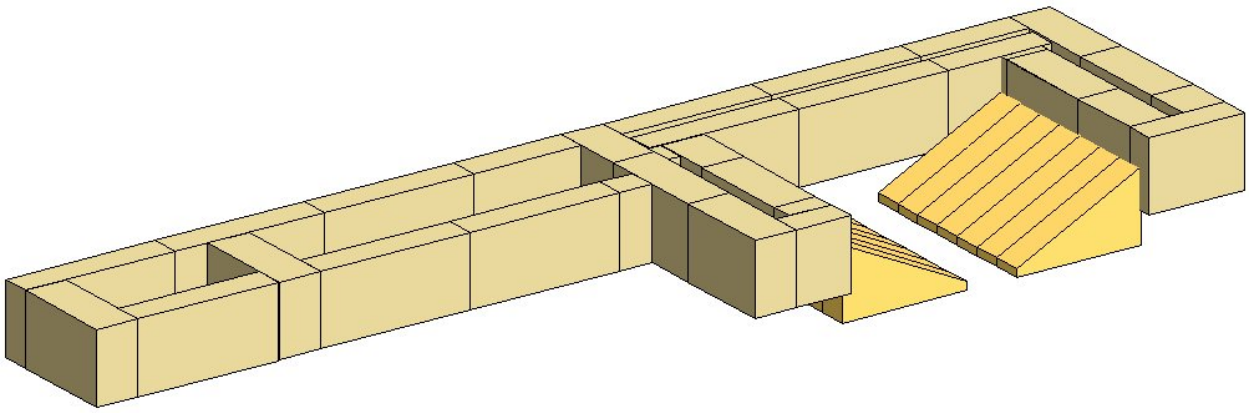


Figure 31 – course 5

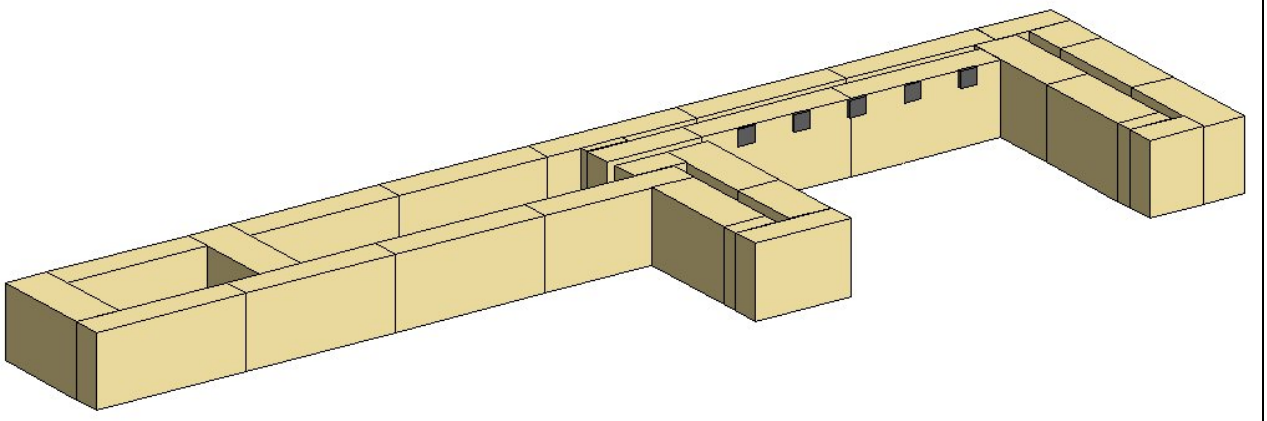


Figure 32 – course 6

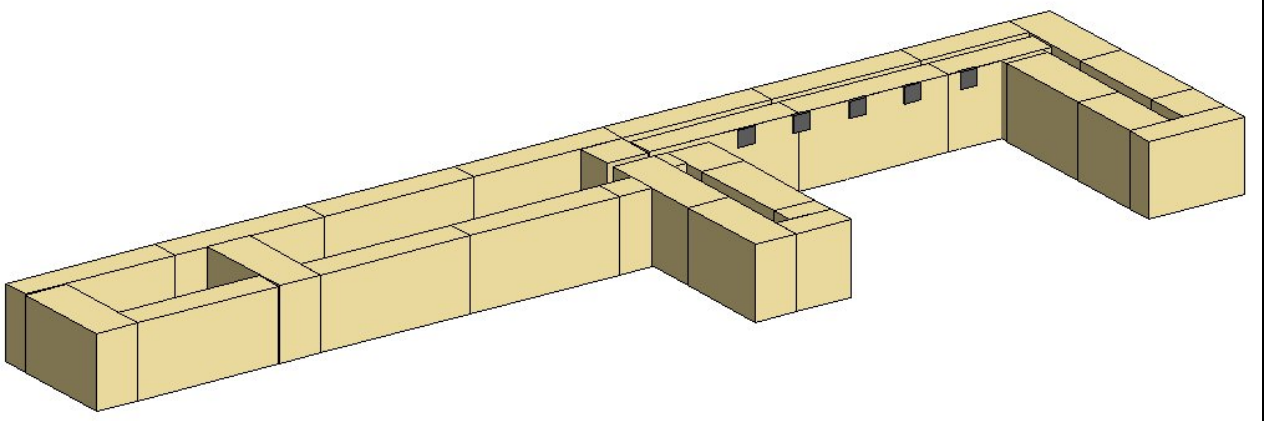


Figure 33 – course 7

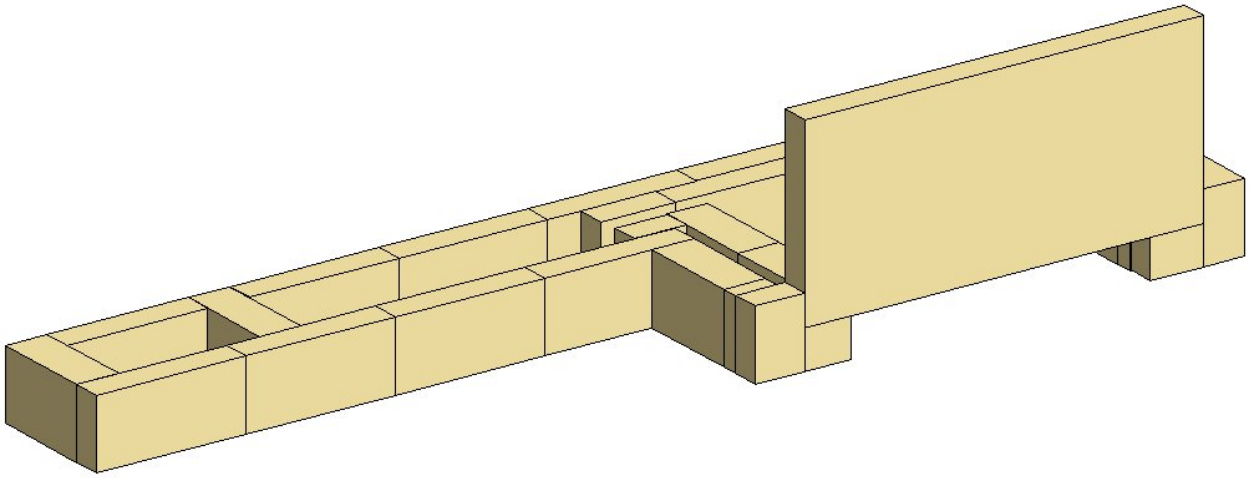


Figure 34 – course 8

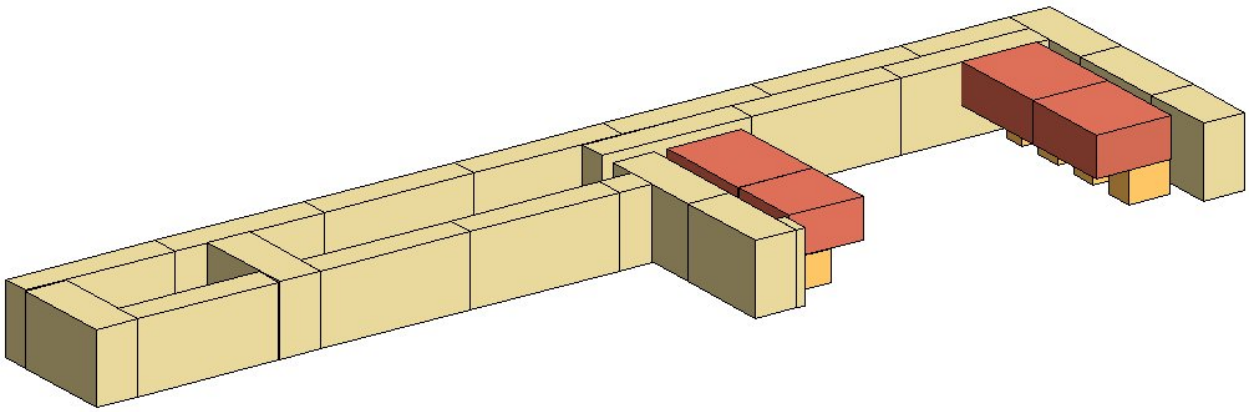


Figure 35 – course 9

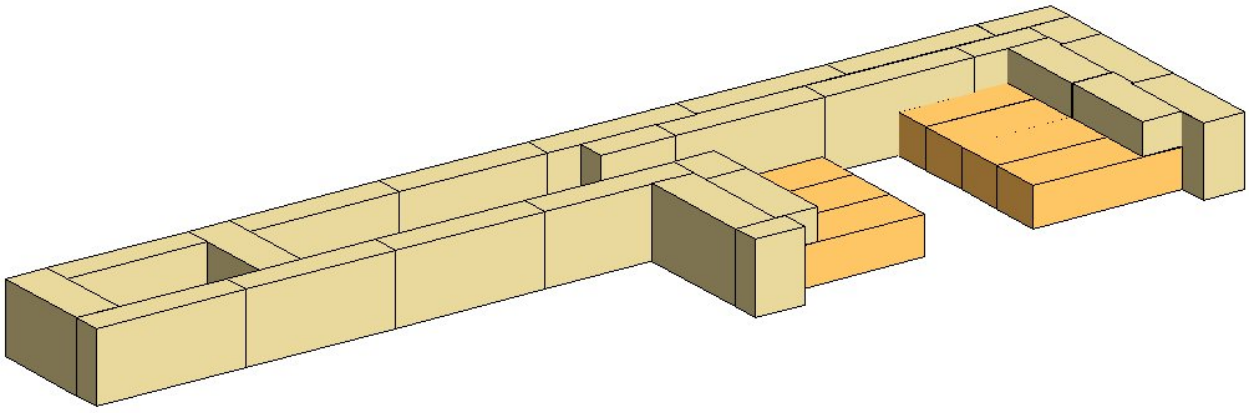


Figure 36 – course 10

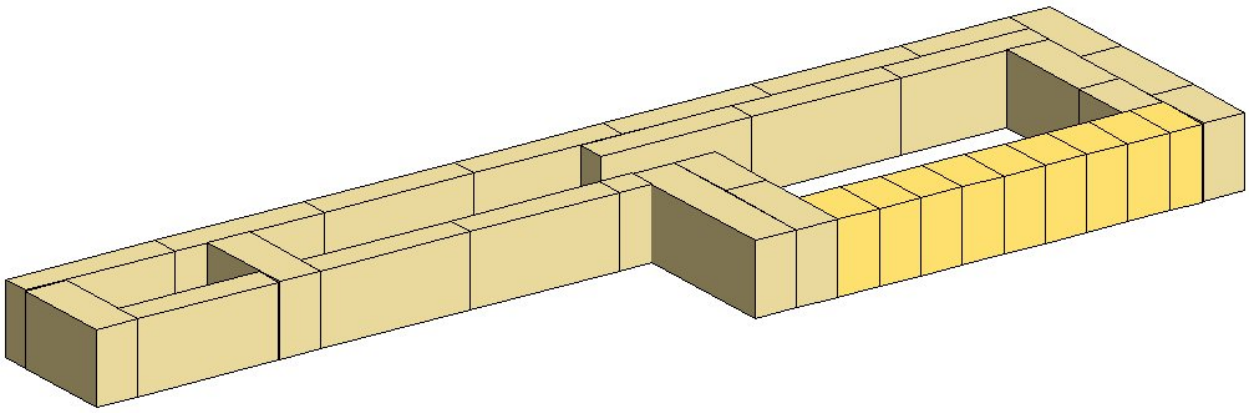


Figure 37 – course 11

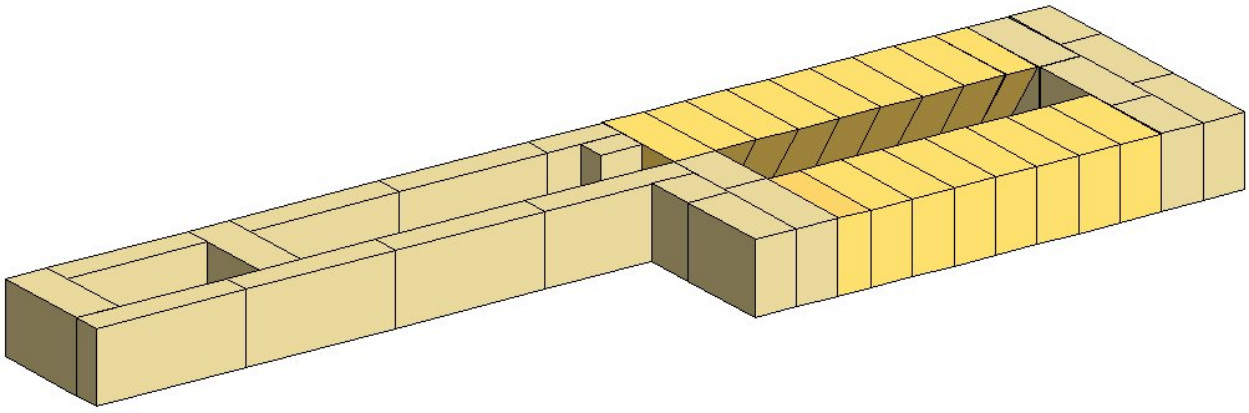


Figure 38 – course 12

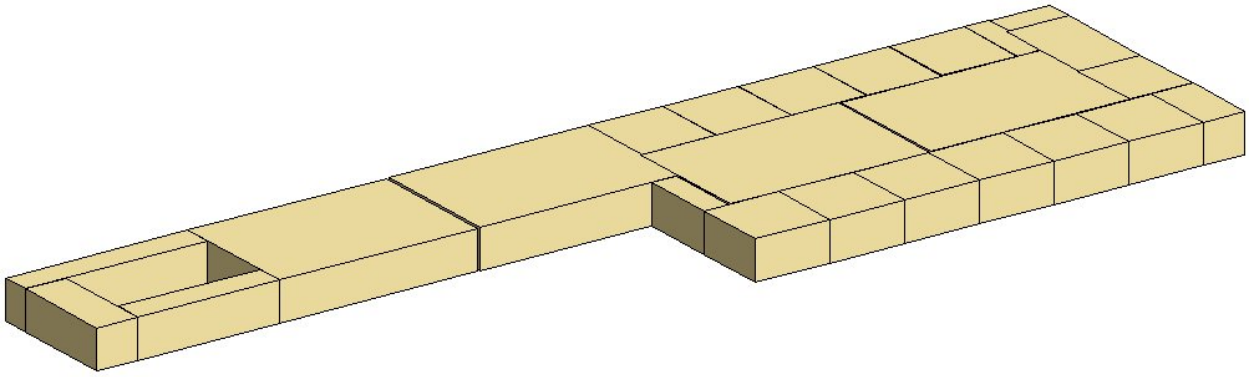


Figure 39 – course 13

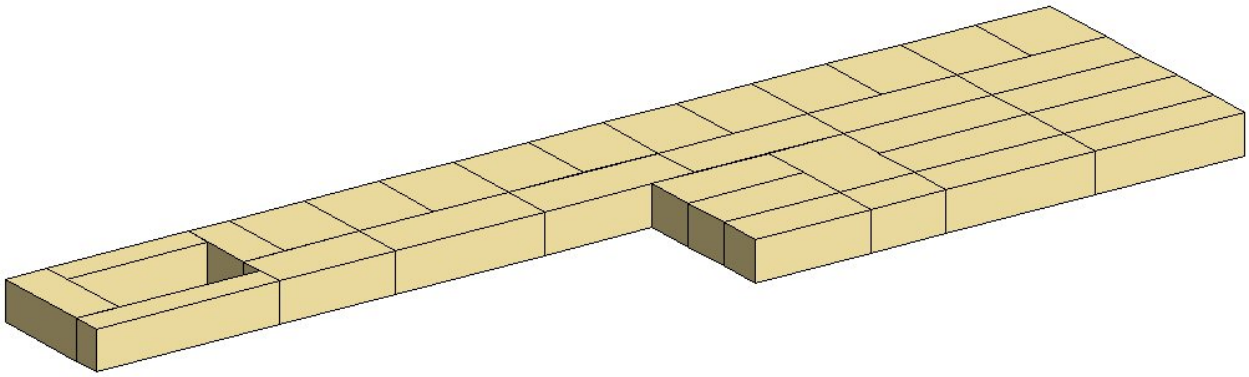


Figure 40 – course 14

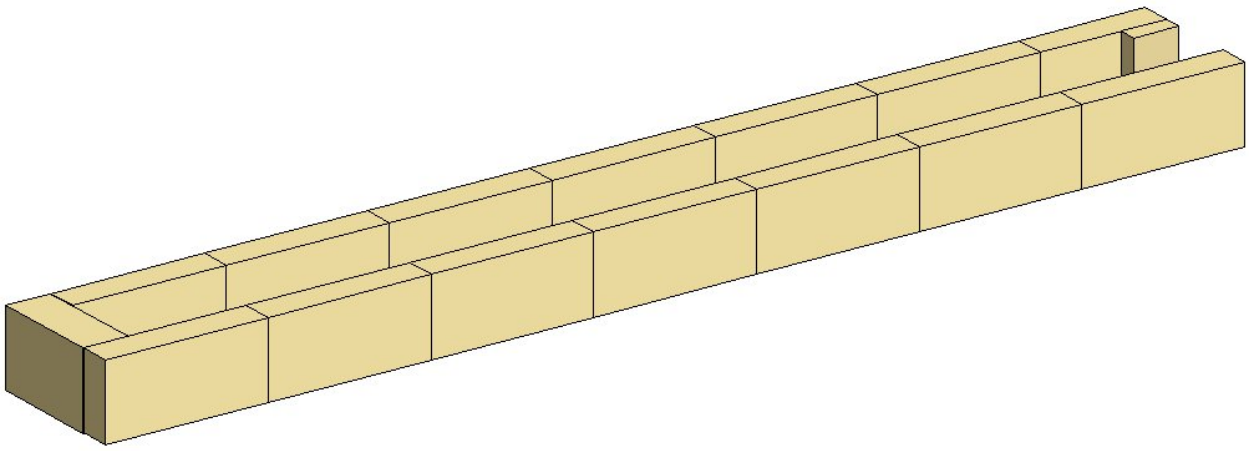


Figure 41 – course 15

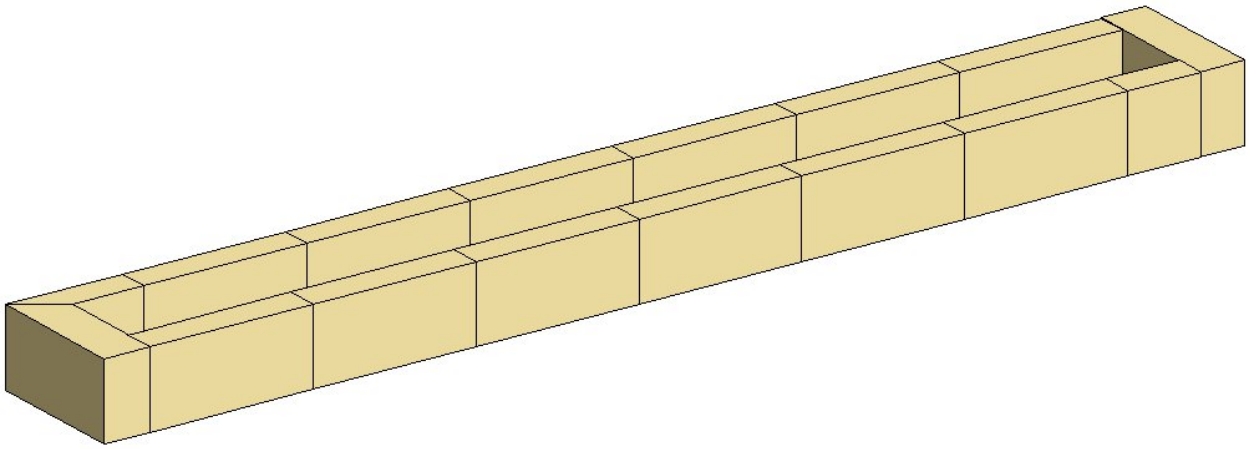


Figure 42 – course 16

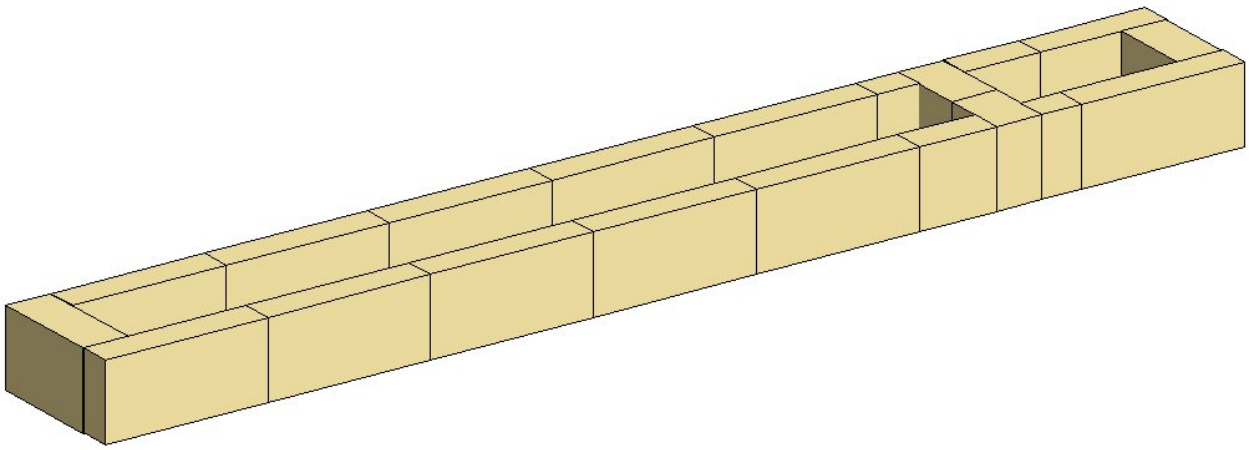


Figure 43 – course 17

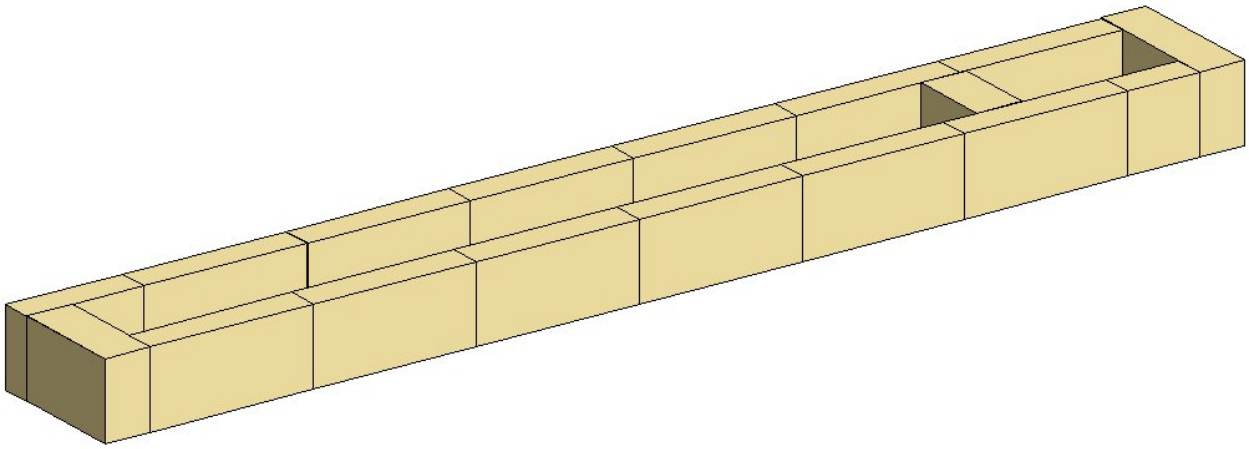


Figure 44 – course 18

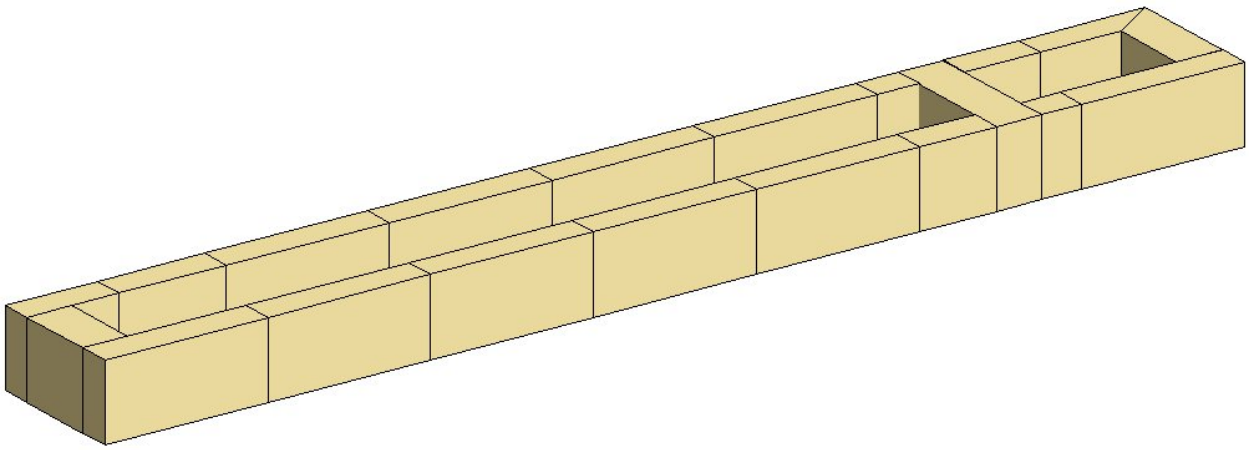


Figure 45 – course 19

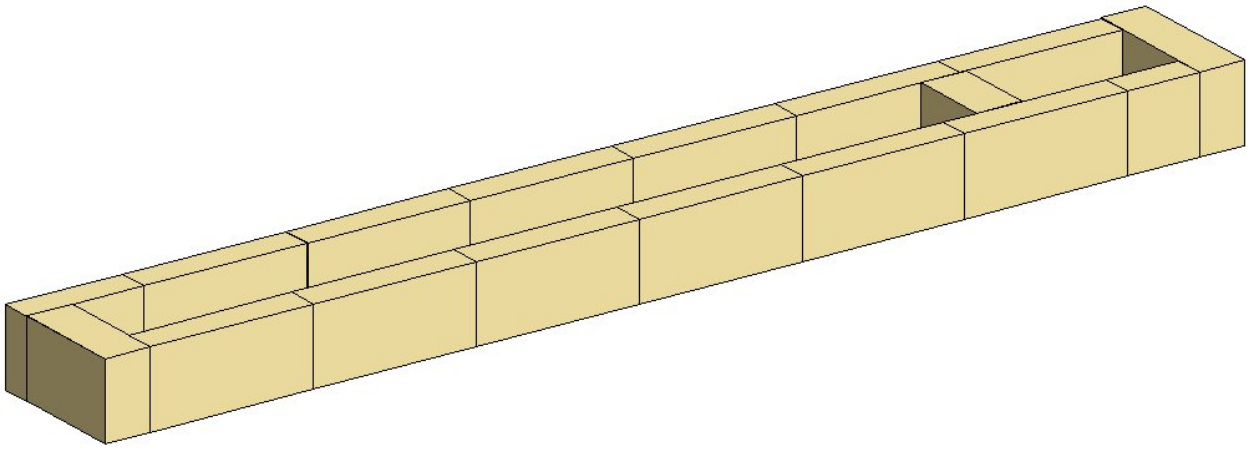


Figure 46 – course 20

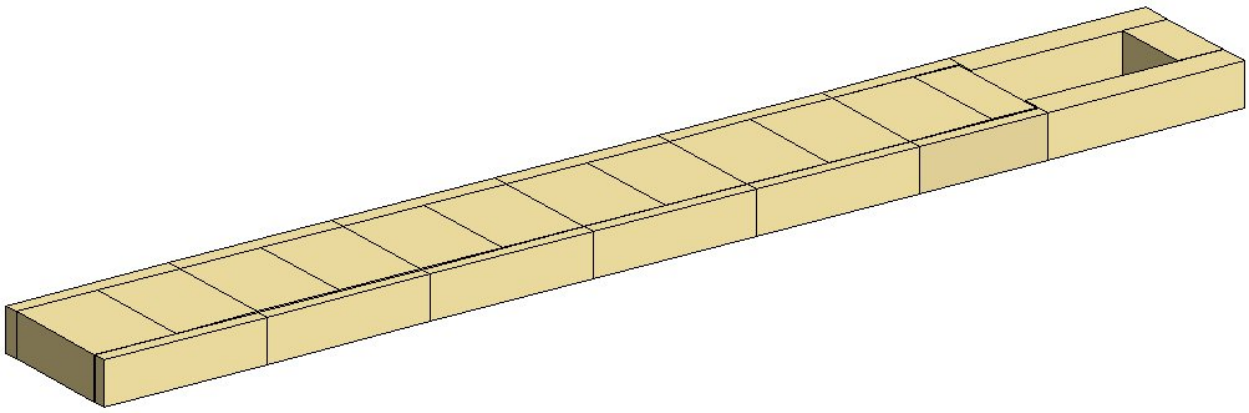


Figure 47 – course 21

Plan Drawings with Notes

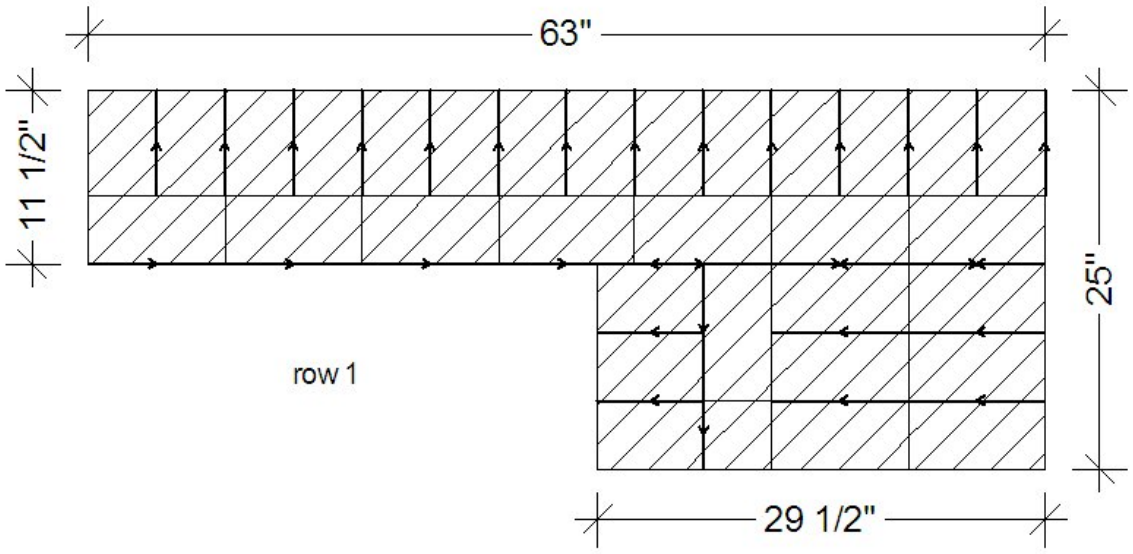


Figure 48 – course 1

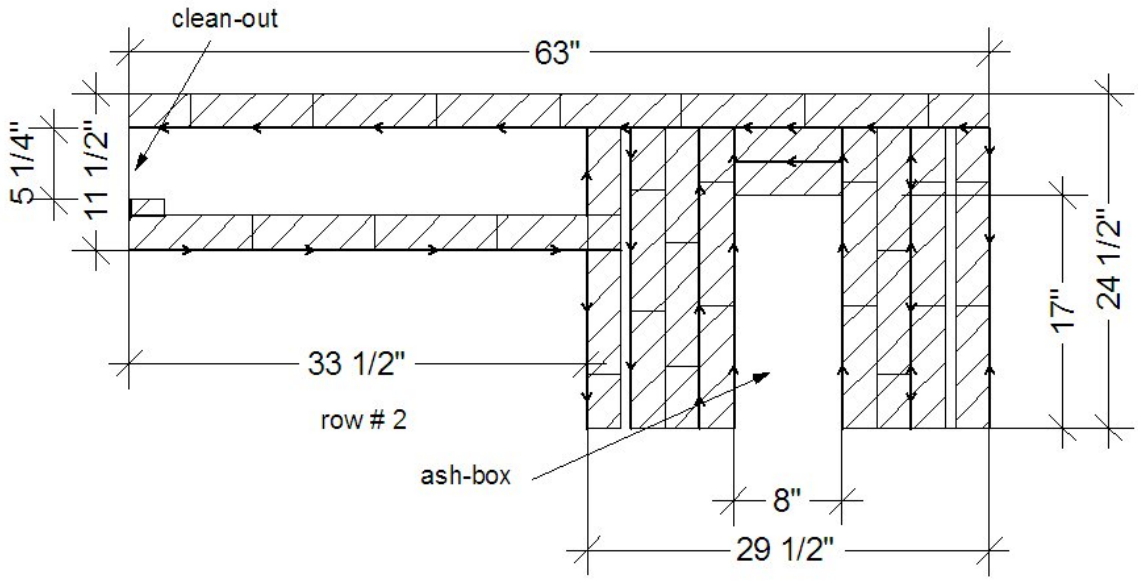


Figure 49 – course 2

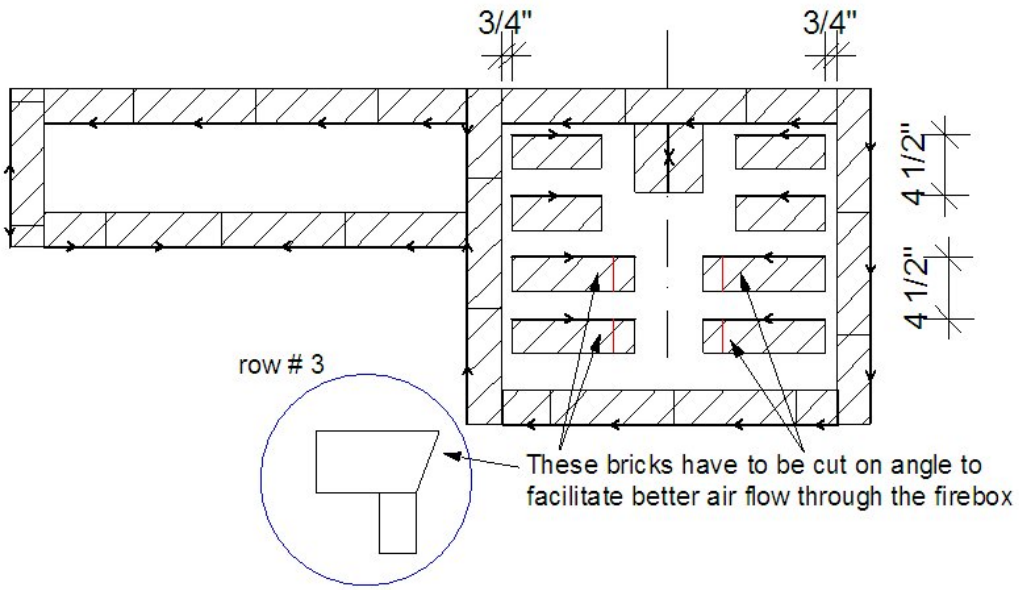


Figure 50 – course 3

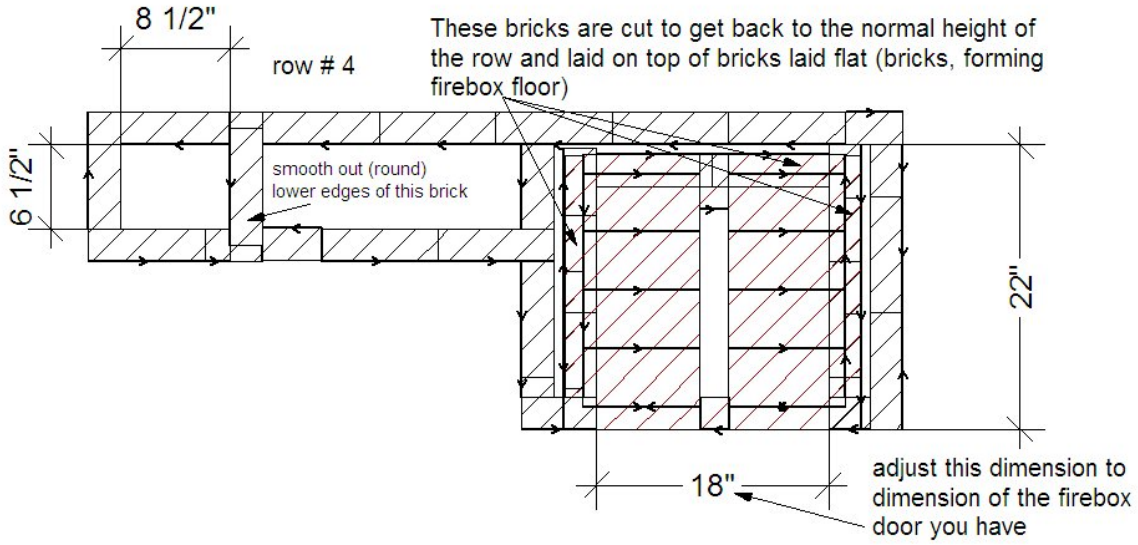


Figure 51 – course 4

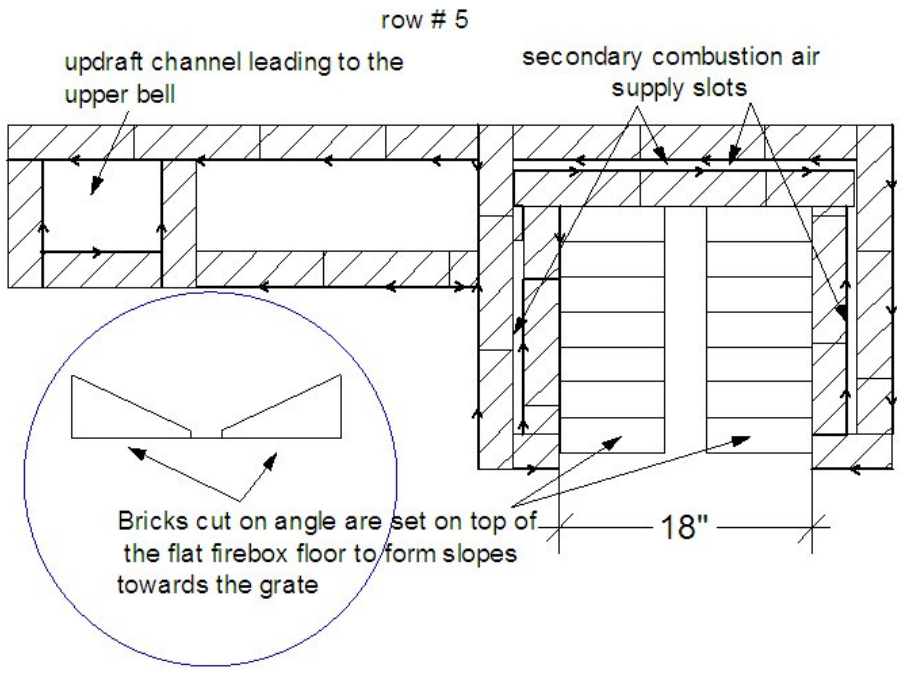


Figure 52 – course 5

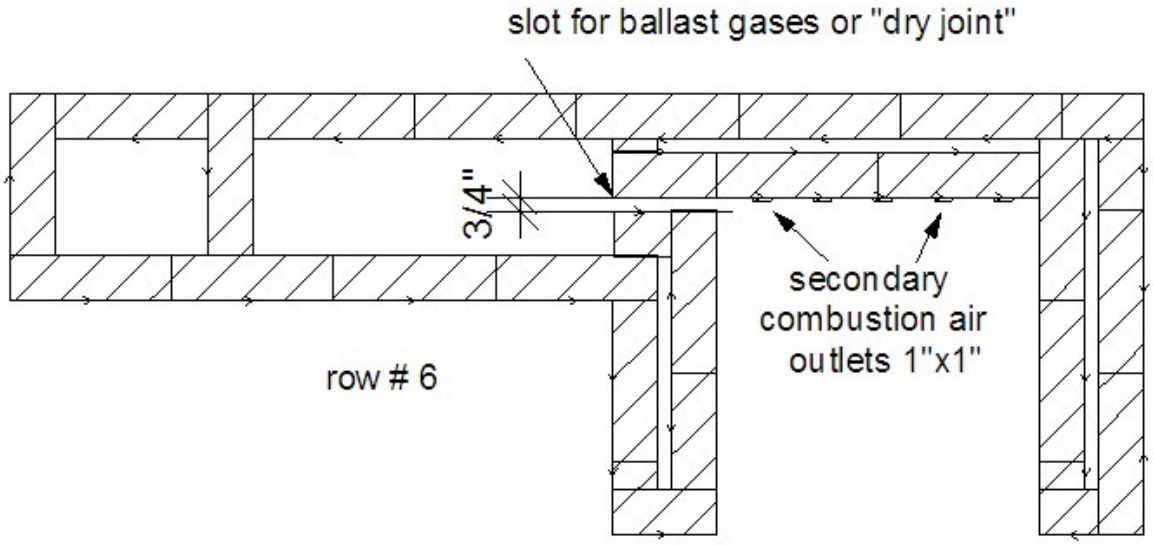


Figure 53 – course 6

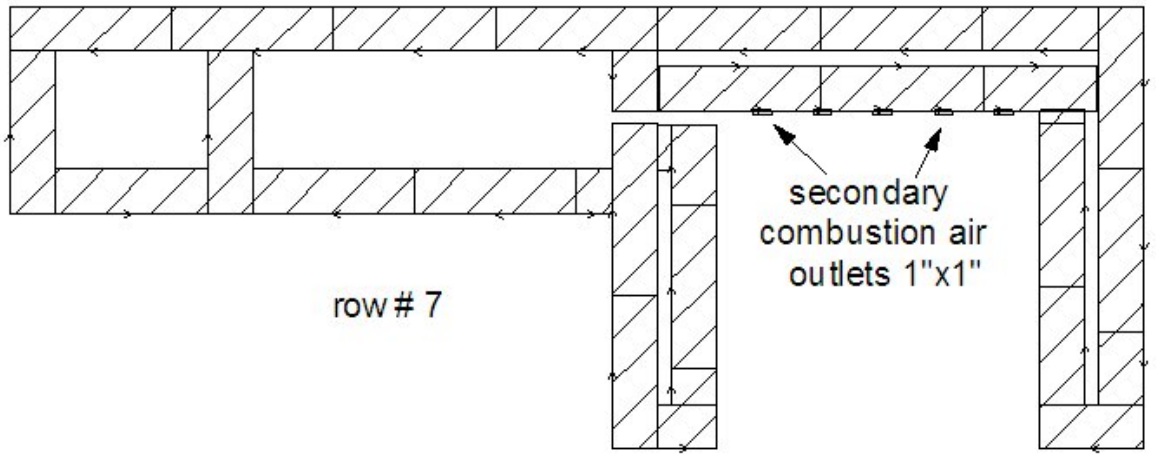


Figure 54 – course 7

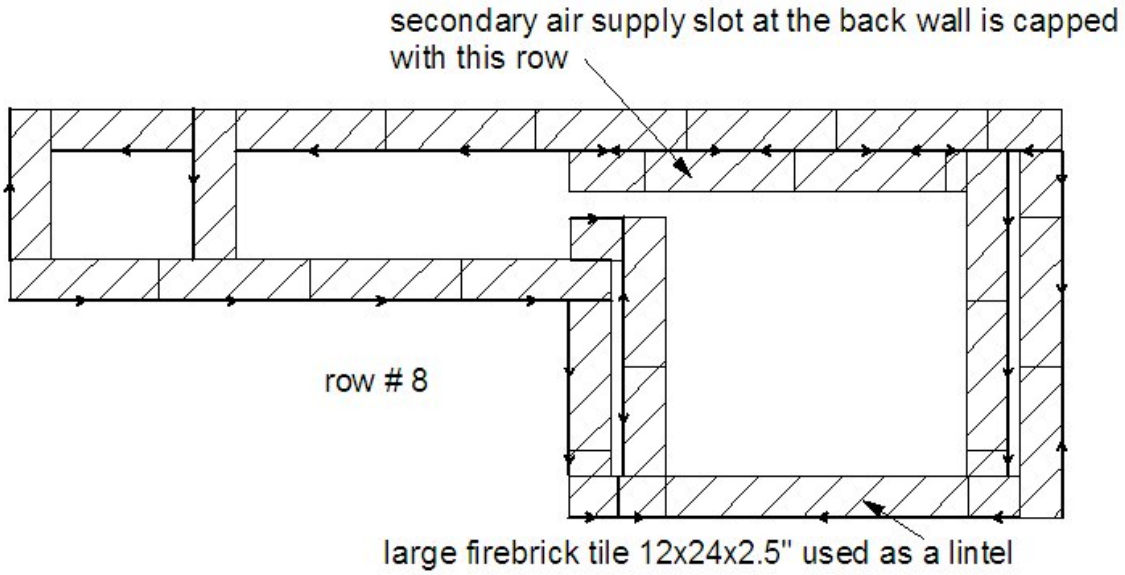


Figure 55 – course 8

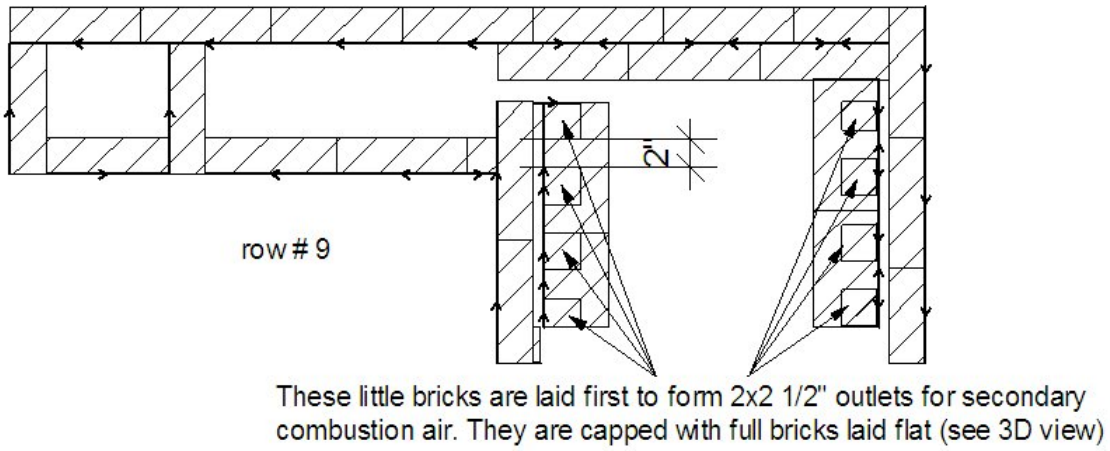


Figure 56 – course 9

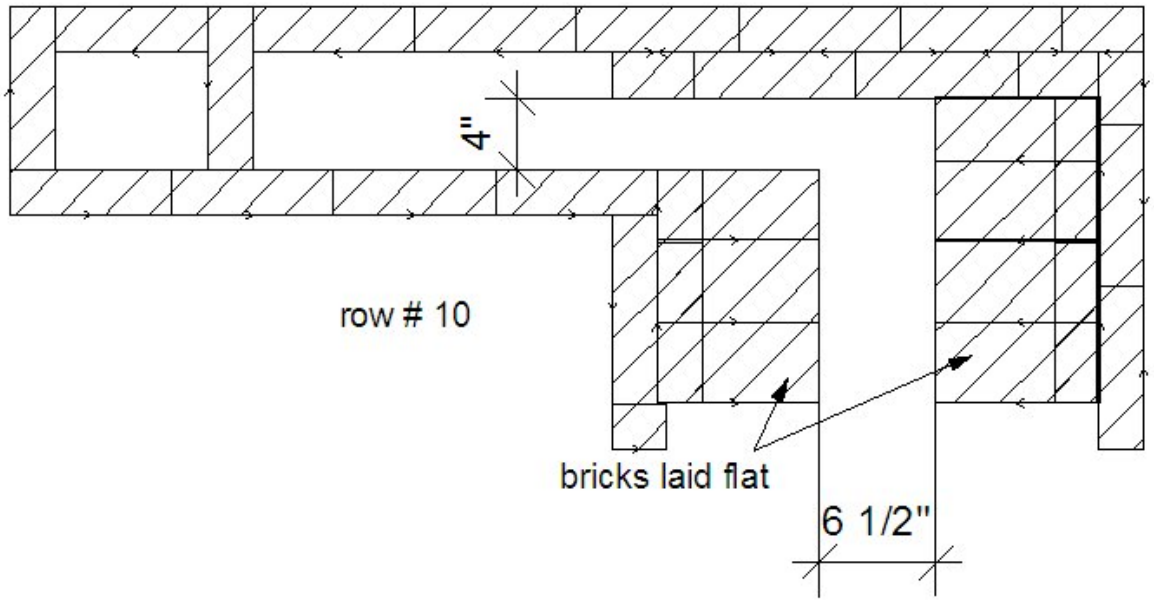


Figure 57- course 10

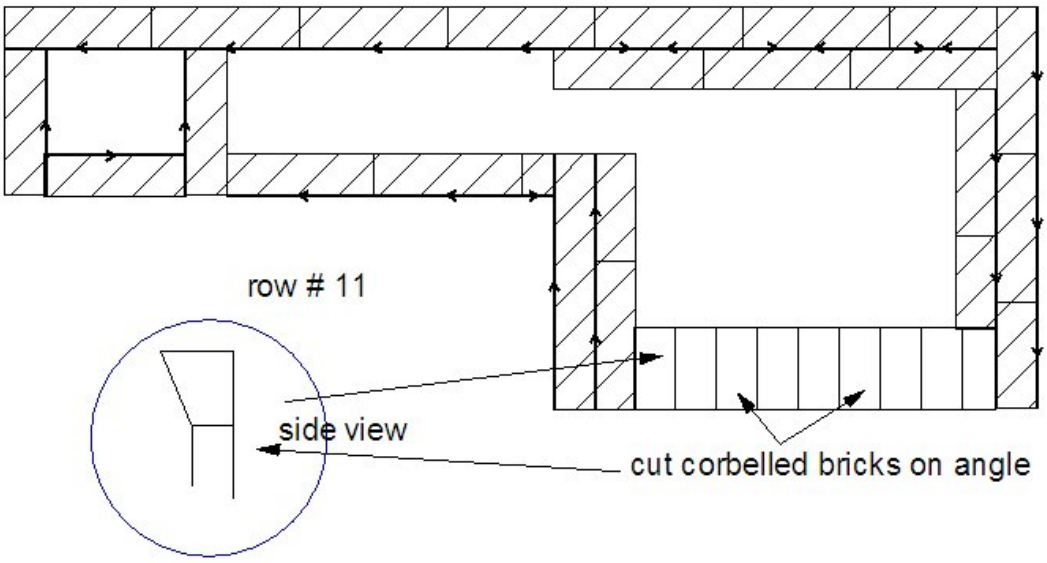


Figure 58 – course 11

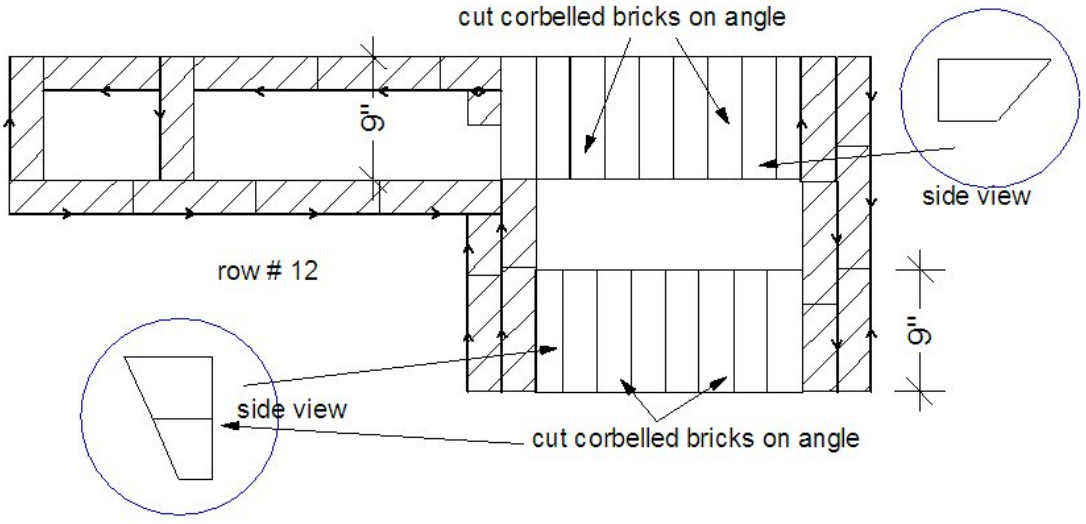


Figure 59 – course 12

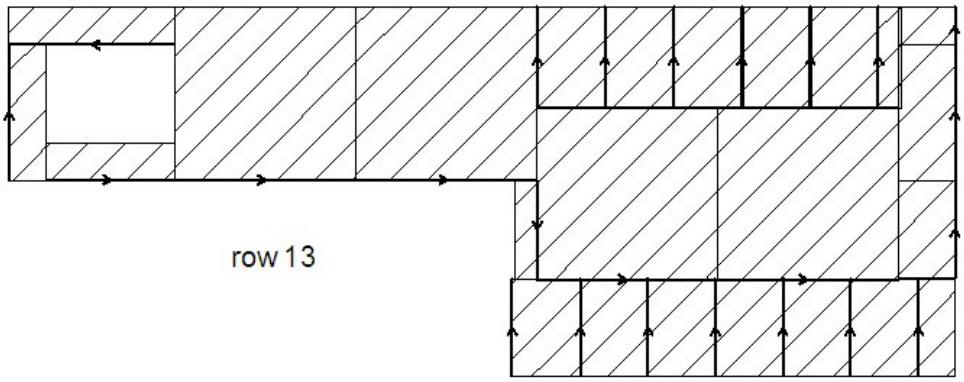


Figure 60 – course 13

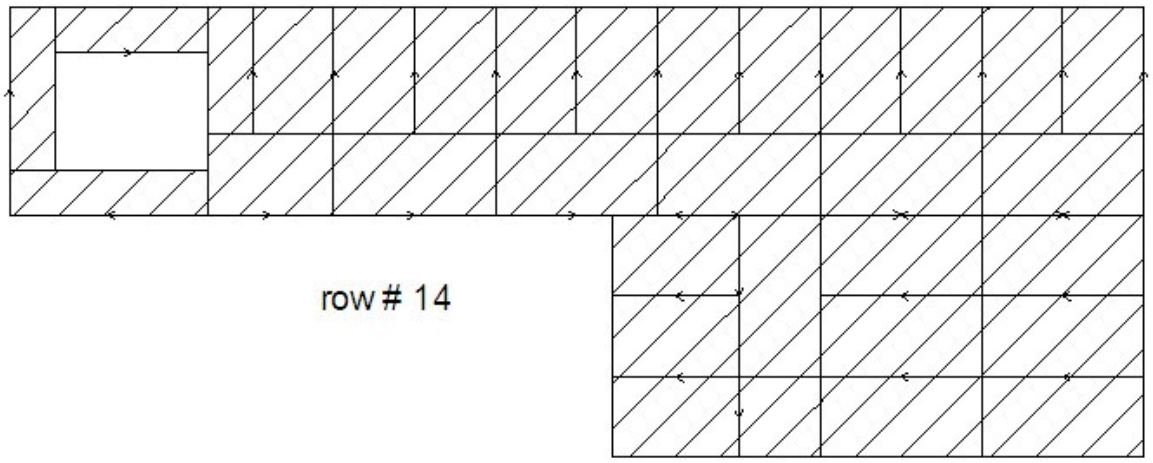


Figure 61 – course 14

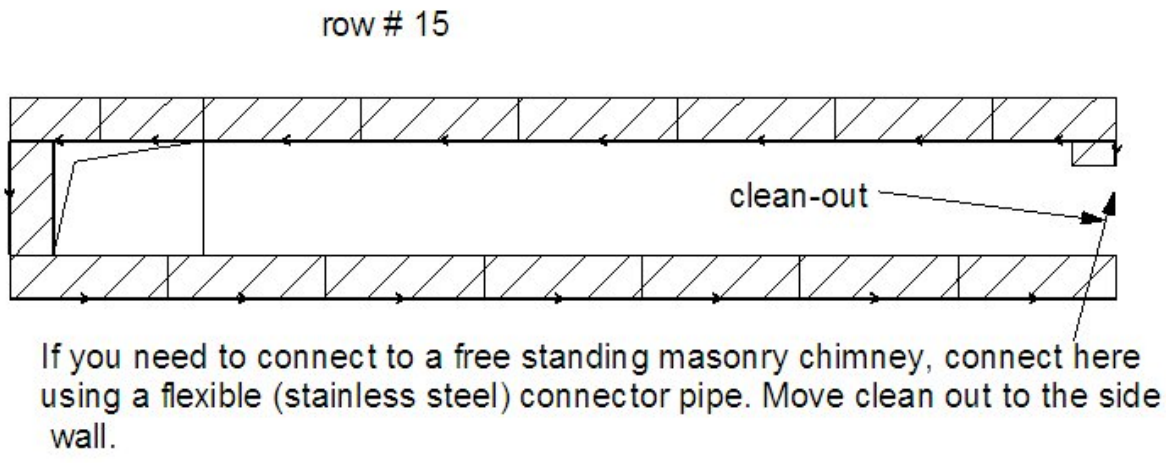


Figure 62 – course 15

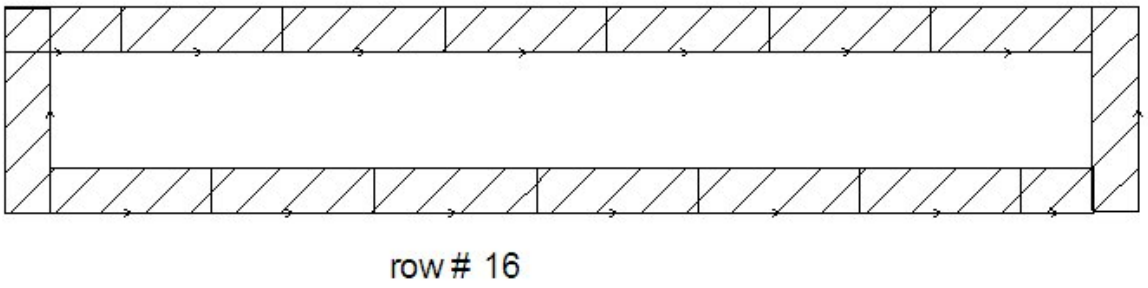


Figure 63 – course 16

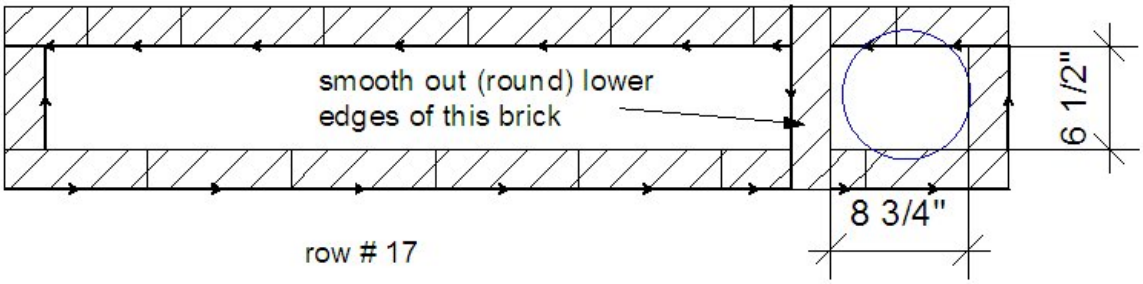


Figure 64 – course 17

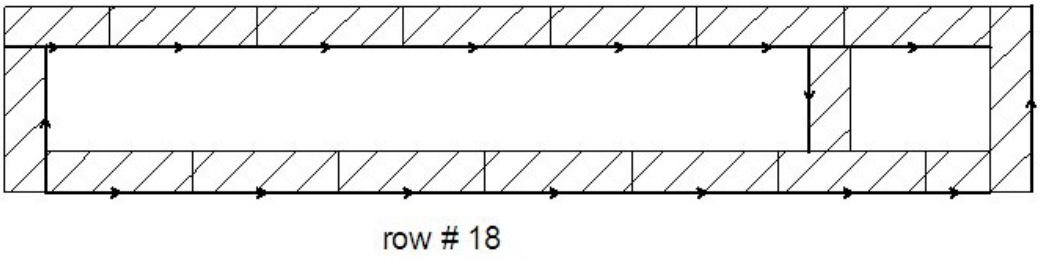


Figure 65 – course 18

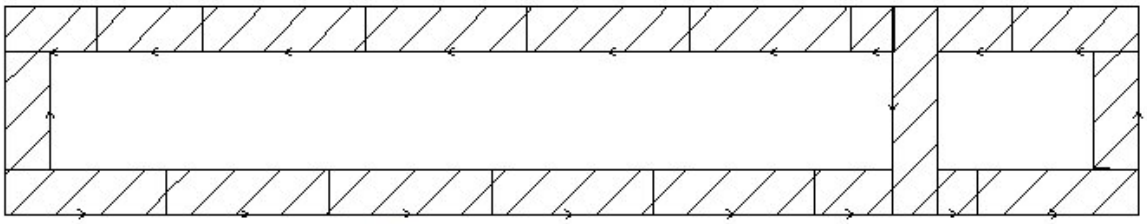


Figure 66 – course 19

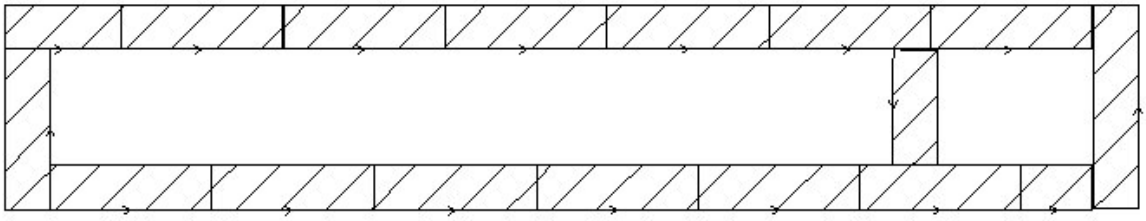
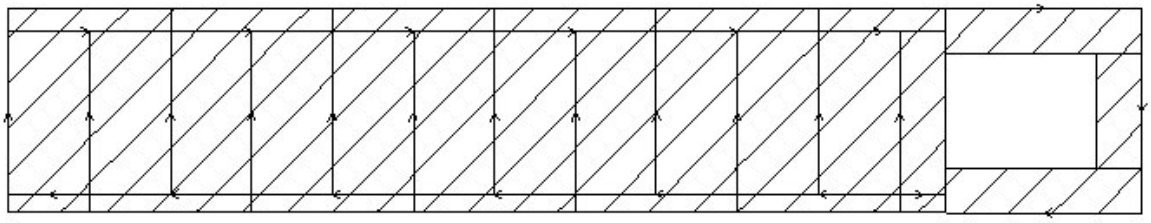


Figure 67 – course 20



row # 21

Figure 68 – course 21

Photo Assembly Sequence:

http://mha-net.org/docs/v8n2/wildac08f.htm

Revised: Nov. 2008

Downdraft Heater
with bake oven

Drawing Not to Scale

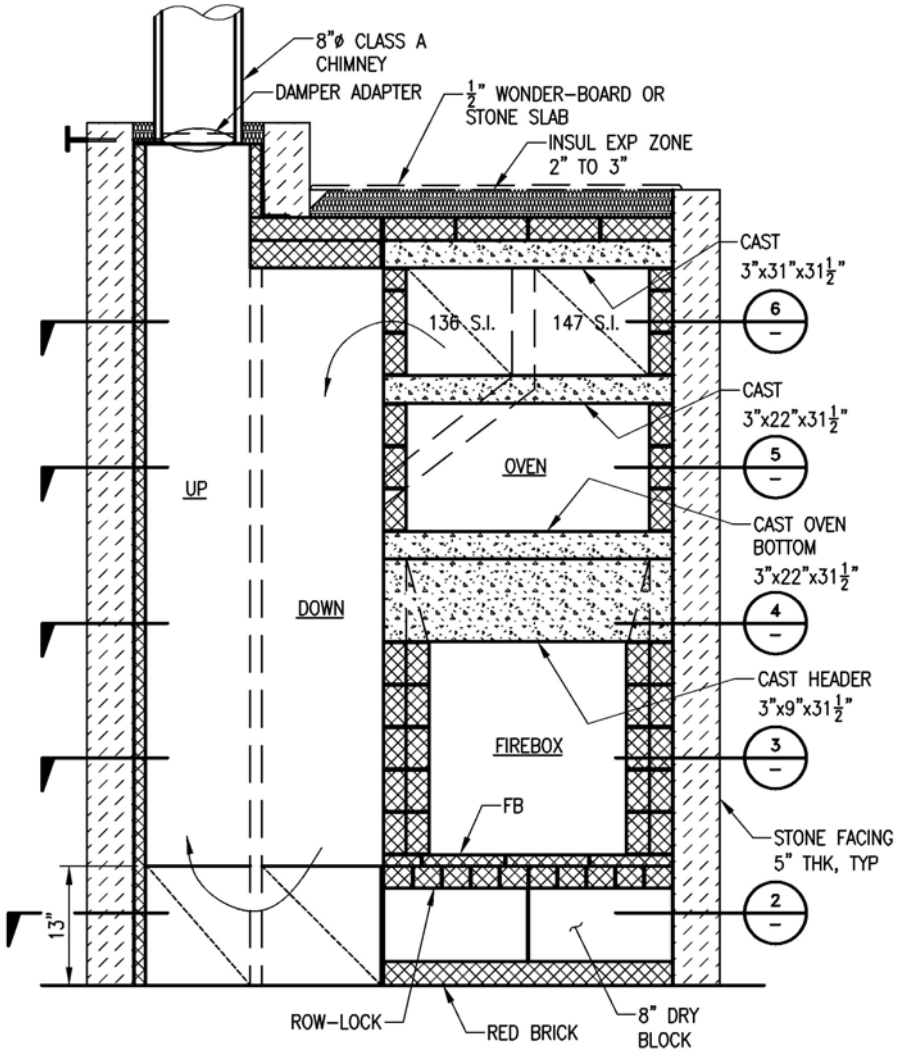
Material List

8	8”x8”x16” CMUs (concrete blocks)
100	Red bricks, solid or cored
200	Standard firebricks
170	Firebrick splits
3	50 lb pails of Sairset or Titebond or Heat-Stop refractory mortar
3	3”x3”x3/16”x30” angle irons

18 to 20 bags – KS4Plus general purpose castable refractory 2000F

1	Oven damper
1	Flue damper
2 or 3	2”x12”x24” firebrick slabs to cap flues, or precast as needed
2	Clean outs
1	Oven door
1	Firebox door

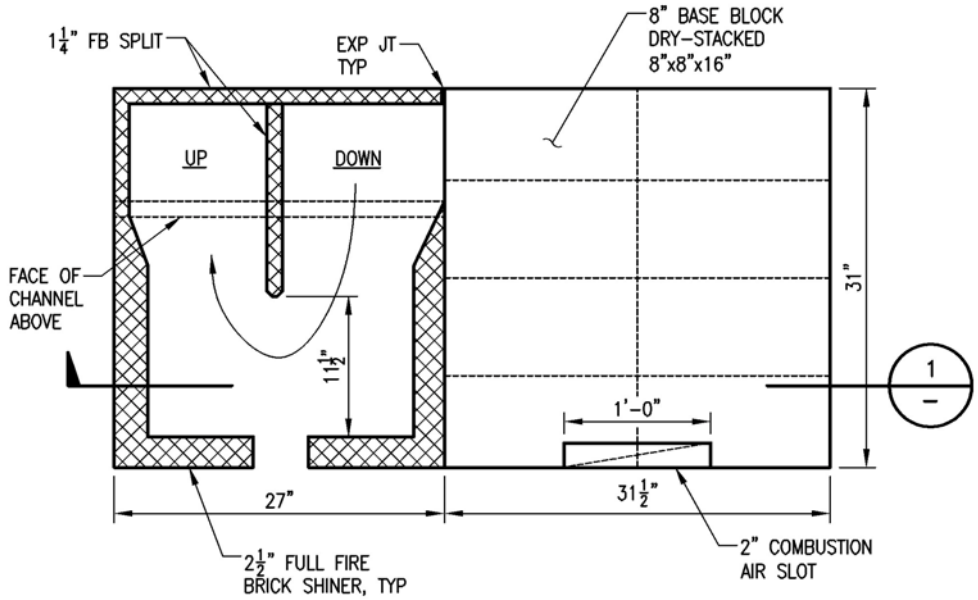
Plus materials for base, facing, and flue



NOTE: 13" HIGH BENCH COULD BE LOWERED
BY 5" AND STILL WORK FINE.

1 / – CROSS-SECTION

3/4"=1'-0" SEC1

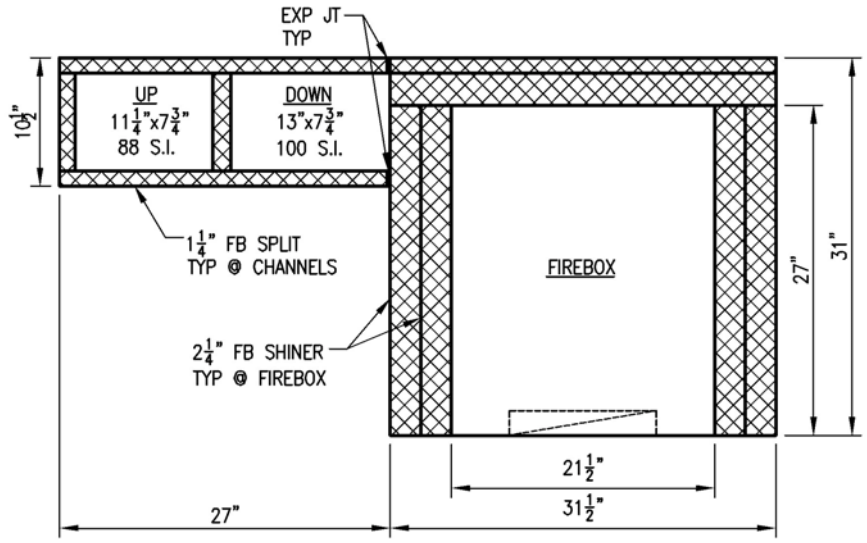


NOTE: FACING NOT SHOWN, TYP.

2 — SECTION AT BASE

1"=1'-0"

SEC2

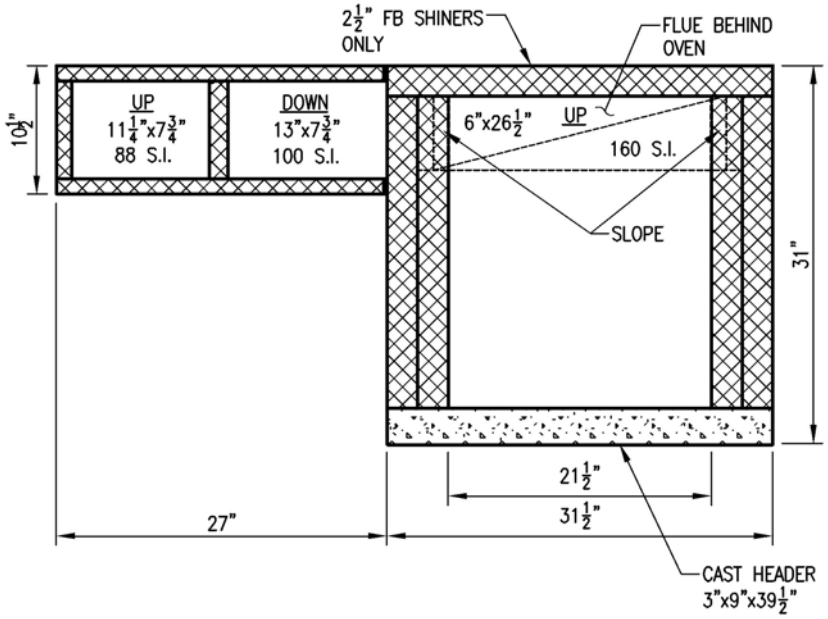


3
—

SECTION AT FIREBOX

1"=1'-0"

SEC3

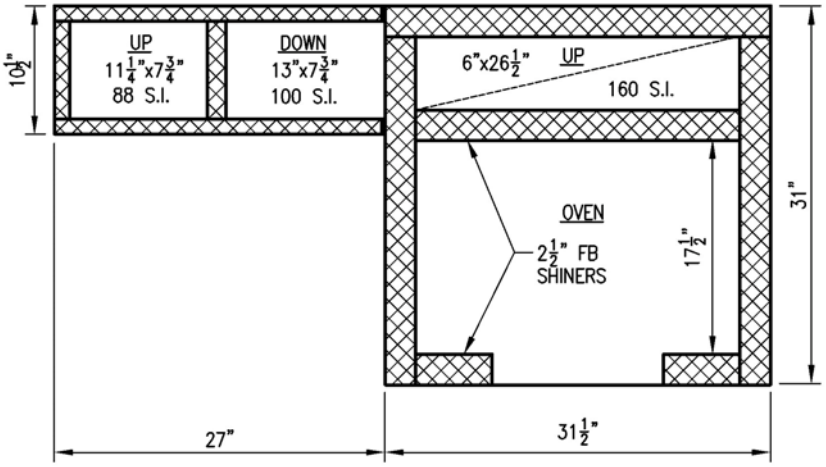


SECTION BELOW OVEN

4 / –

1"=1'–0"

SEC4

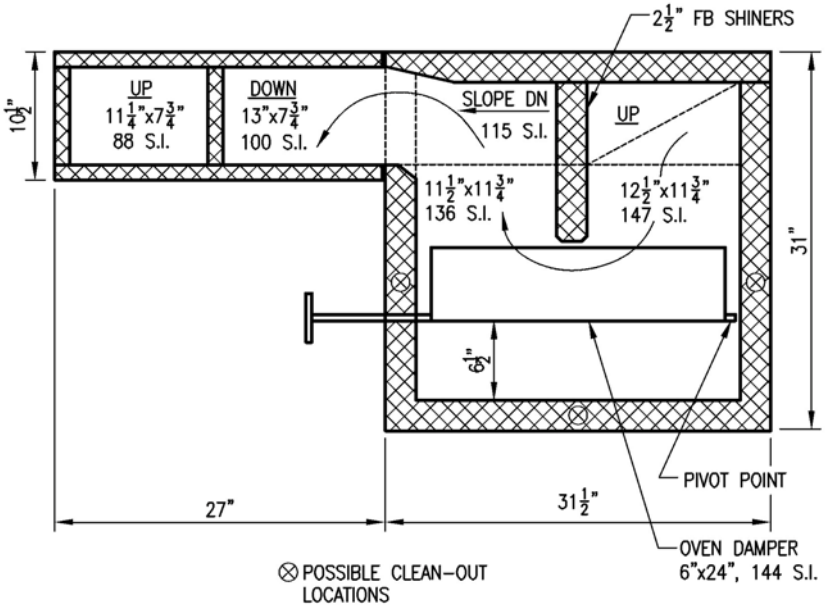


5
–

SECTION AT OVEN

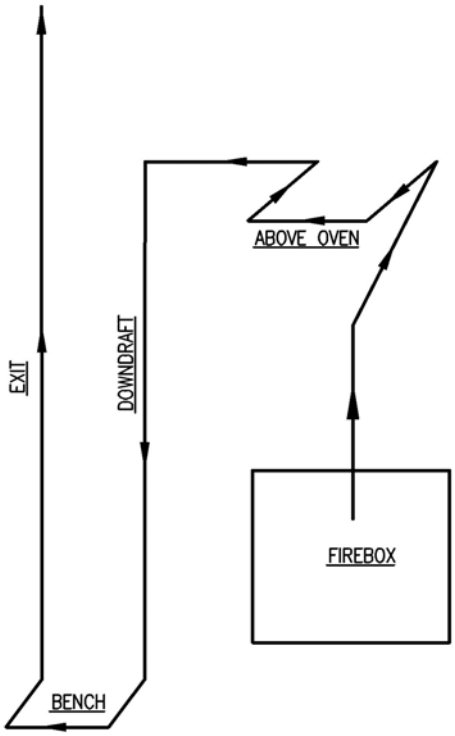
1"=1'–0"

SEC5



6 / – SECTION ABOVE OVEN

1"=1'-0" SEC6



7 FLOW PATH

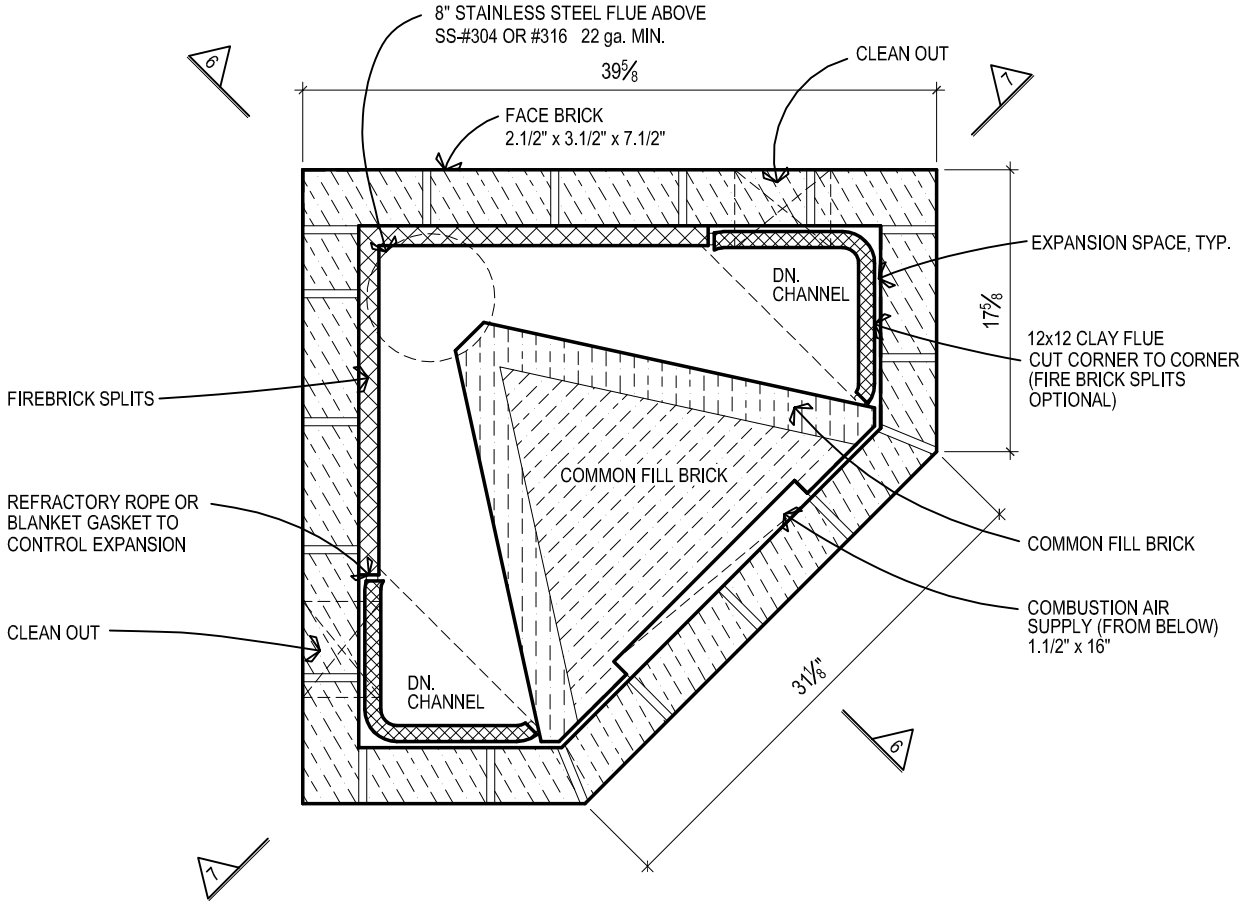
3/4"=1'-0"

FLOW

CORNER 1 OF 7
Medium Size Corner Finnish Heater

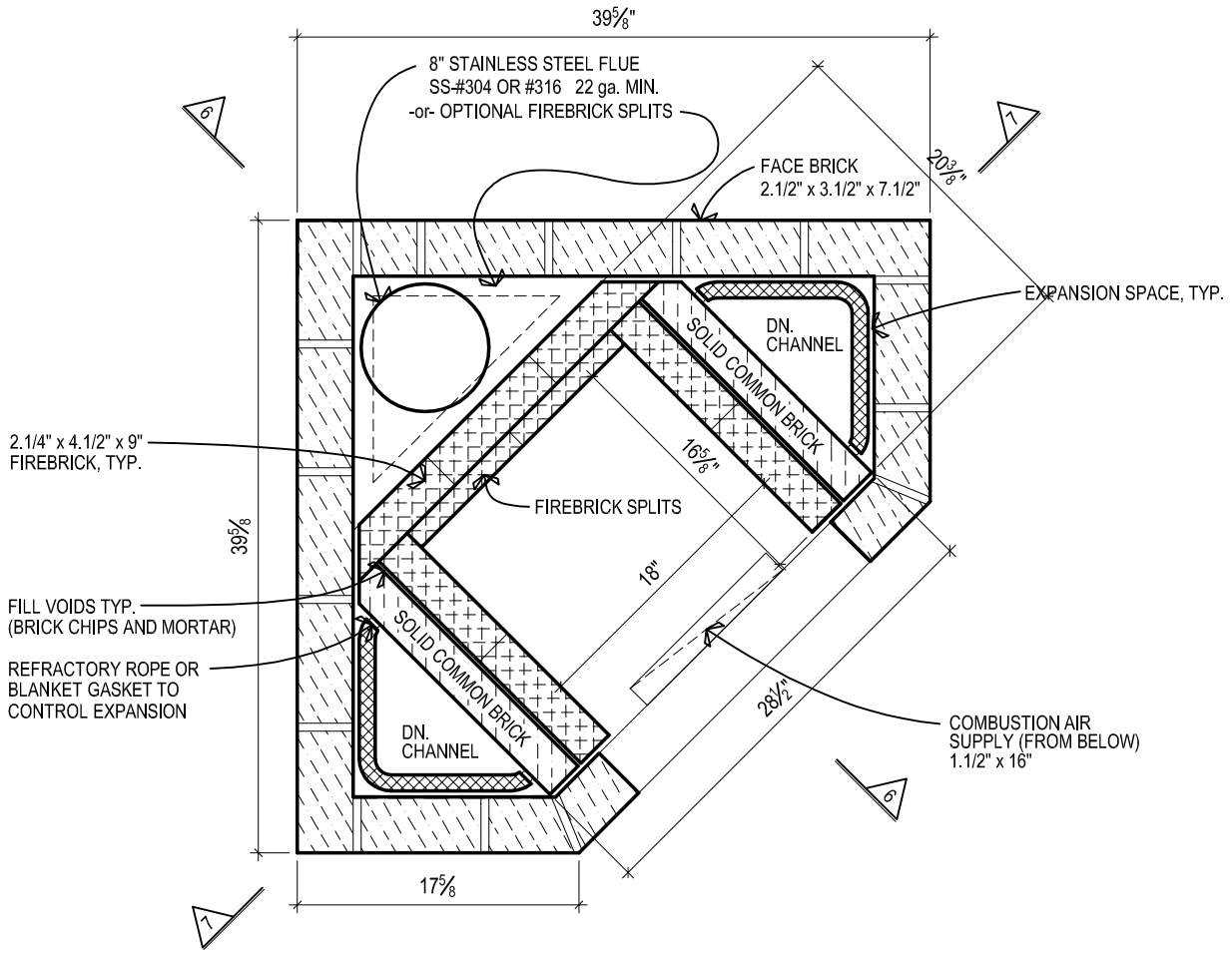
Revised: Nov. 2008

Drawing Not to Scale



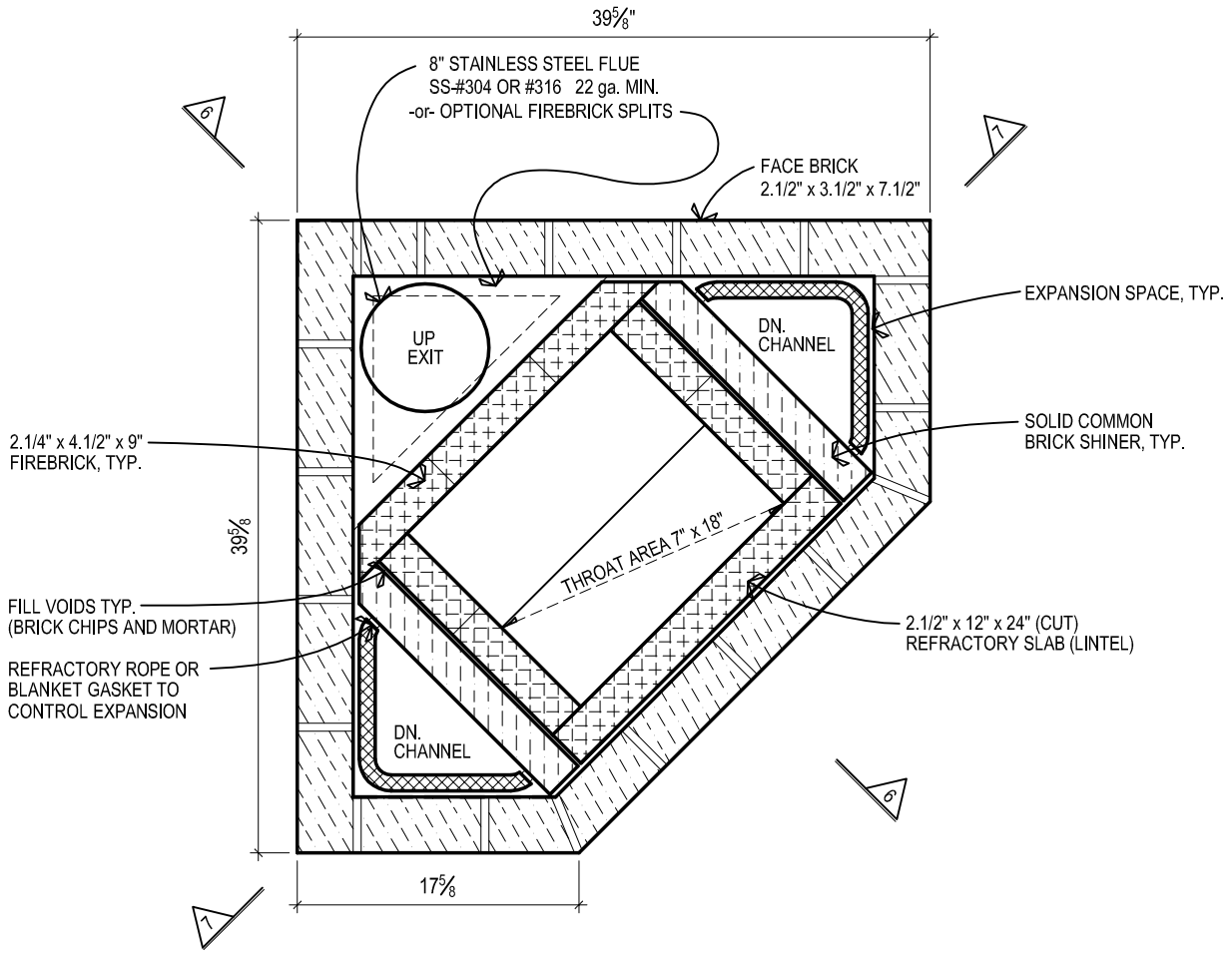
1. PLAN AT BASE CHANNELS

Medium Size Corner Finnish Heater 1" = 1'-0"



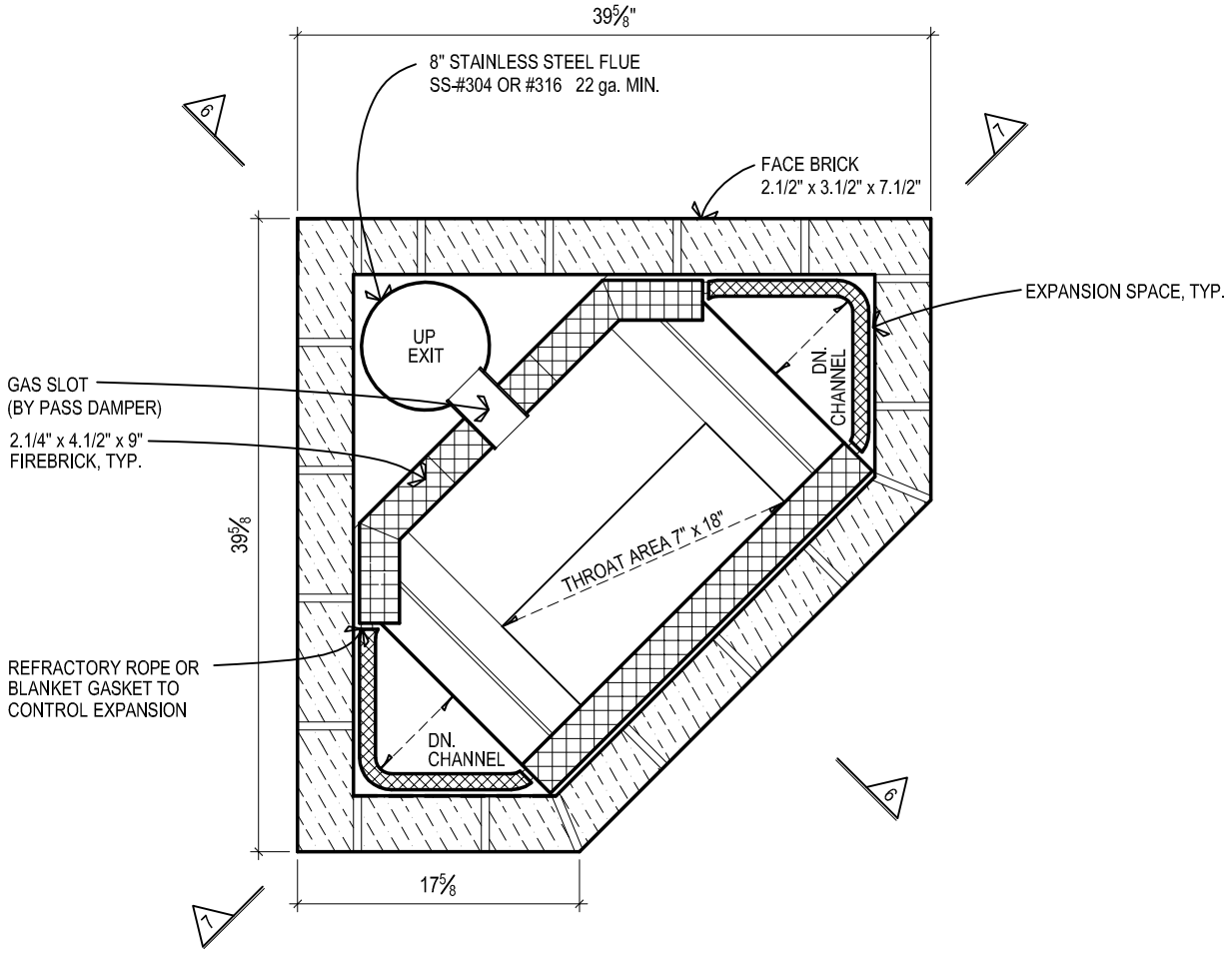
2. PLAN AT FIREBOX

Medium Size Corner Finnish Heater 1" = 1'-0"



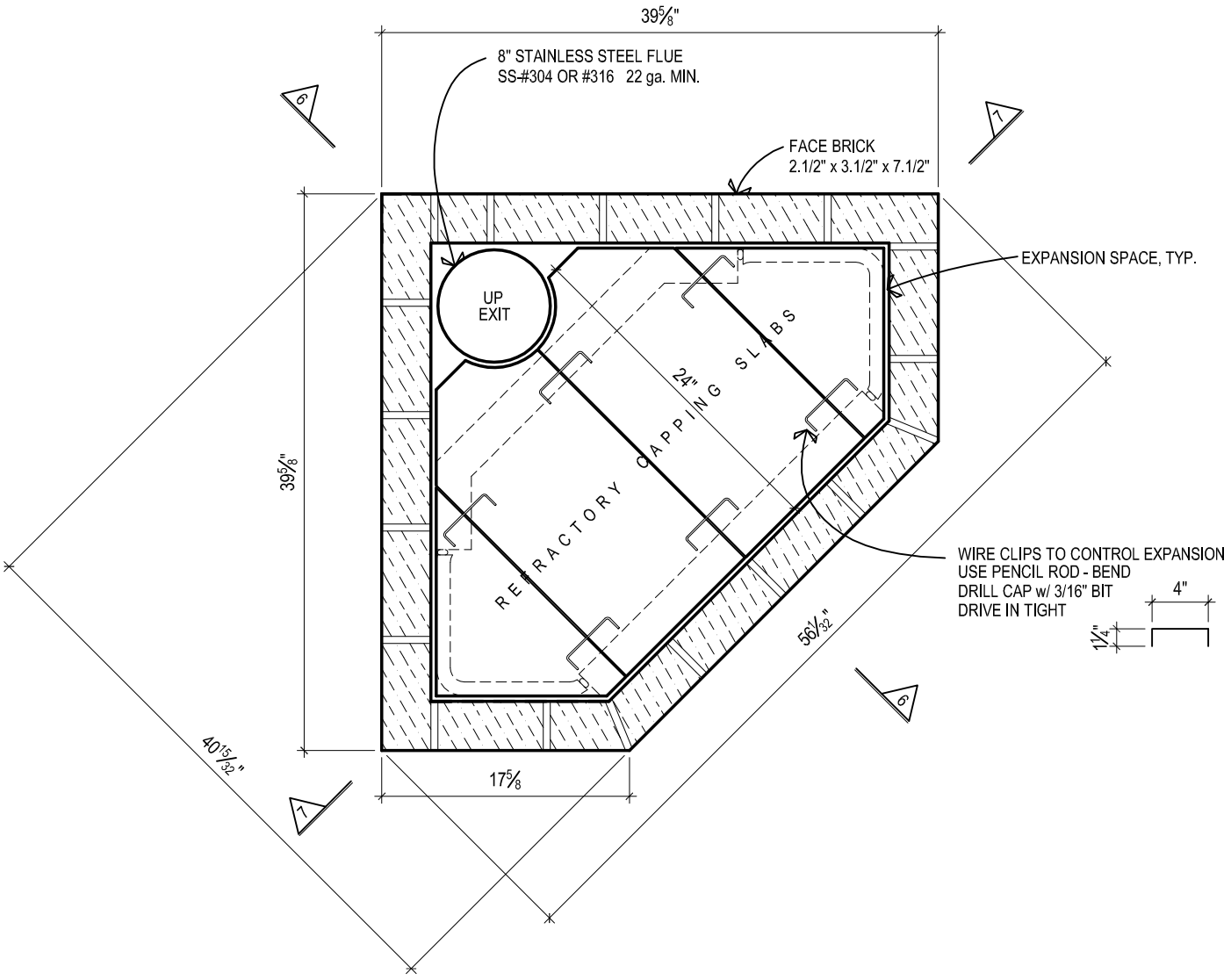
3. PLAN AT THROAT

Medium Size Corner Finnish Heater 1" = 1'-0"



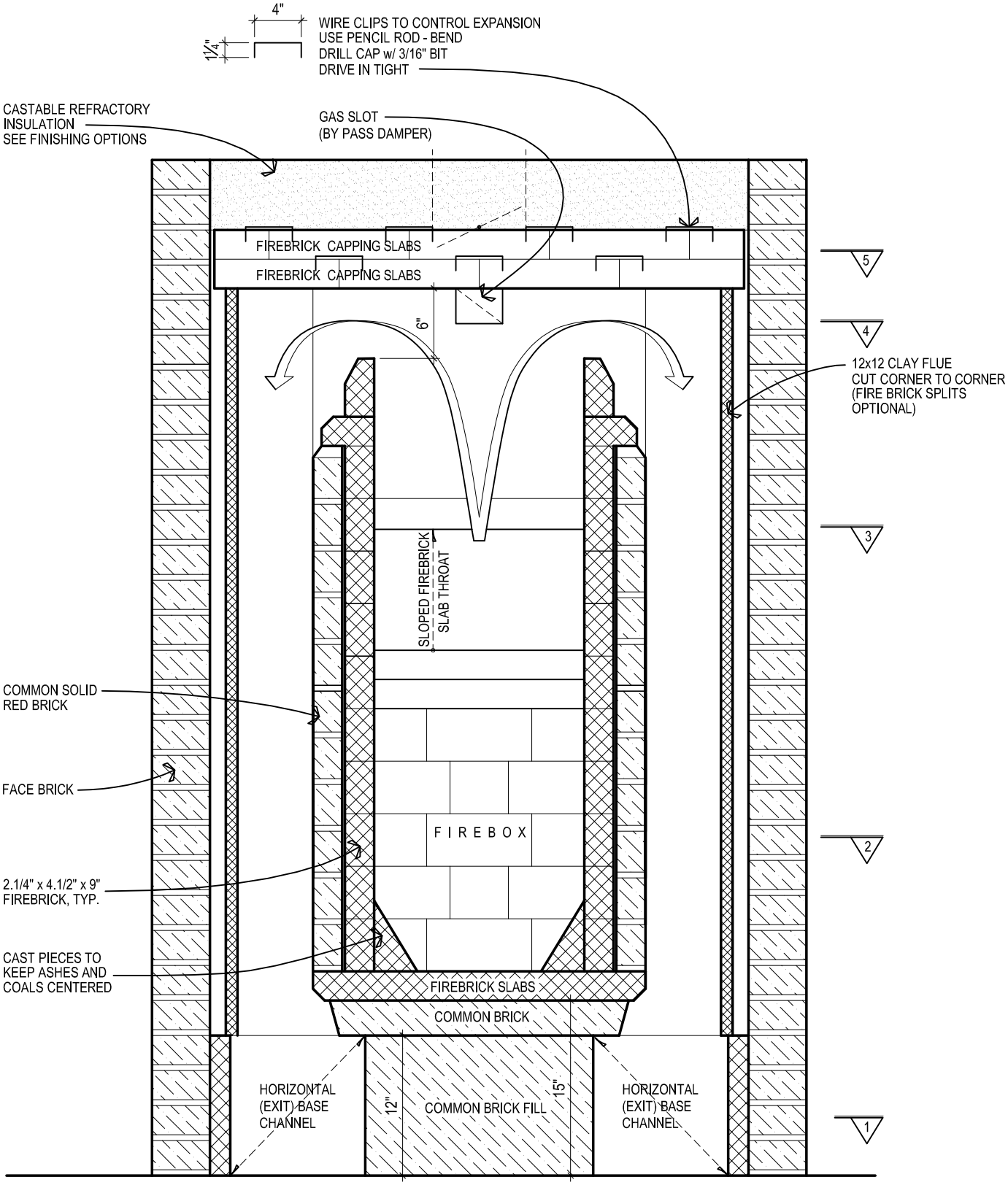
4. PLAN AT TOP EXIT (under capping slab)

Medium Size Corner Finnish Heater 1" = 1'-0"



5. PLAN AT TOP CAPPING SLABS

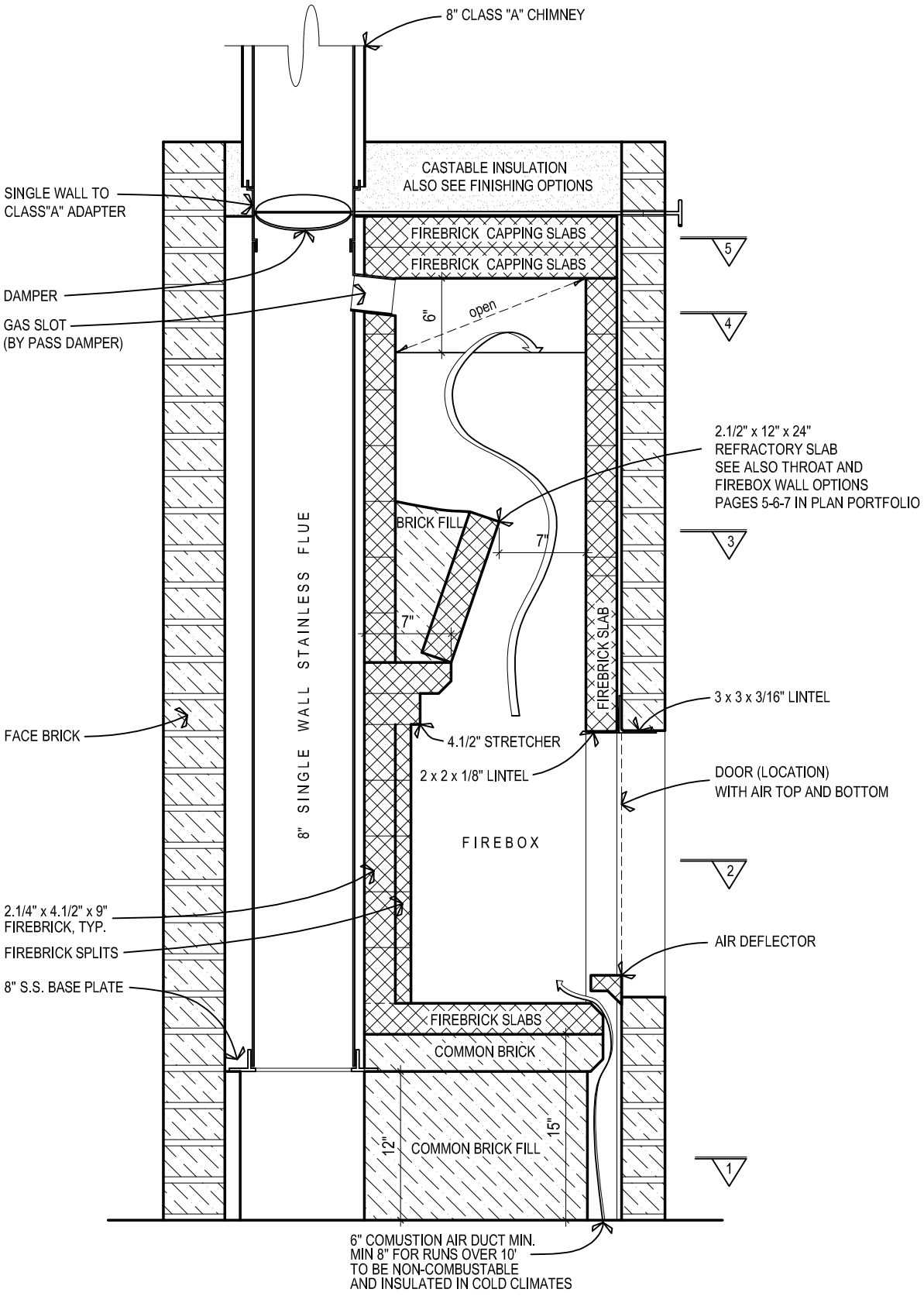
Medium Size Corner Finnish Heater 1" = 1'-0"



6. LONGITUDINAL SECTION THRU FIREBOX and SIDE CHANNELS

Medium Size Corner Finnish Heater

1" = 1'-0"



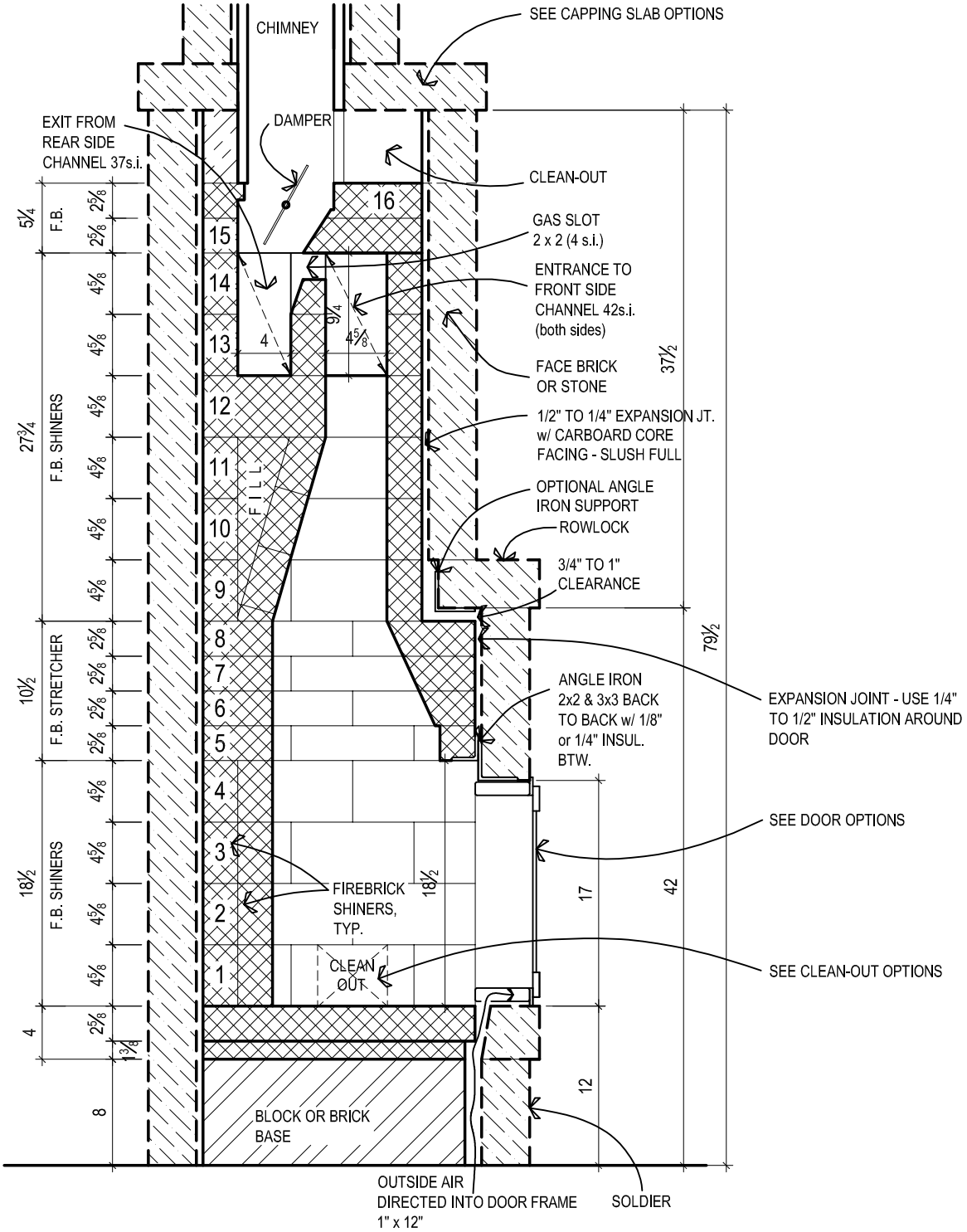
7. CROSS SECTION THRU FIREBOX and FLUE

Medium Size Corner Finnish Heater 1" = 1'-0"

SWEDISH HEATER 1 OF 5
(KAKELUGN)

Revised: Nov. 2008

Drawing Not to Scale



1. CROSS SECTION thru firebox

SWEDISH HEATER 1" = 1'-0"

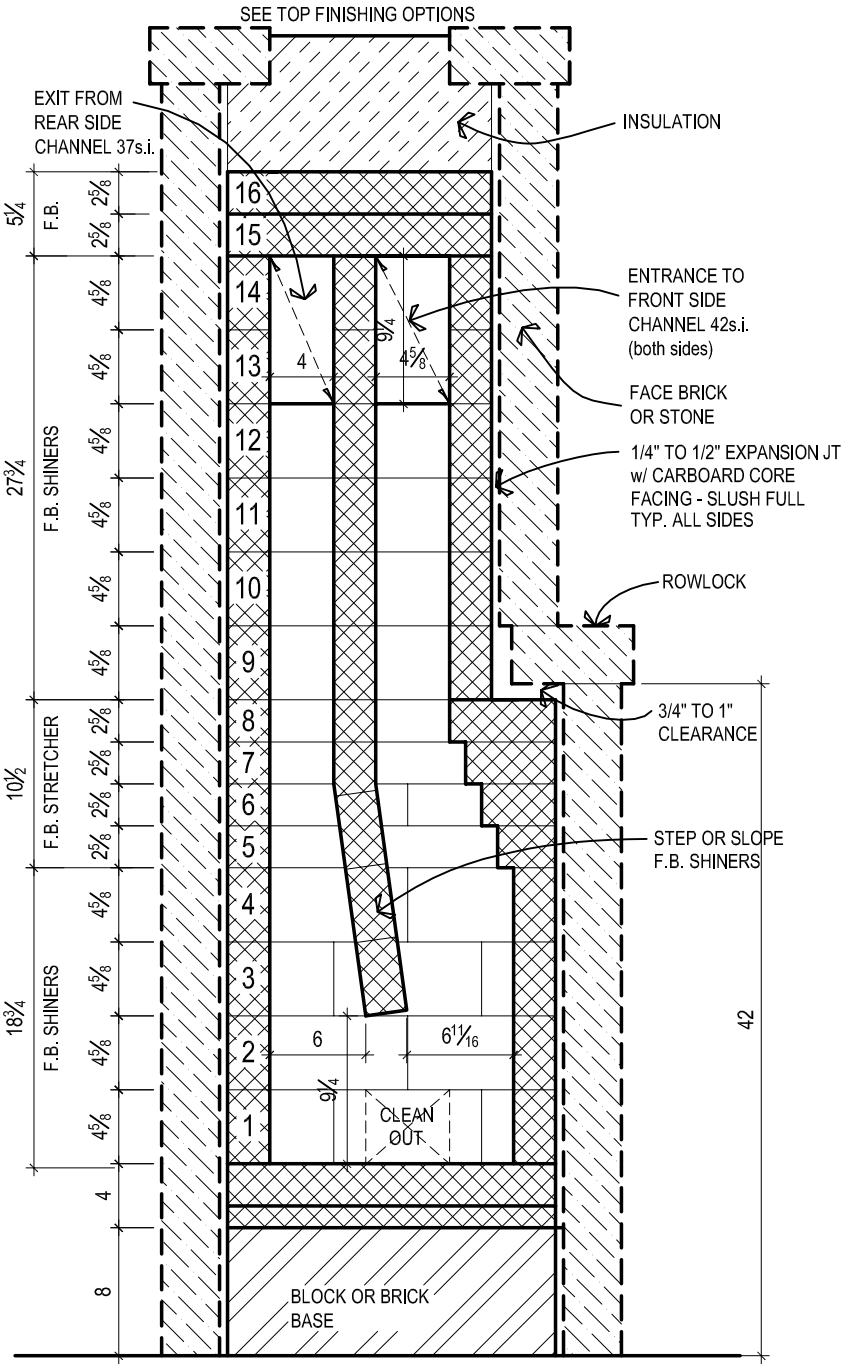
NOTES :

ON ALL STEEL LINTEL, ETC. BE SURE TO COVER ENDS WITH INSULATION TO ALLOW FOR EXPANSION

Swedish Heater (Kakelugn)

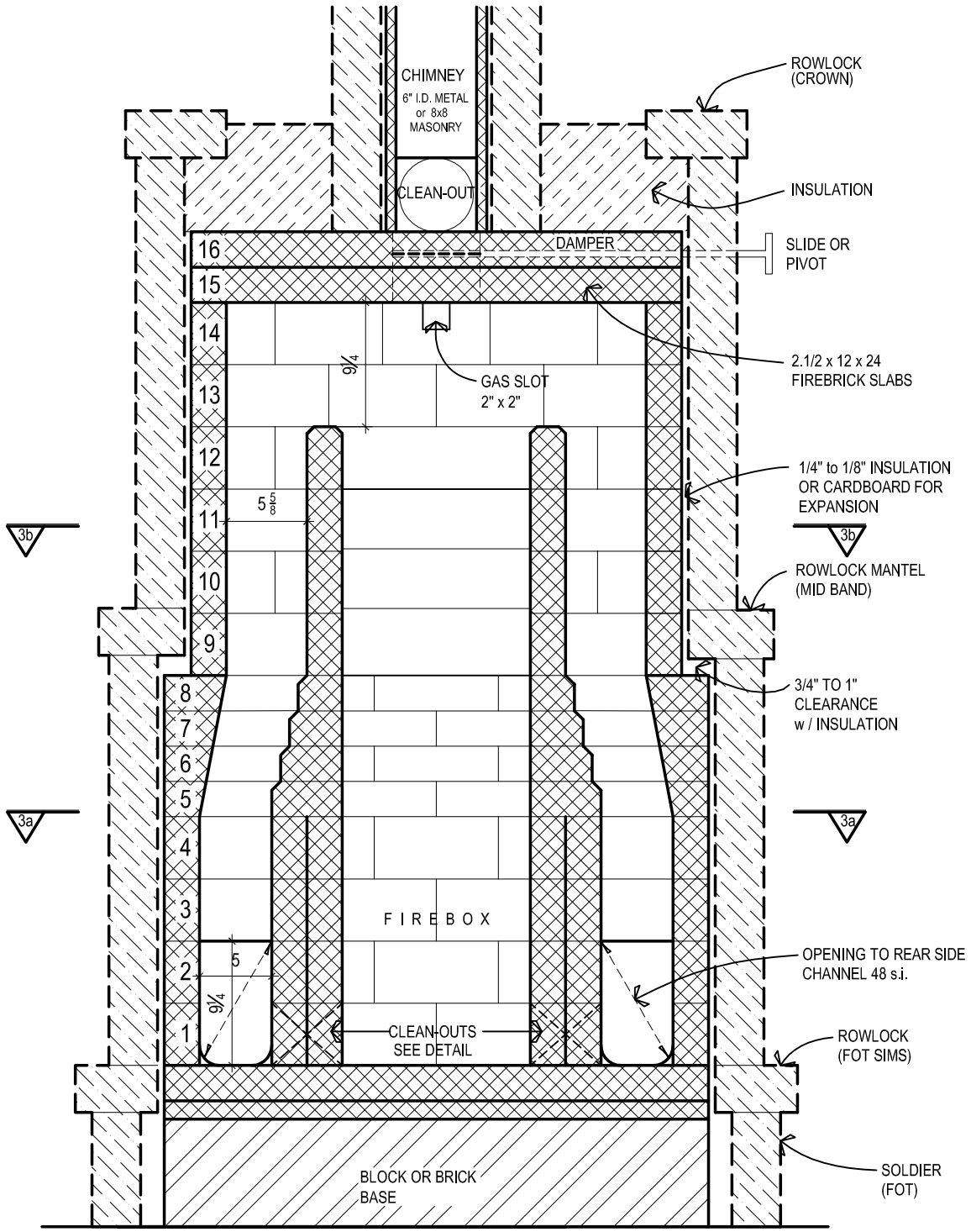
Materials List

500 - 2 5/8 x 3 5/8 x 7 5/8 Standard Face Brick
15 - 80 lb. bags Type "S" Premixed Mortar (if you use Type "N" add 20% Portland Cement)
300 - Standard 2 5/8 x 4 ½ x 9" Fire Brick
30 - 1 ¼ x 4 ½ x 9" Fire Brick Splits
2 - 50 lb. Refractory Mortar (Premixed)
(i.e. Sair/set - Tennex - Heat/stop) or Equal
3 - 2 ½ x 12" x 24" Refractory Slabs (Straights) Cut to 2 ½ x 12 x16 ½"
1 - Chimney Damper (For 8 x 8 Masonry Chimney or 6" ID Class "A" Metal Flue
1 - 2" x 4" Bypass Damper (optional could replace gas slot)
1 - 2 x 4" Outside Air Damper
3 - Cleanout Doors, 1 Flue Area/Damper, 2 Flue Channels
2 sq. ft. ½" Ceramic Blanket Insulation (4 lb. Density)
1 - Door for 14" w x 17" hi opening
1 - 18" - 3 x 3 x 3/16 Angle Iron (Lintel)
1 - 18" - 2 x 2 x 1/8 Angle Iron (Lintel)
1 - Air Supply Baffle
60 sq. ft. ¼" Mineral Wool Insulation (or Cardboard)
4 - 8 x 8 x 16 + 1 - 4 x 8 x 16 + 1 - 4 x 8 x 8 CMU for Base below firebrick
or
75 - 2 5/8 x 3 5/8 x 7 5/8 Standard Solid Brick (Commons) for Base below firebrick
+ Footing
+ Hearth and 8 x 8 Masonry Chimney or 6" Class "A" Metal Flue



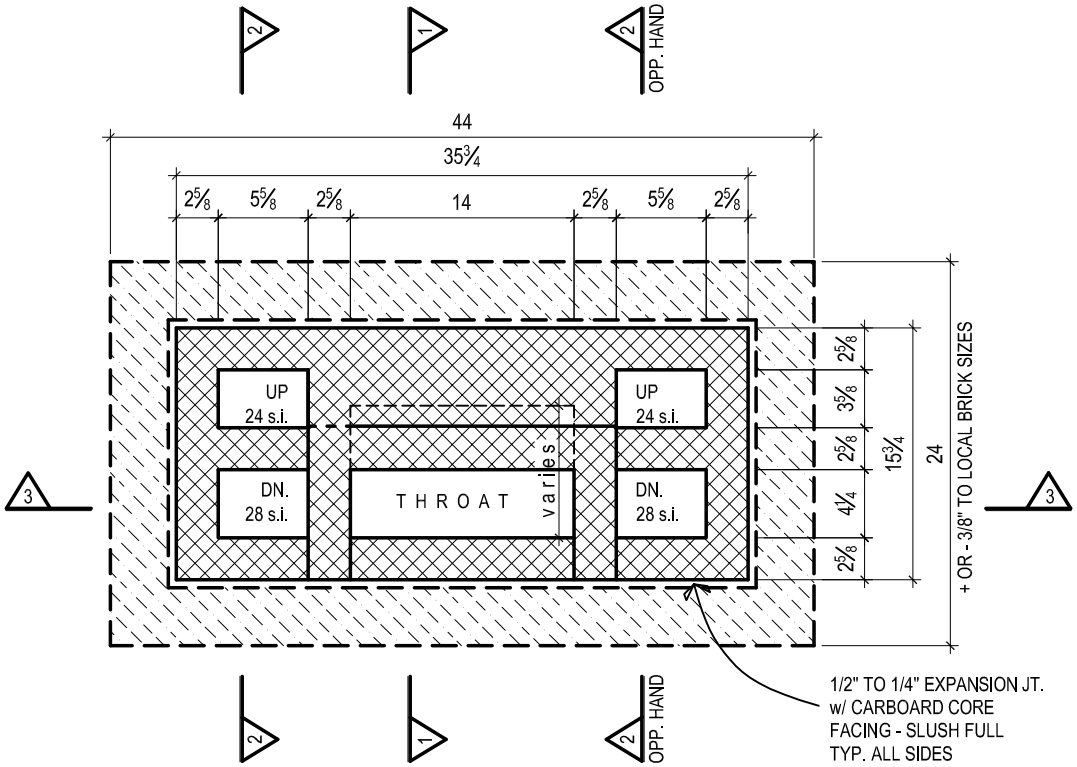
2. CROSS SECTION thru exchange channels

SWEDISH HEATER 1" = 1'-0"



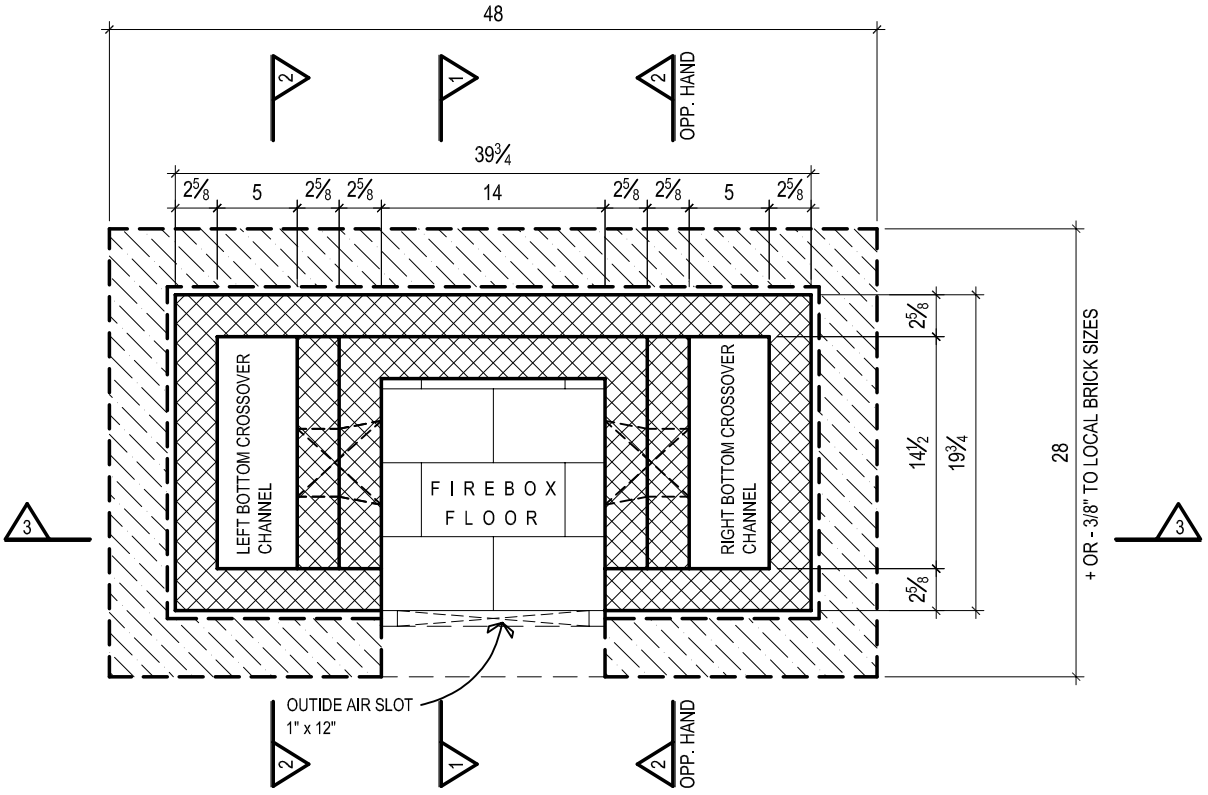
3. LONGITUDINAL SECTION thru front channel

SWEDISH HEATER 1" = 1'-0"



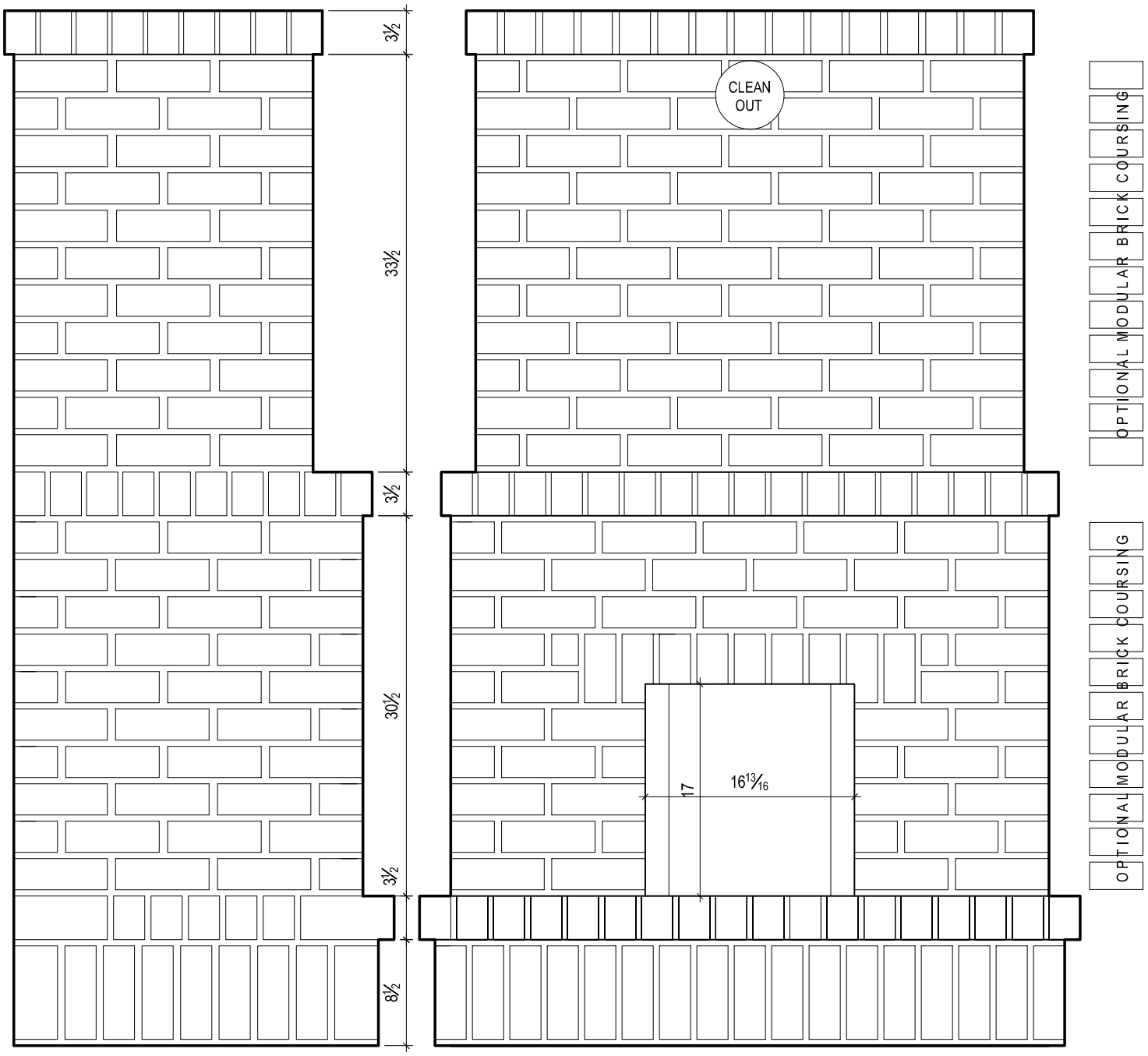
4b. PLAN @ THROAT (COURSES 8-15)

SWEDISH HEATER 1" = 1'-0"



4a. PLAN @ FIREBOX (COURSES 4-7)

SWEDISH HEATER 1" = 1'-0"



5. BRICK FACING

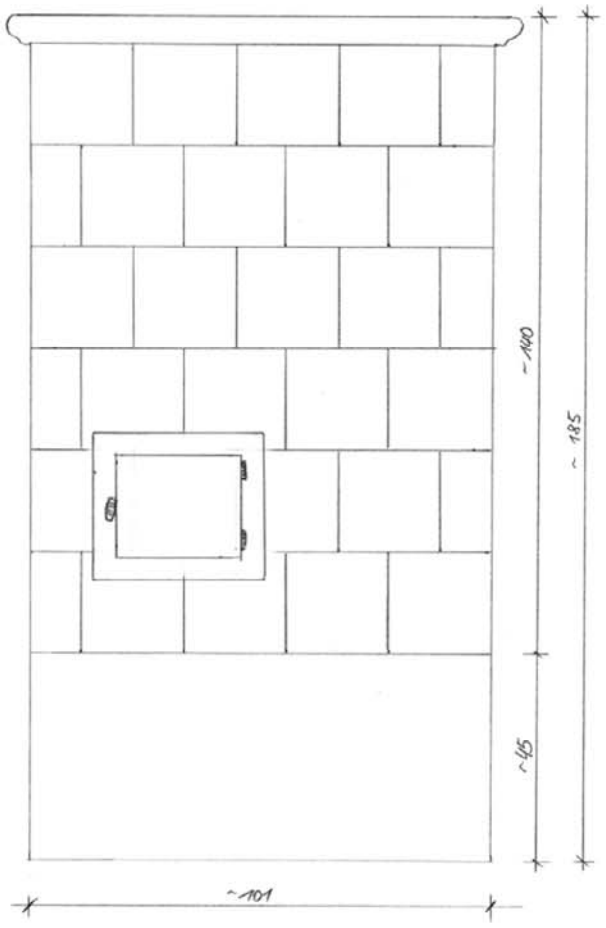
SWEDISH HEATER

1" = 1'-0"

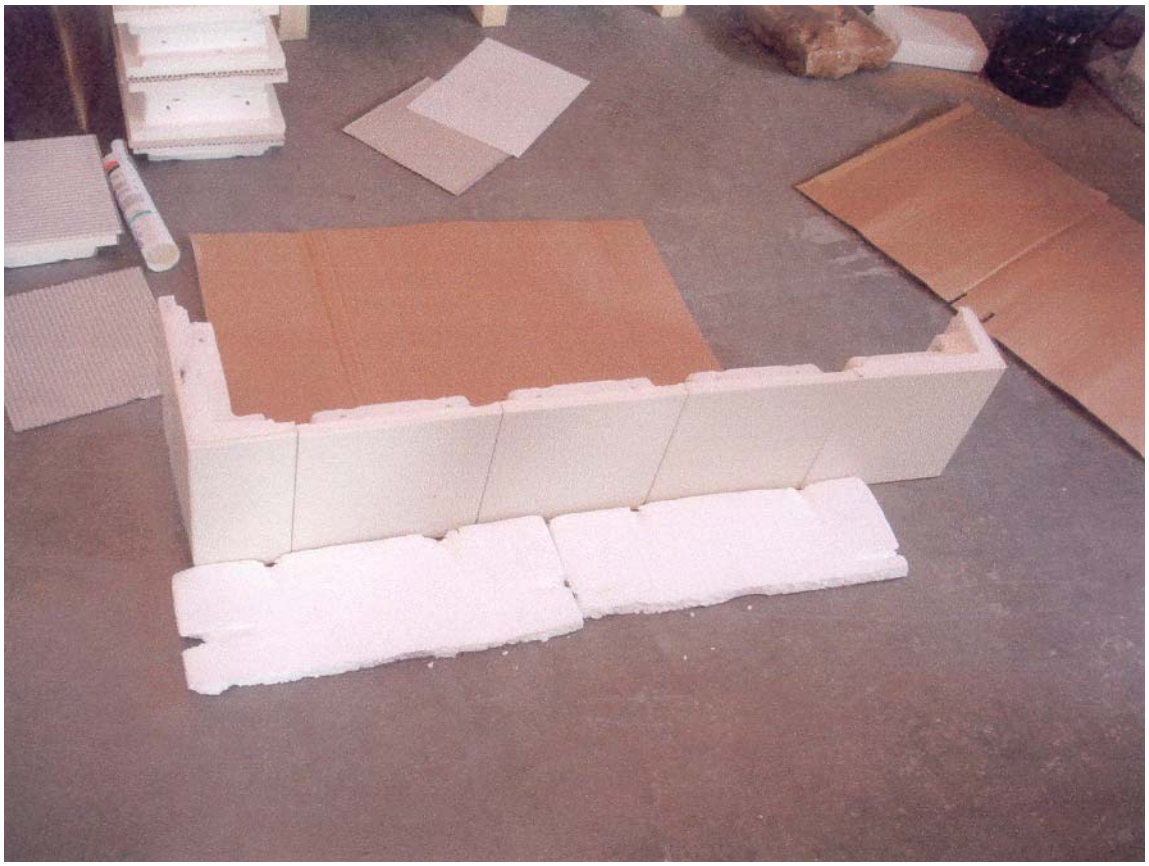
SOMMERHUBER

Keramik Manufaktur Steyr 1491

TILE STOVE FRONT VIEW 1:10 in cm

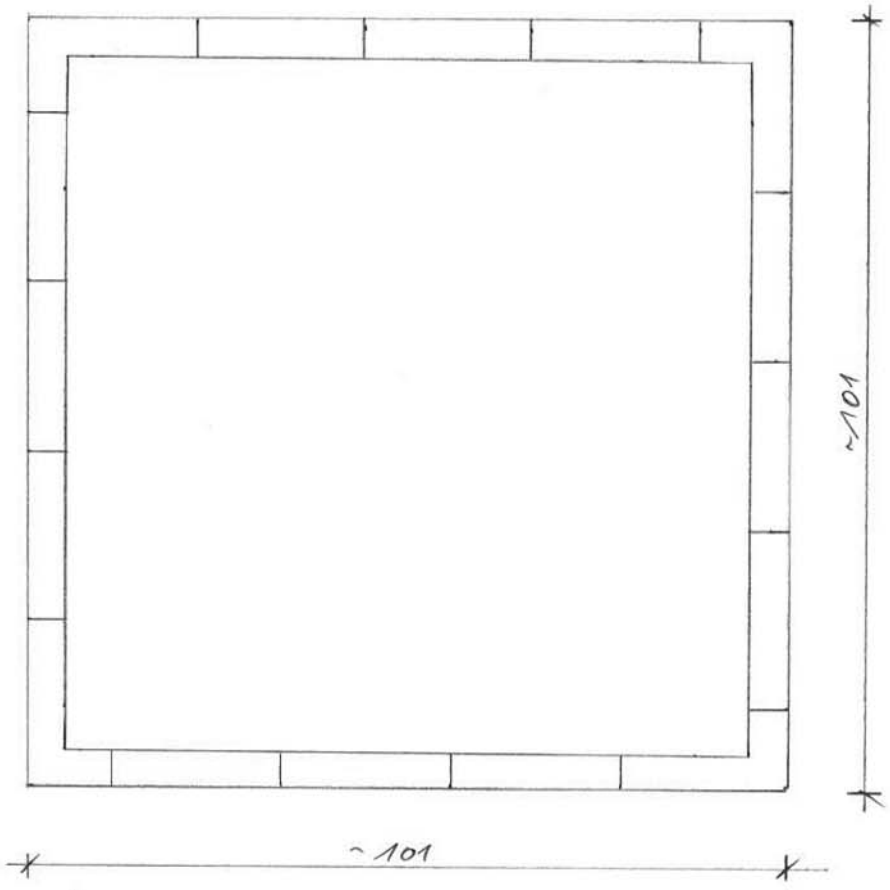


Preparing the first row of tiles in the
ATSA//Austrian Tile Stove Association

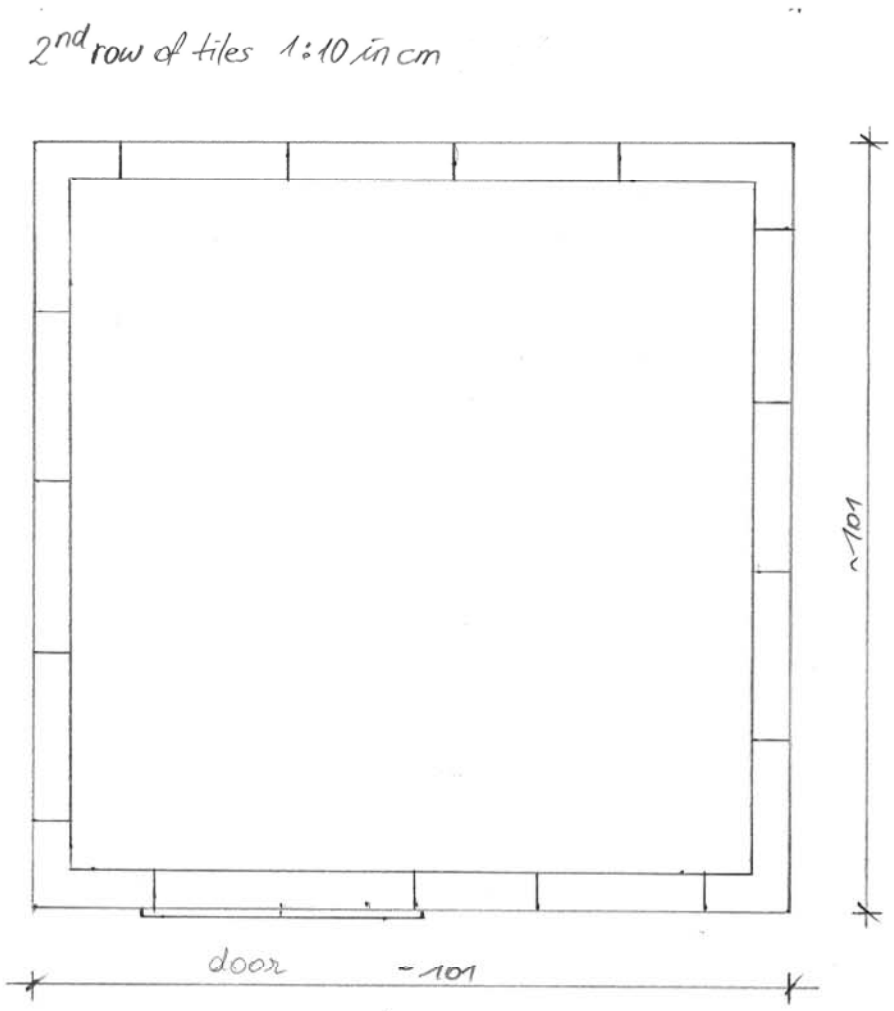


First row/course of tiles, measurement in cm
one tile has 22.3 cm x 22.3 cm

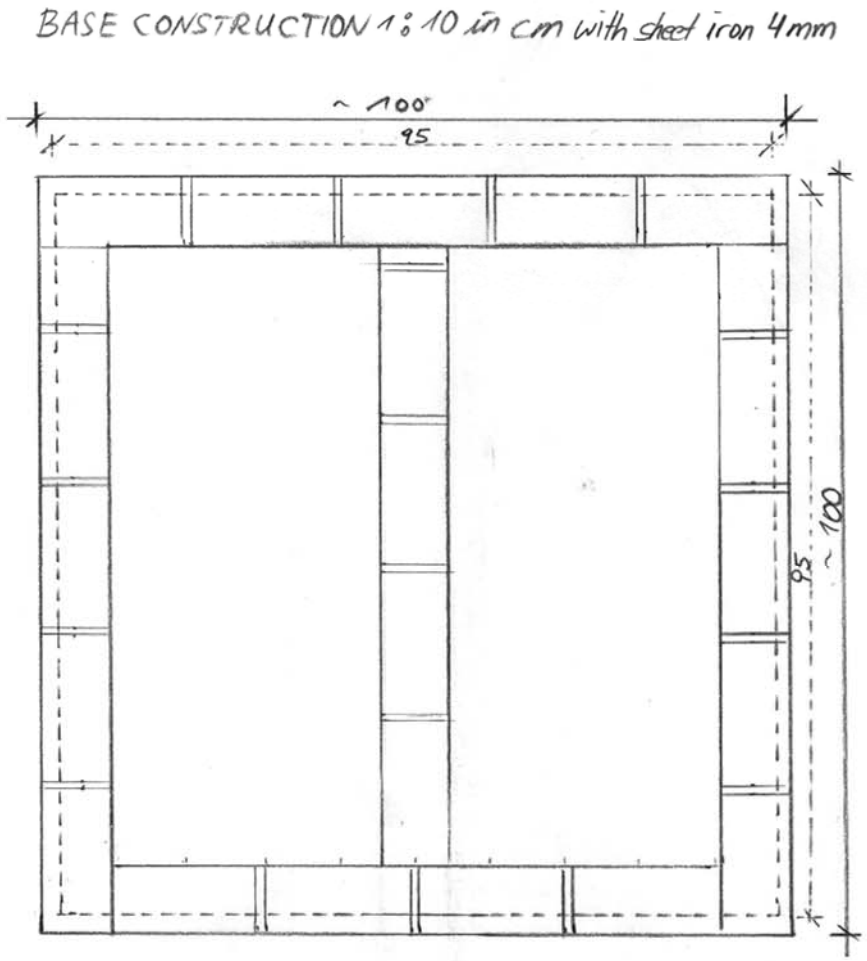
1st row of tiles 1:10 in cm



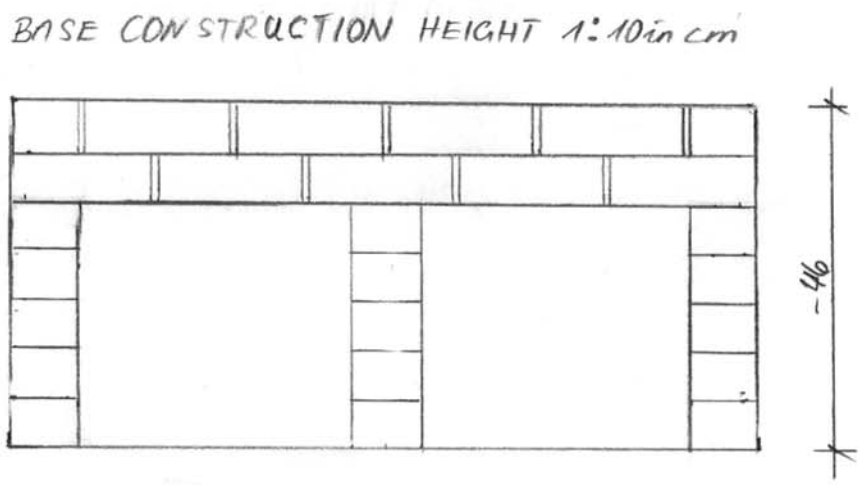
Second row/course of tiles, measurement in cm, one tile has 22.3 cm x 22.3 cm



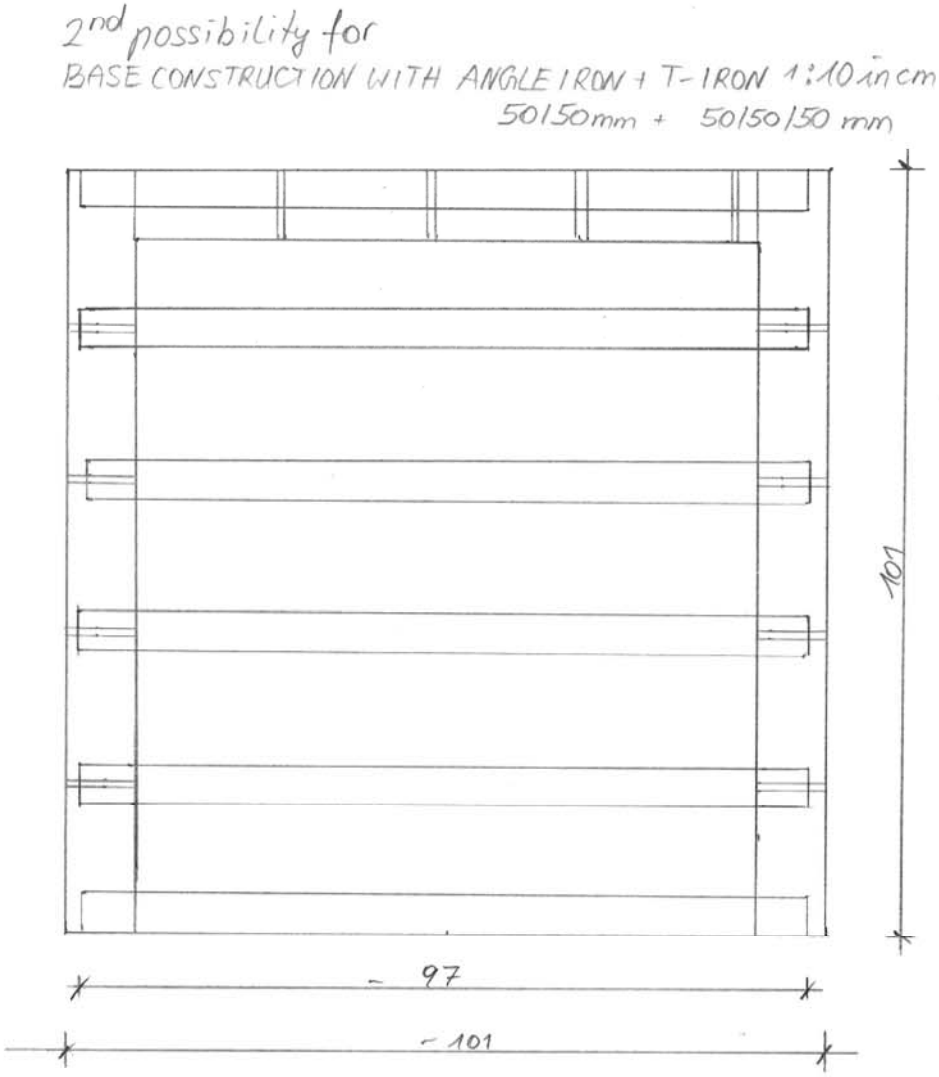
1st possibility for base construction, the base is made out of approximately 110 standard brick, the sheet iron plate with 4 mm thickness supports the surface of the tile stove made out of 100 standard bricks



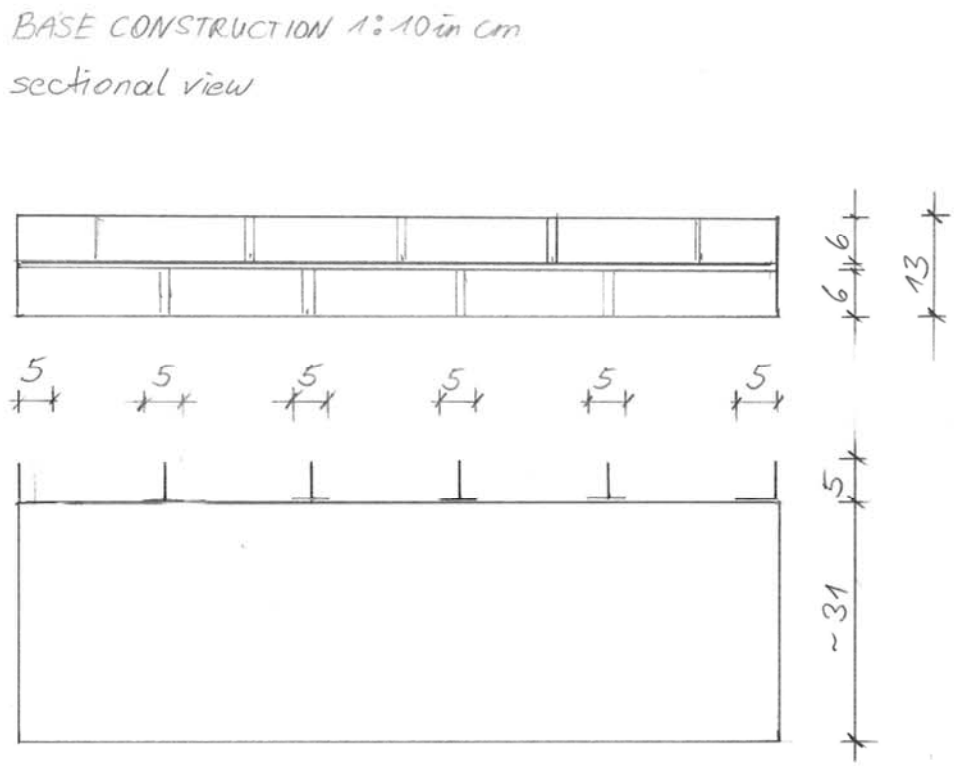
1st possibility for base construction, 110 standard bricks and another 100 standard bricks for the surface above, a sheet iron plate, thickness 4 mm, with 95 cm x 95 cm



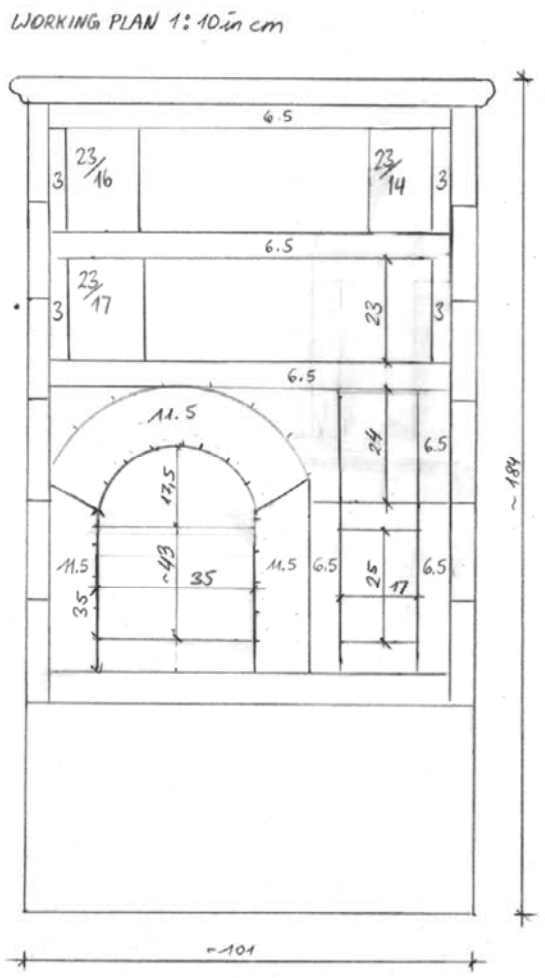
2nd possibility for base construction using 2 angle irons length 97cm, 4 t-irons length 97 cm, 44 standard bricks and another 100 standard bricks for covering the surface, standard brick measures are 19 cm x 11 cm x 6 cm



2nd possibility for the base construction, sectional view showing how the 2 angle irons and the t-irons support the surface made out of 2 layers of standard bricks



Working plan for tile stove



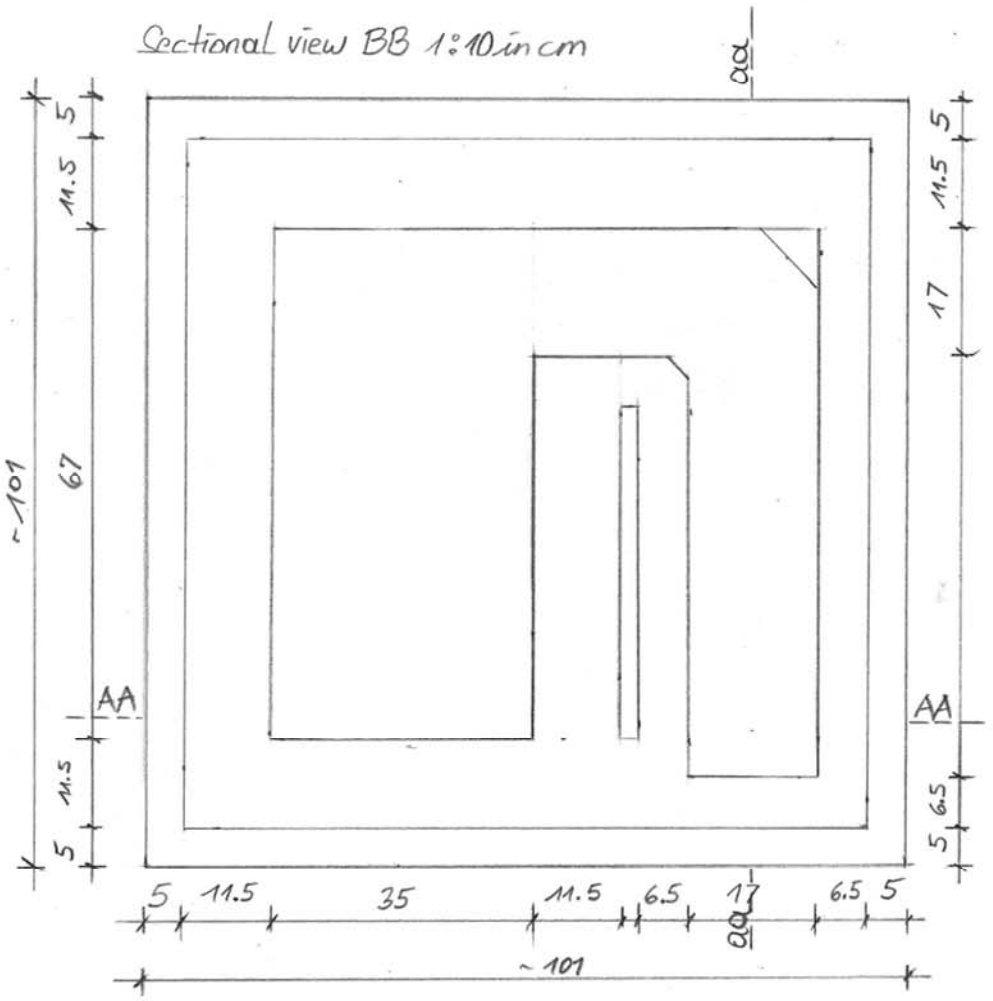
North American Building Code Note:
Required clearances to combustibles:

The 2006 International Residential Code references NFPA 211, and states that clearances to combustibles should be 36".
It states the following exception:

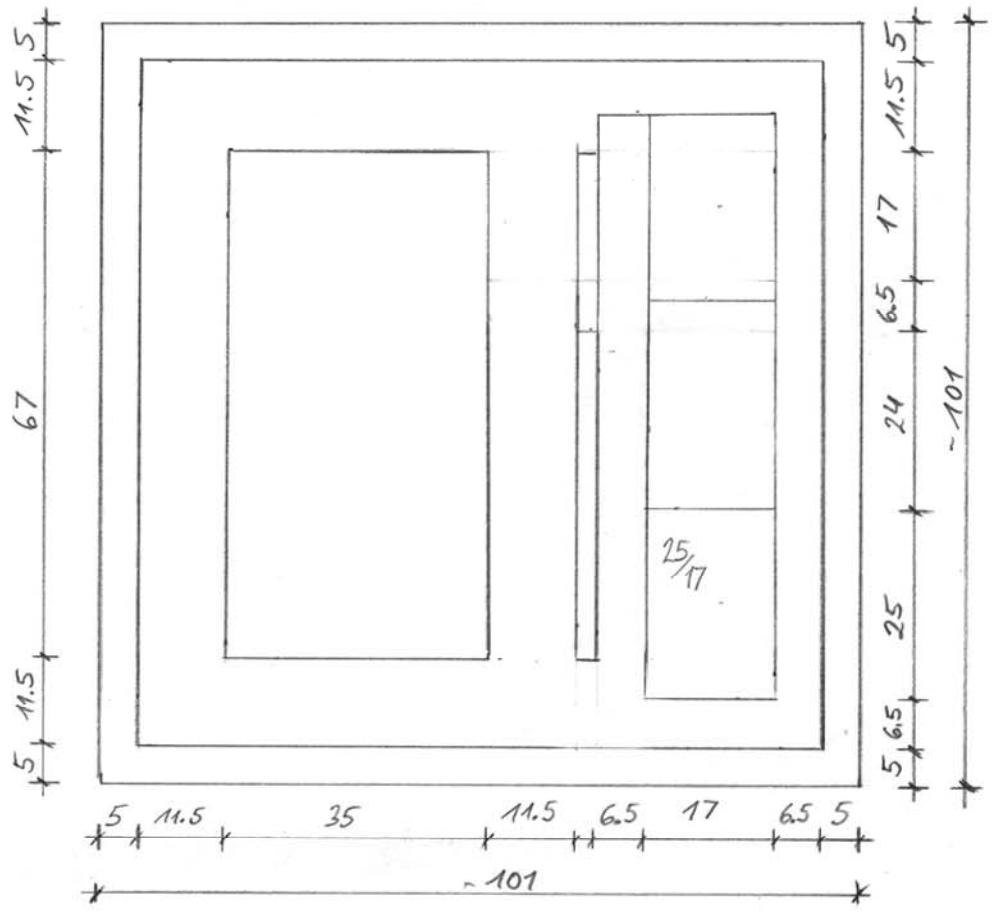
"exception: if the firebox is at least 8" thick clearances can be reduced to 4".

This plan may be modified to meet the 4" clearance provision by thickening the wall section at the firebox to give an overall thickness to the outside of 8".

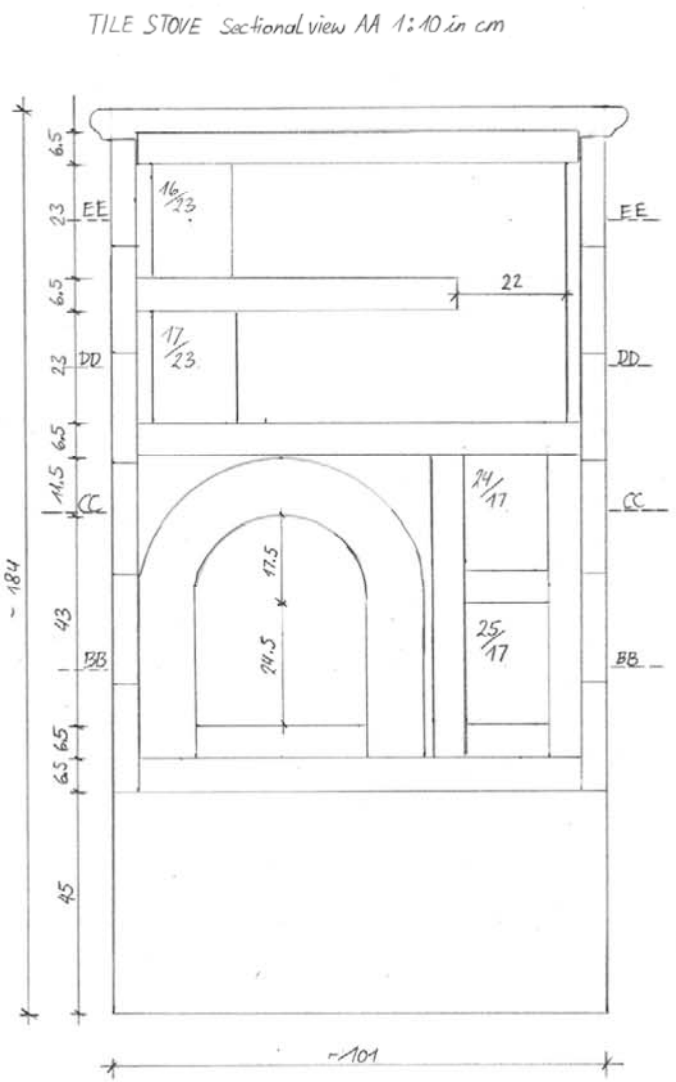
Ground plan for tile stove
sectional view BB in 1:10 in cm



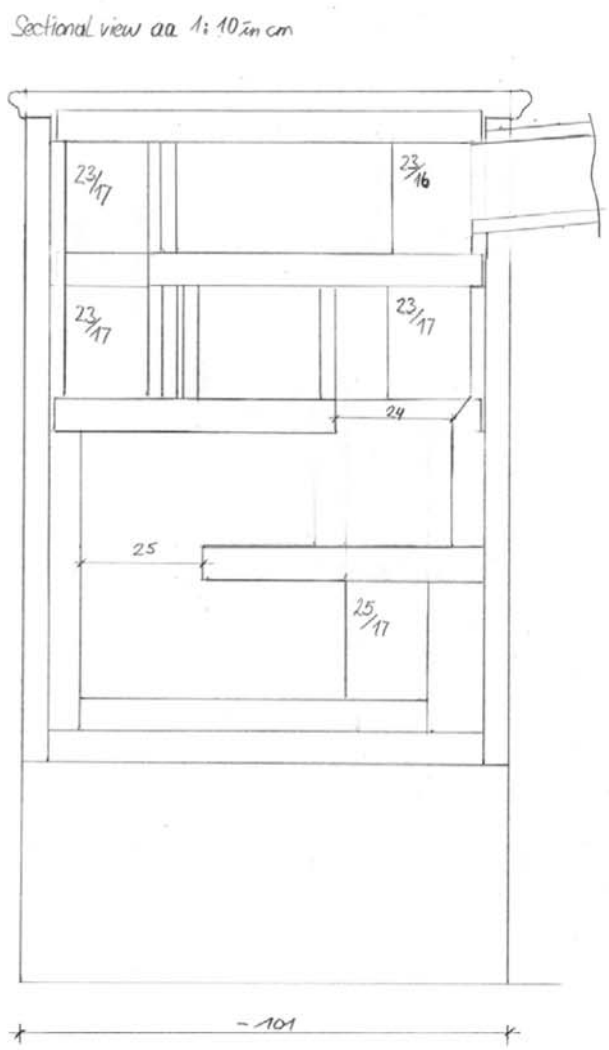
Ground plan for tile stove
sectional view CC in 1:10 in cm



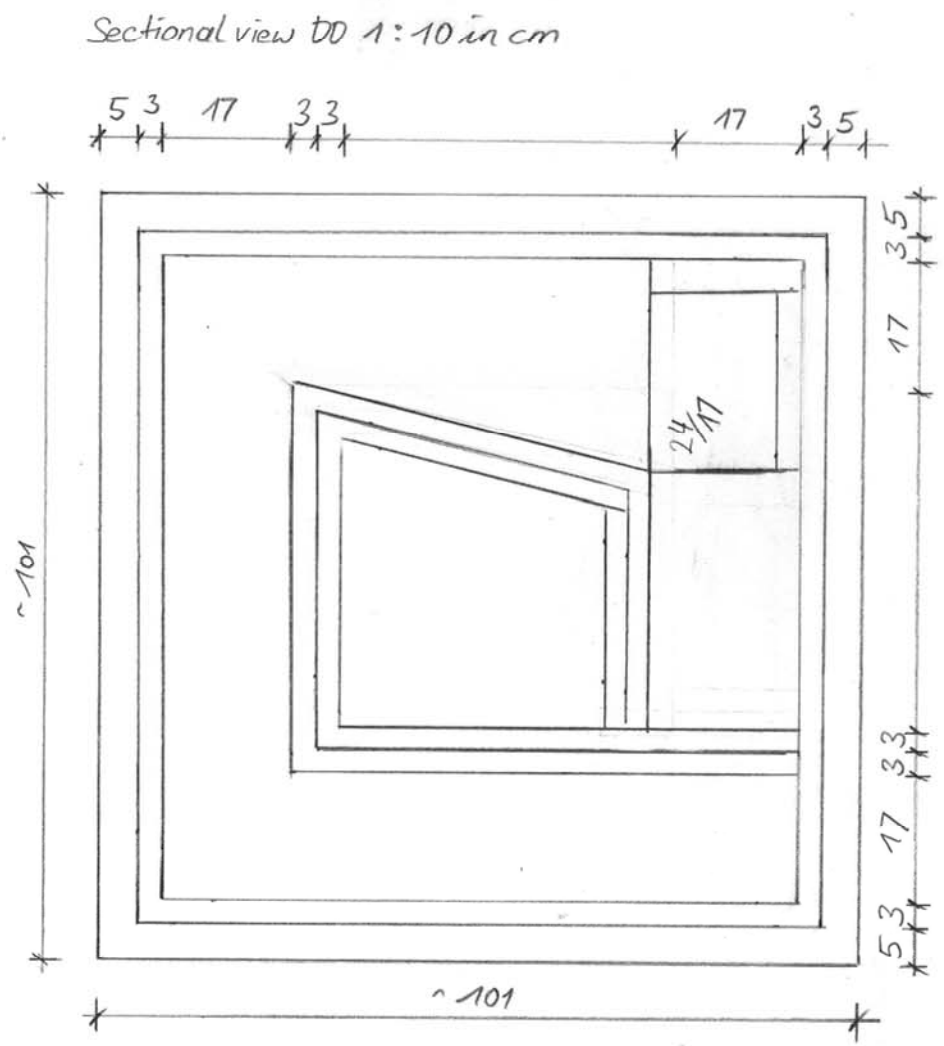
Tile stove sectional front view
in 1:10 in cm



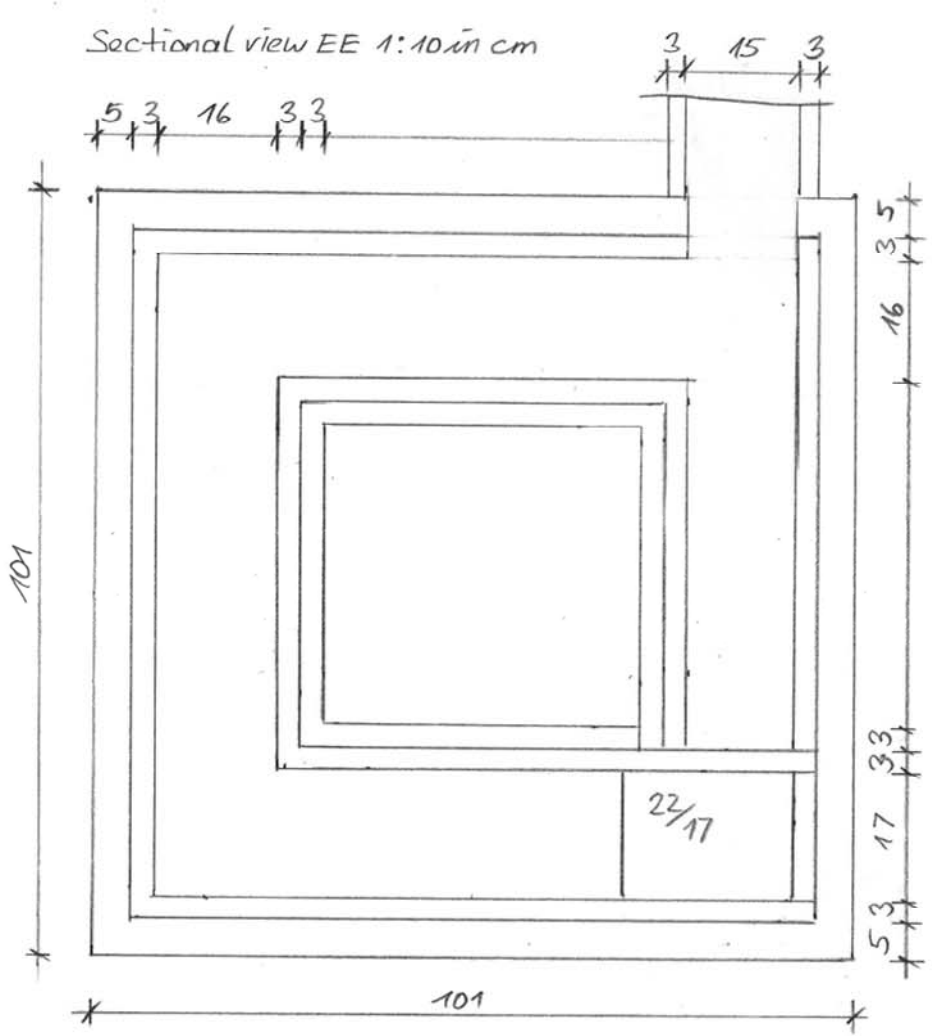
Tile stove sectional back view



Tile stove sectional view showing the measurements of the flues



Tile stove sectional view showing the measurements of the flues



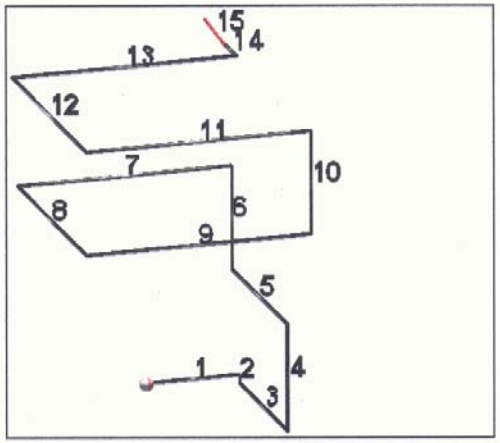
Print out the standard drawing showing all measurements of the combustion chamber and the flues

PRINT FOR BUILDING SITE

Kachelofen calculation - flue details

Nr.	l[m]	b[cm]	h[cm]	Wall	Ceiling	Dir.	Bemerkung
flue 1	0,27	17,0	25,0	40	40	Righ	
flue 2	0,03	17,0	25,0	40	40	Down	
flue 3	0,45	17,0	25,0	40	40	Forw	
flue 4	0,31	17,0	25,0	40	40	Up	
flue 5	0,52	17,0	24,0	40	40	Back	
flue 6	0,30	17,0	24,0	40	40	Up	
flue 7	0,62	17,0	23,0	30	30	Left	
flue 8	0,65	17,0	23,0	30	30	Forw	
flue 9	0,65	17,0	23,0	30	30	Righ	
flue 10	0,30	17,0	22,0	30	30	Up	
flue 11	0,65	17,0	23,0	30	30	Left	
flue 12	0,70	16,0	23,0	30	30	Back	
flue 13	0,65	16,0	23,0	20	30	Righ	
flue 14	0,10	14,0	23,0	20	30	Back	
conn.15	0,20	15,0	15,0			BU5	Fireclay pipe 15x15

conn.15: Fireclay pipe 15x15



TECHNICAL DATA:
Heat output:3,6 kW
Nominal heating time:12 Hours
Altitude (above sea level):1006 m
Maximum fill-up quantity of wood:13,5 kg
Minimal fill-up quantity of wood:6,7 kg
Standard combustion chamber horizontal
Base:2344 cm²
Vertical grate cross-section:200 cm²
Gas slot cross-section:13 cm²
h = 43cm
a = 35cm
b = 67cm

Ofenbau + Feuerstellen

The calculation corresponds to the proved calculation guideline of the "Versuchsanstalt der Hafner" (Research Center of the Austrian stove-fitters). (State 2005):1.118)

Print out of the technical documentation for the customer

Technical documentation

Name of the producer	Ofenbau + Feuerstellen
Office of the producer	A-3920 Groß Gerungs
Owner	Dr. Thomas Schiffert
Address	Wildacres
Location	NC
Altitude (above sea level) (m)	1006
Device type	Tile stove
Output (kW)	3,6
Nominal heating time (h)	12 Hours
Max. fill-up quantity of fuel (kg)	13,5 kg
Min. fill-up quantity of fuel (kg)	6,7 kg
Efficiency (%)	83 %
Name of the testing laboratory	TU-Wien - Institut für Verfahrenstechnik
Number of the type approval certificate	VTWS-9714-P
Date of the type approval certificate	09.09.1997
Emission values (mg/MJ)	CO: 870 NO2: 91 OGC: 54 Staub: 22

This device is conform to the agreement according to Article 15-a B-VG about the precautions concerning small combustions and about the economy of energy.

Stamp and signature of the stove-fitter Location and date

Wildacres, 14th of April 2007 Richard Jussel

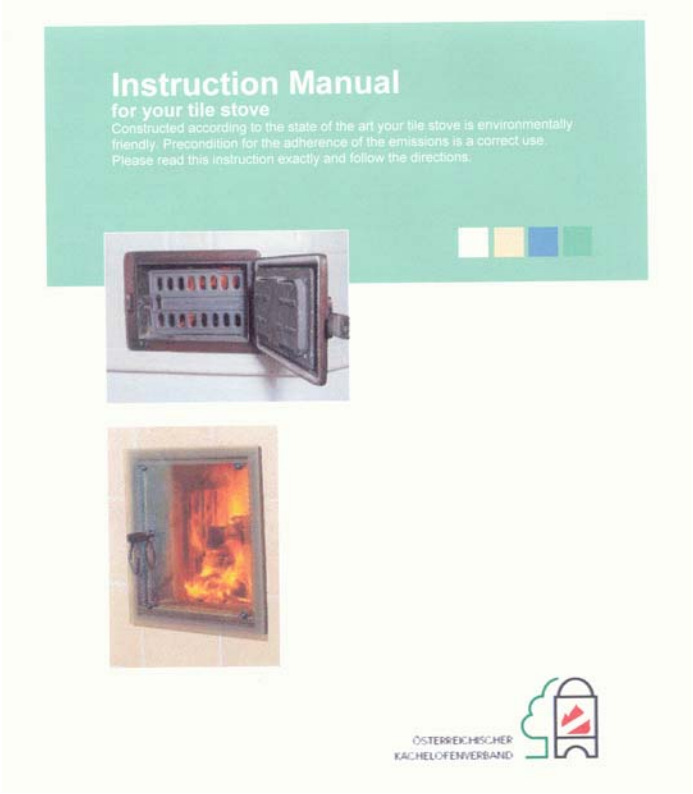
OFENBAU + FEUERSTELLEN
Richard Jussel
Kl. Wetzles 35
3920 Gr. Gerungs
fon+f. 02812/51128
www.feuermacher.com

Print out of the blank for the type plate that is used in Austria as proof that the tile stove was made by a master stove fitter entrepreneur

Blank for the type plate

Name and office of the producer	Ofenbau + Feuerstellen A-3920 Groß Gerungs
Type / Trade name	Tile stove
Production number / Year of construction	/ 08.04.2007
Nominal heat output	3,6 kW
Range of heat output	1,8 - 3,6 kW
Max. fill-up quantity of fuel	13,5 kg
Nominal heating time	12 Hours
Allowed fuels	Log wood, wood briquettes
Standard identification	

Print out the instruction manual
for the customer‘s tile stove



HTC: Refractory mortar and its use in core construction.

The following images illustrate the use of air set refractory mortar in this case Refracol 1.

By Marcus Flynn
2008

On opening a new bucket of mortar, it is important to thoroughly stir the contents. Due to the agitation of transport the consistency of the mortar may no longer be homogeneous. The heavier aggregate will have tended to fall to the bottom of the bucket and the sodium silicate rise to the top. If not stirred, the portion at the bottom will be weak in sodium silicate.

During initial stirring it is common practice to add water in order to bring the mortar to a workable consistency. When liquid enough, if a refractory brick is placed on the surface, half of the brick should sink into the mortar. This though is only a general rule and each mason will add water until arriving at their own preferred consistency.

If no water is added when opening a new bucket it will be difficult to lay the brick with the extremely tight joints required. As work progresses and relatively dry 'scrape off' is remixed back into the bucket it will become necessary to add more water to maintain the original consistency.
While working it is important to keep the inner surfaces of the bucket free from mortar 'scrape off' that is scraped back onto the inner rim of the bucket - it can dry surprisingly fast, and when mixed back in, will cause the contents of the bucket to be lumpy.
At lunch time and breaks, the bucket should be firmly closed with its lid.

There are two methods of applying mortar to the brick. The mortar can be spread onto the brick with a margin trowel. Or the brick can be 'dipped' directly into the bucket, with excess mortar being scraped off by trowel.
Using a margin trowel is important as the square end enables hardening mortar to be completely scraped from the bed in instances where a brick must be re-layed, and new mortar applied.
Mortar is, as a rule, applied to the brick and never to the bed on to which it will be layed.

As the brick is layed, mortar should be seen to squeeze out from all the length of the bed and head joint, ensuring 100% contact. Squeeze out should be scraped off by trowel immediately after laying and scraped back into the bucket.
Refractory brick should always be dry when layed, though superficial moisture from a long saw cut is not detrimental.
Due to the brick being dry, and tight joints required, it necessary to lay the brick a quickly as possible after the mortar has been applied. The rate at which the mortar is affected by sorption once applied to the brick will vary between different brands of brick, and mortar.

Joints should never be more than 3mm thick with 1mm and less being optimum. Some stove builders, using very liquid mortar will, when laying, slide the brick backwards and forwards along the bed until it is felt to physically contact the brick below.
With most quality brick being extremely uniform, once the first row has been leveled subsequent rows will not need to be checked for level.
On the occasions that a brick needs to be knocked into place with a hammer, it is preferable to use a brick hammer rather than a rubber mallet.
Though care must be taken not to crack the brick, the sharp directly transfered shock of a blow from a hard hammer is way more efficient than that of a dull blow from a soft mallet.

As regularly as possible the work should be sponged down with a wet sponge. This keeps the work clean, allowing the 'eye' to be in full control, and not distracted by variations in texture and color. Also mortar allowed to dry in to the work can effect the accuracy of the level if the work is being checked for plumb.

A professional cellulose tilers sponge will last longer and make sponging much easier than a domestic sponge.

HTC can be used to parge the surface of a ceramic wool or paper gasket. This provides a thin, though resistant, layer of mortar to the exposed surface of a gasket. A very liquid mix of mortar and water is applied by sponge or paint brush.

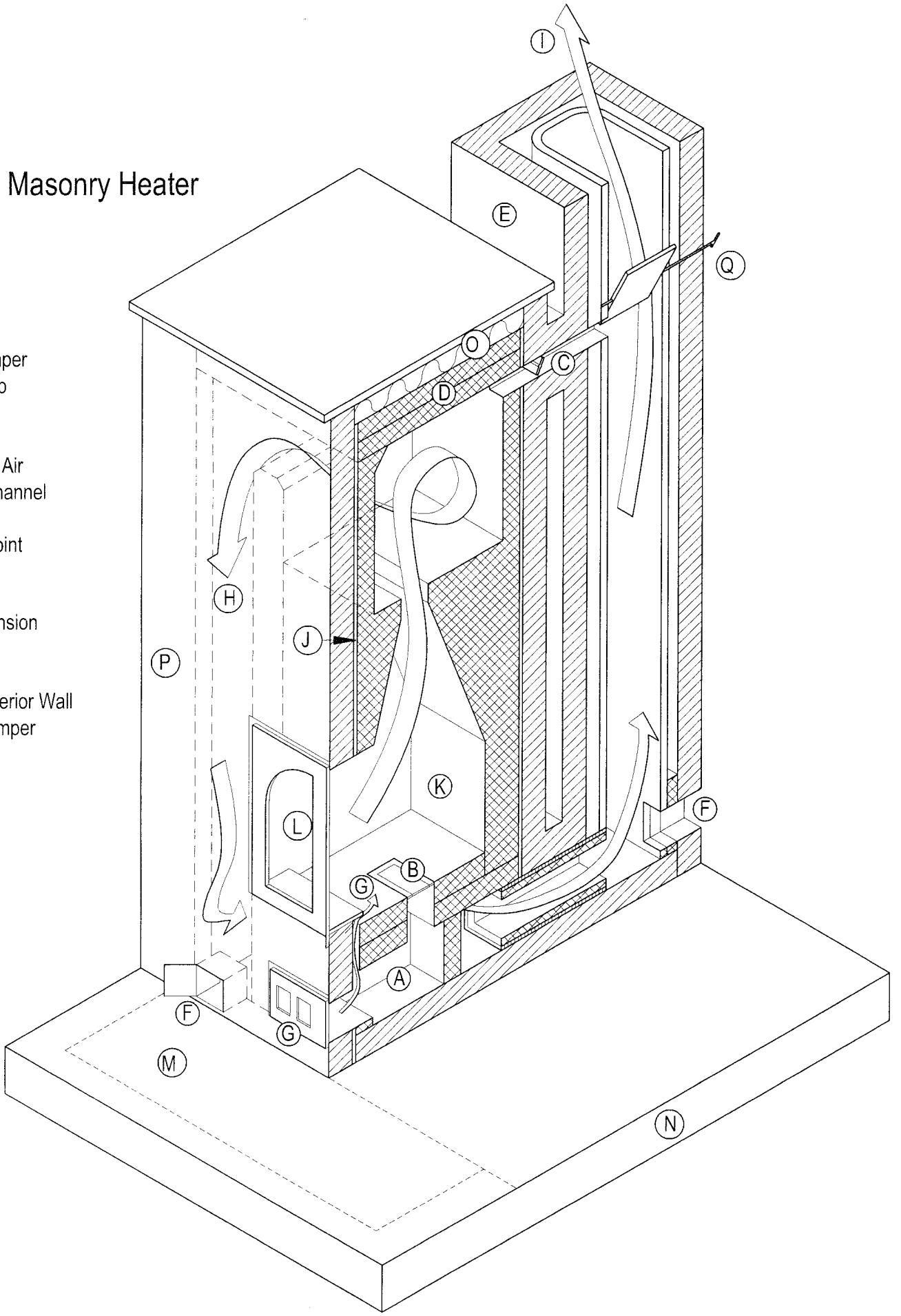
Refractory mortar can also be used to hold strips of ceramic wool in place.
It is important to wear gloves as both the clay base of the mortar and the sodium silicate are extremely astringent. Tools, especially levels should be wiped clean regularly. Many stove builders oil their levels at the start of each day.
The margin trowel should only ever be placed in the mortar bucket, the sponge bucket or upon the work. Keeping the mortar bucket free from granular contaminants is important.

The air set mortar generally used on heaters, will remain soft in the bed inside of the joints for weeks if not months, making removal of brick relatively easy at any time
All air set mortars will remain soluble in water, unless fused. This should be noted when protecting flue tiles layed in refractory mortar from potential water infiltration.
The use of refractory mortar to lay any elements of the facing, even if hidden behind a common mortar joint, is not recommended

Marcus Flynn

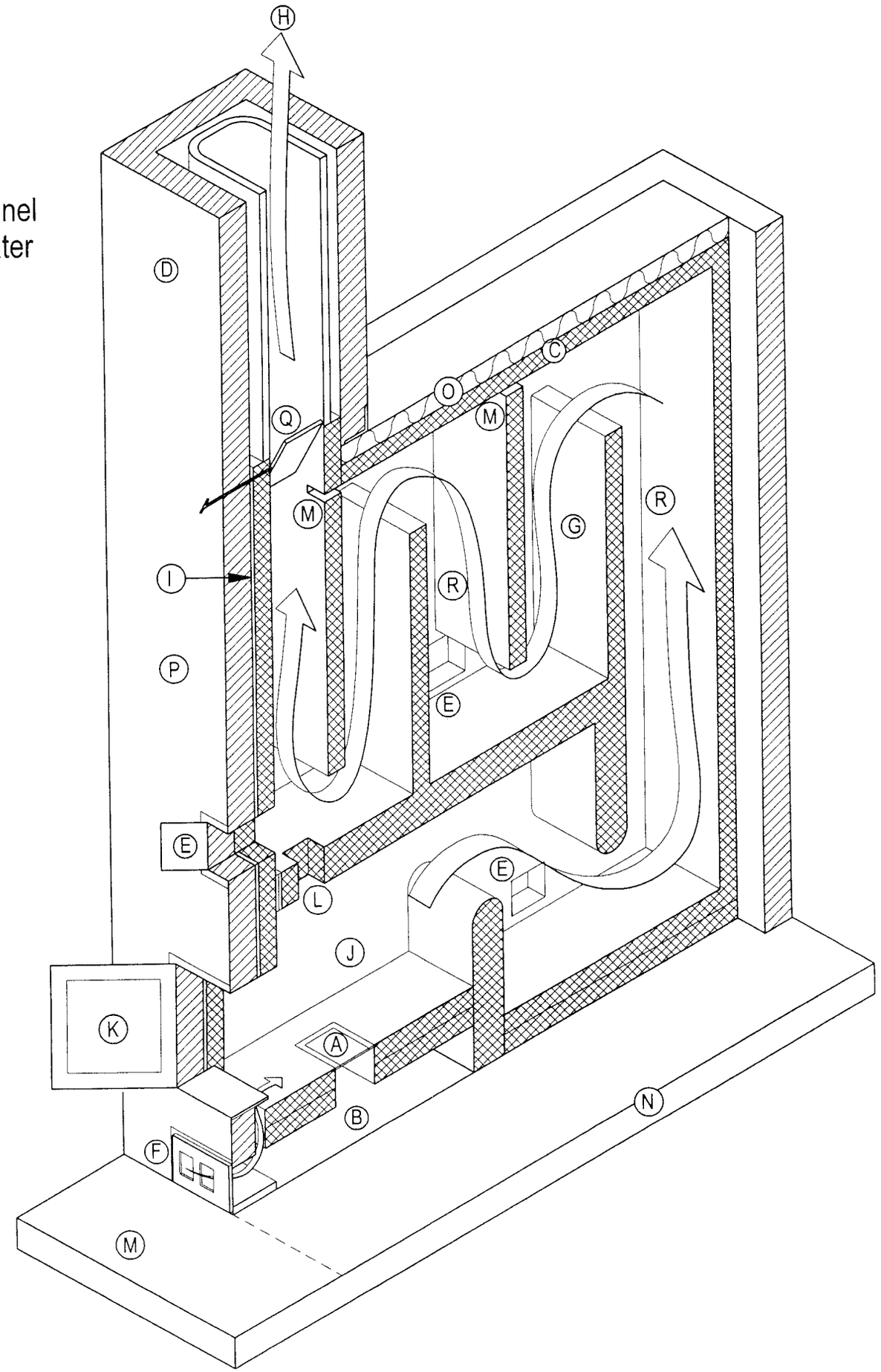
Contraflow Masonry Heater (Finnish)

A. Ashbox
B. Ash Dump
C. Bypass Damper
D. Capping Slab
E. Chimney
F. Clean-Out
G. Combustion Air
H. Downdaft Channel
I. Exhaust Gas
J. Expansion Joint
K. Firebox
L. Firebox Door
M. Hearth Extension
N. Heater Base
O. Insulation
P. Masonry Exterior Wall
Q. Shut-Off Damper



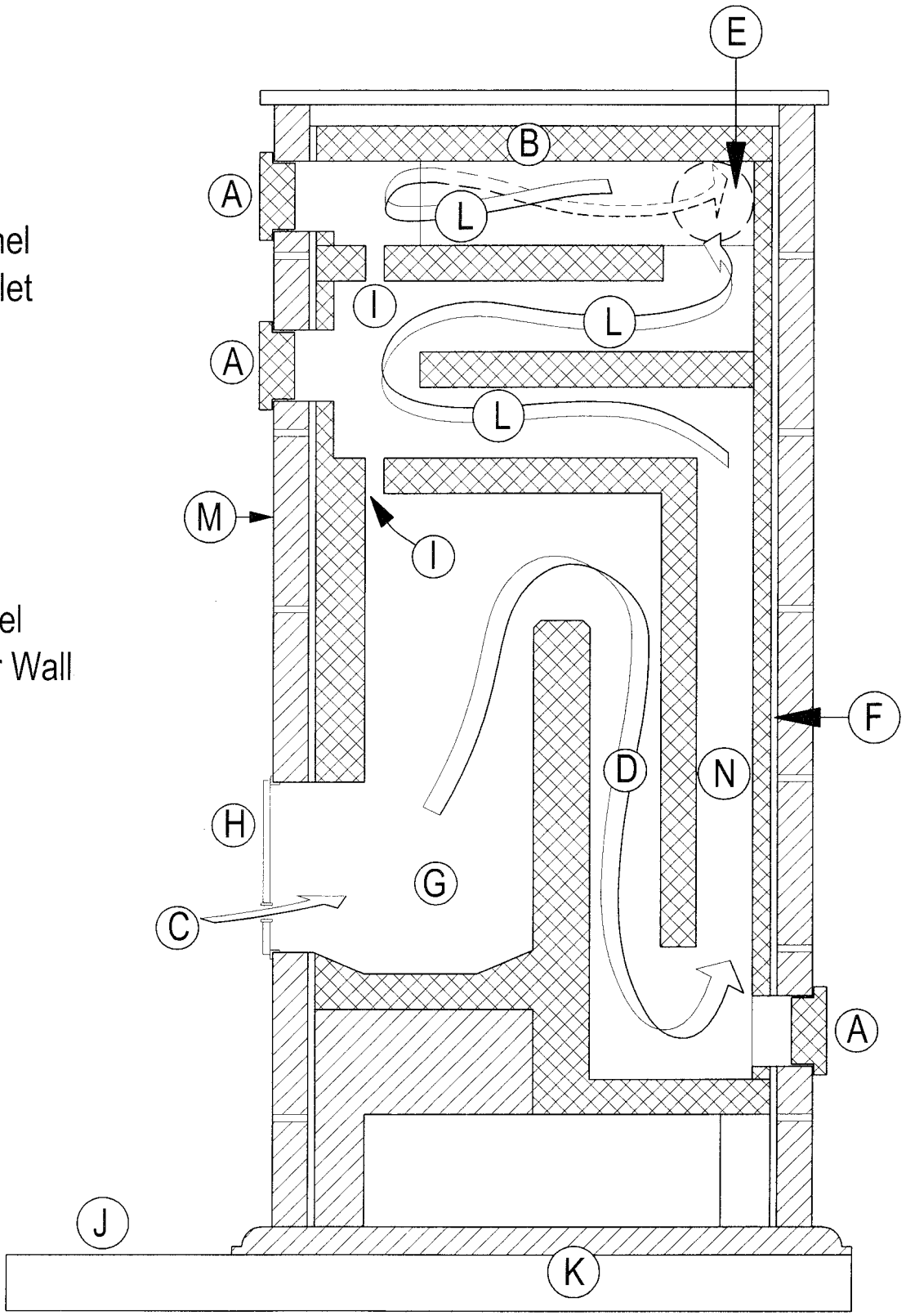
Vertical Channel Masonry Heater (Russian)

A. Ash Dump
B. Ashbox
C. Capping Slab
D. Chimney
E. Clean-Out
F. Combustion Air
G. Downdraft Channel
H. Exhaust Gas
I. Expansion Joint
J. Firebox
K. Firebox Door
L. Gas Slot
M. Hearth Extension
N. Heater Base
O. Insulation
P. Masonry Exterior Wall
Q. Shut-Off Damper
R. Updraft Channel



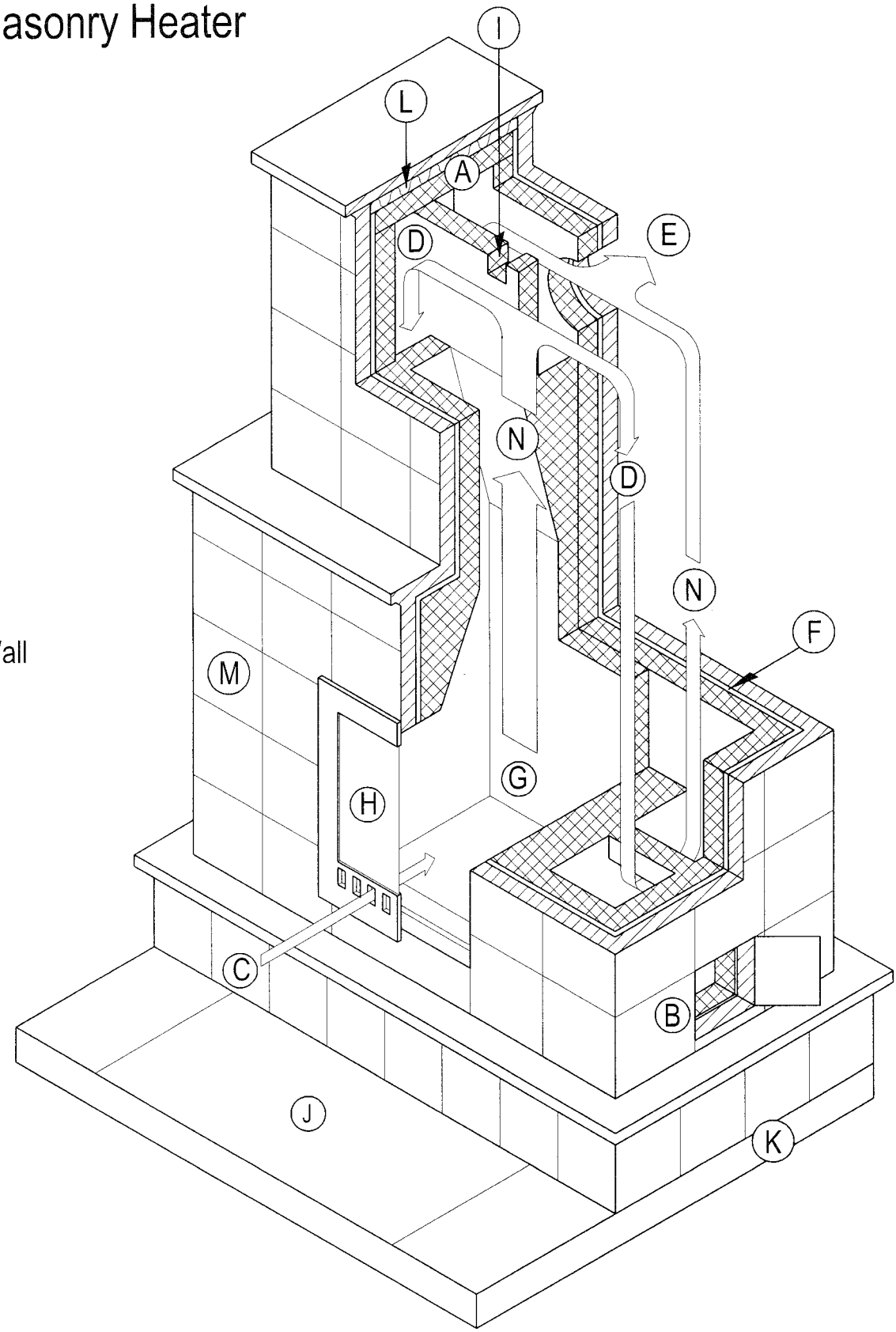
Combination Channel Masonry Heater (German)

A. Clean-Out
B. Capping Slab
C. Combustion Air
D. Downdraft Channel
E. Exhaust Gas Outlet
F. Expansion Joint
G. Firebox
H. Firebox Door
I. Gas Slot
J. Hearth Extension
K. Heater Base
L. Horizontal Channel
M. Masonry Exterior Wall
N. Updraft Channel



Five Channel Masonry Heater (Swedish)

A. Capping Slab
B. Clean-Out
C. Combustion Air
D. Downdraft Channel
E. Exhaust Gas Outlet
F. Expansion Joint
G. Firebox
H. Firebox Door
I. Gas Slot or Bypass
J. Hearth Extension
K. Heater Base
L. Insulation
M. Masonry Exterior Wall
N. Updraft Channel



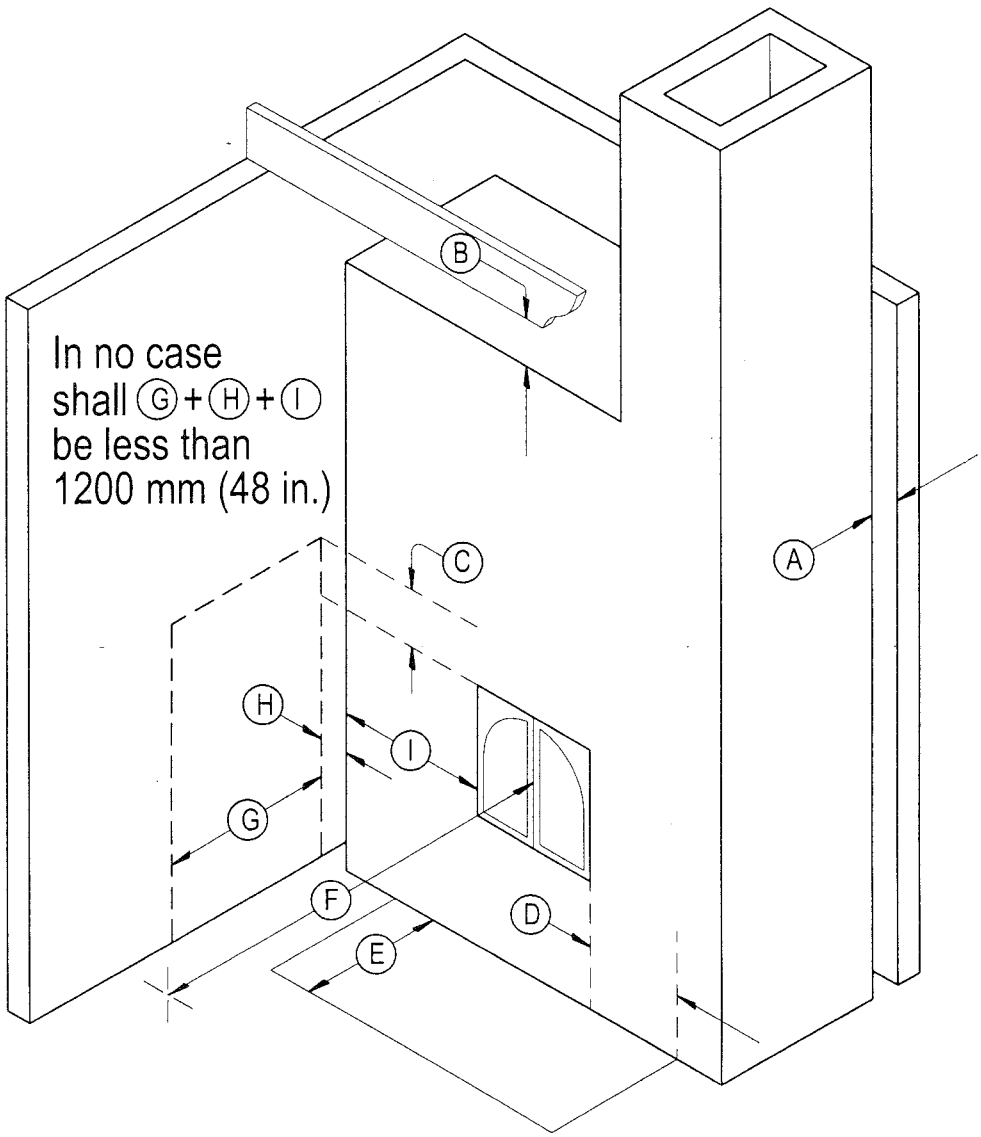


FIG. 3 Clearances to Combustibles

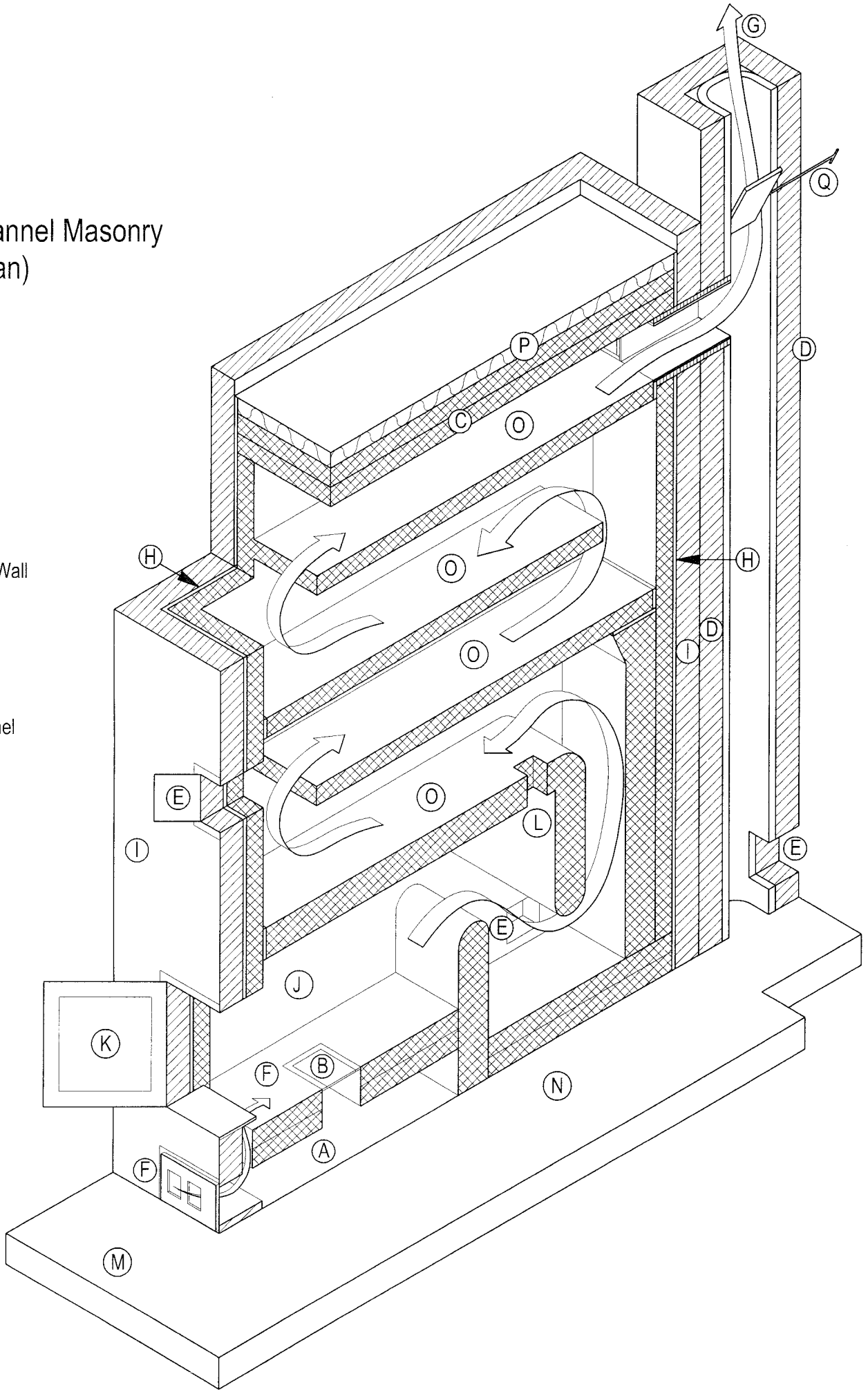
A. 100 mm (4 in.) to combustible framing
B. 200 mm (8 in.) to ceiling
C. 200 mm (8 in.) minimum extent of side wall heat shield above firebox door
D. 300 mm (12 in.) hearth extension (sides)
E. 500 mm (20 in.) hearth extension (front)
F. 1200 mm (48 in.) in front of firebox doors to combustible material perpendicular to door
G. Extent of mandatory side wall heat shield in front of masonry heater required only when clearance to combustible materials from firebox door of the heater is less than 1200 mm (48 in.)
H. Distance from combustibles to a side wall of a masonry heater
I. Distance from firebox door to a side wall of the masonry heater

NOTES

- Clearances from combustible walls or framing may be reduced with an engineered protection system
- G + H + I shall be 1200mm (48 in.) or greater

Horizontal Channel Masonry Heater (Russian)

A. Ashbox
B. Ash Dump
C. Capping Slab
D. Chimney
E. Clean-Out
F. Combustion Air
G. Exhaust Gas
H. Expansion Joint
I. Masonry Exterior Wall
J. Firebox
K. Firebox Door
L. Gas Slot
M. Hearth Extension
N. Heater Base
O. Horizontal Channel
P. Insulation
Q. Shut-Off Damper



A TYPICAL GENERIC HEATER BUILDING SEQUENCE

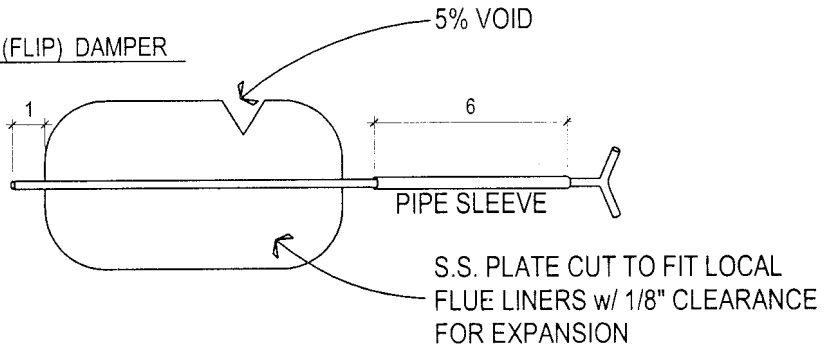
Hand built from plans (no cast core), could vary slightly from design to design. READ COMPLETE INSTRUCTIONS. BEFORE YOU START READ LINE NOTES YOU NEED TO REMEMBER.

1. **Determine heater location** (central/room divider location preferred).
2. **Layout footprint** on floor.
3. **Cut out floor** and frame 4" back of finish facing line (if the floor is not pre cut). If the floor is pre cut and the framing is 4" back for fire safety, then proceed.
4. **Set up scaffold** (work platform) and stock with a full selection of the first materials needed.
5. **Establish** – set up Jack Lines/speed leads on the four corners.
6. **Build up** 8 x 8 x 16 CMU foundation walls on pre poured footer (to be 6" wider all four sides and 12" deep minimum).
7. **Lay CMU** up to a point 5 to 7" below rough floor.
8. **Form and pour** a 4" minimum to 6" concrete slab approx. 1" below rough floor. Use metal form in center; remove wood forms from outer edge. Place _" re bar 8 to 12" on center, both ways. Locate air supply in center of slab left to right and 7 to 8" to center from front face line of heater.
9. **Locate clean outs** and chimney connection, etc.
10. **Lay up** first 12 to 18" of face brick – remove excess mortar droppings from inside space. Type "S" Hi strength mortar is recommended, however some masons use Type "N" or clay mortar.
11. **Place expansion material** (also acts as a slip joint). Use _ high temp insulation around all openings (clean outs, doors, dampers, chimney connection) and a thin insulation on the solid areas. Some masons use cardboard on the solid non-opening surfaces.
12. **Lay core brick** against expansion material forming side channel to plan and base for firebox support as needed. **"NOTE": Be sure to direct air to front and center as needed or suggested on plans. Bring core up to a point level or slightly higher than face brick.**
13. **If hearth is to be heated** lay out exits from side channels into hearth area, to have flue gas flow right to left make right side exit 2 to 3" higher than left exit and 3 to 4" higher than entrance to flue. Opposite for left to right flow. i.e. chimney on right Finnish design, on some designs (Swedish) the exits left to right would be at the same level entering the hearth area. Then lower, but at the same height (level) where they re-enter the return flue channels and join at top to start flue. This creates a balanced flow both sides.
14. **Proceed to lay face brick** up to lintel height (door height). Be careful to prevent mortar droppings from entering the expansion space.

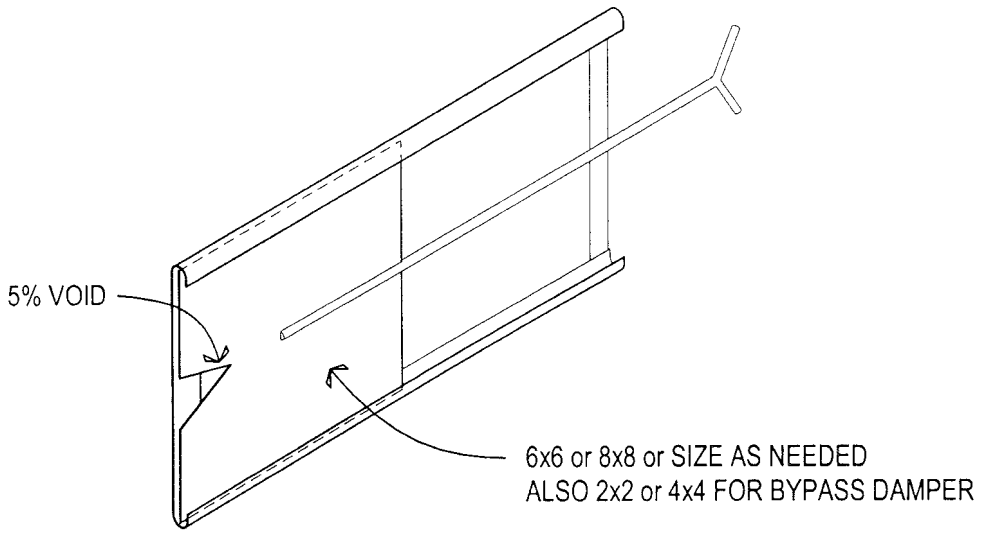
15. **Clean off excess mortar** on inside of face brick then cover with expansion material of your choosing. You are now ready to lay side channels and firebrick firebox up to a point level or above the door height. Use refractory mortar for firebrick.
16. **Build face brick** up 12 to 18" or whatever is comfortable to reach over.
17. **Now lay up core** channels and throat area expansion chamber, etc. to the final height. Be sure when you exceed the face brick height that you do not encroach in to the face brick area. A good plan would be to stay _" back for extra wiggle room, than when you bring up facing, fill the extra void with mortar.
18. **Next** complete facing to a point 3" or more above core. Depends on type of capping slab you desire, is it just function or aesthetics? See capping slab options.
19. **Be sure you have no less than 1" clear** under the top most cross over slab. The top most material below that slab should be a soft insulation. You can mix perlite and lime 3 to 1 for this purpose, (not to wet).
20. **Install door**, clean outs, etc. Check for and remove mortar droppings.
21. **Complete hearth**, chimney, install chimney damper, be sure it moves freely, cap the chimney (every chimney needs a rain/snow cap).
22. **Clean up**, double check and inspect for small things you may have over looked.
23. **Instruct homeowner** on proper use and safety. Leave printed instructions and any warranty papers or disclaimers.
24. **Offer to consult** on first break in fire in person or by phone. It will pay off if the heater functions as designed and the customer is an educated, satisfied user.

DAMPER OPTIONS

A. PIVOT (FLIP) DAMPER

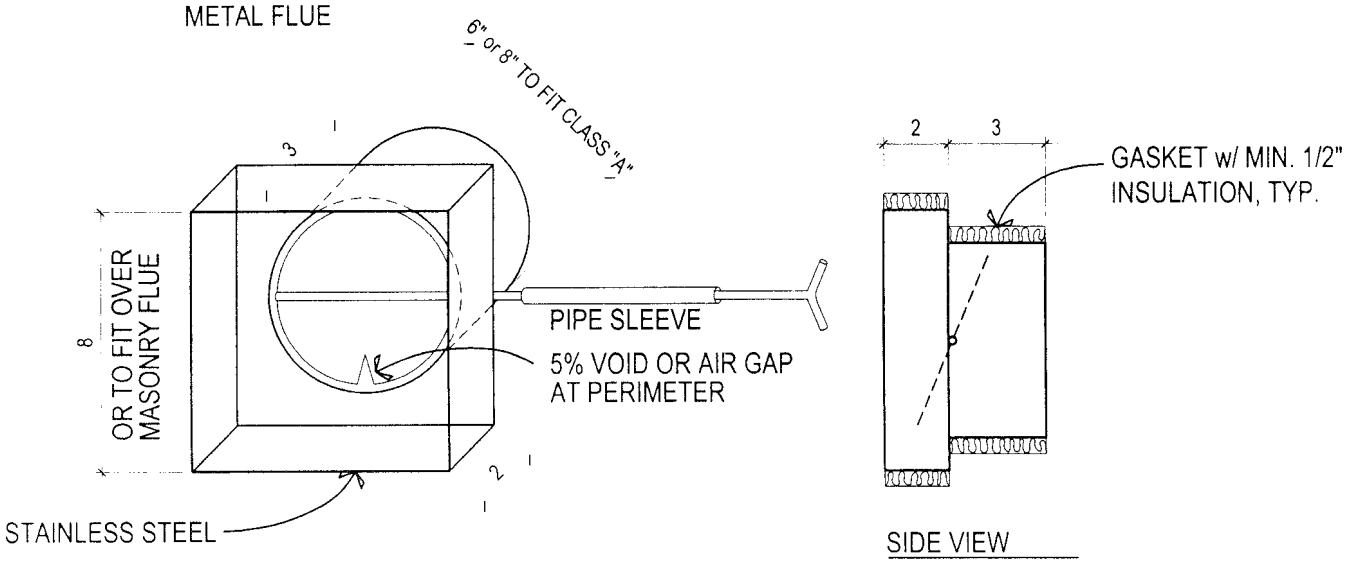


B. SLIDE DAMPER



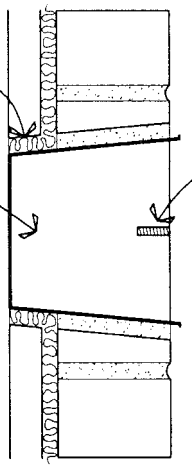
C. SQUARE TO ROUND DAMPER

USED FOR MASONRY SQUARE TO CLASS "A"
METAL FLUE



CLEAN OUT OPTIONS

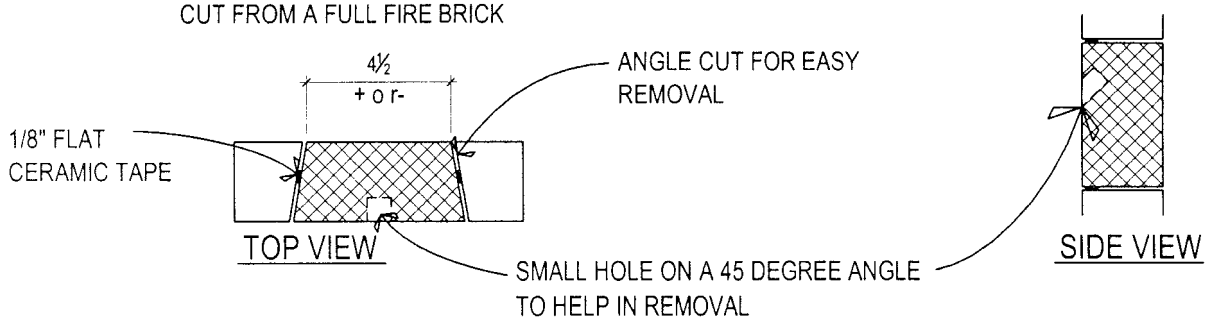
A. ROUND OR SQUARE PLUGS



- FOR SQUARE PLUGS MAKE WOOD MOLDS TO FIT BRICK SIZES

B. CUT FIRE BRICK

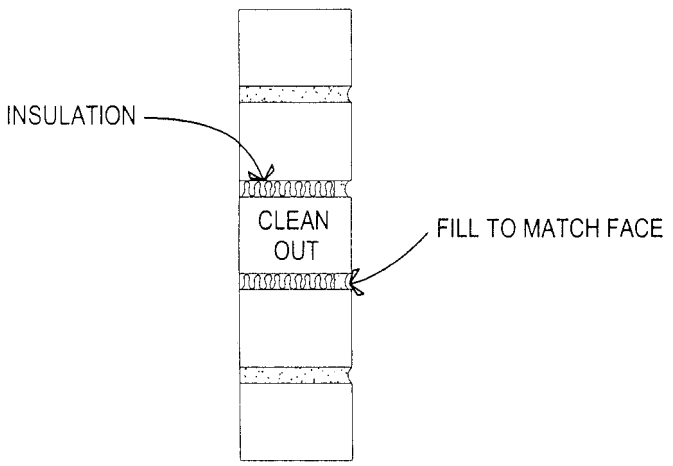
CUT FROM A FULL FIRE BRICK



SET PLUG DRY FOR EASY REMOVAL

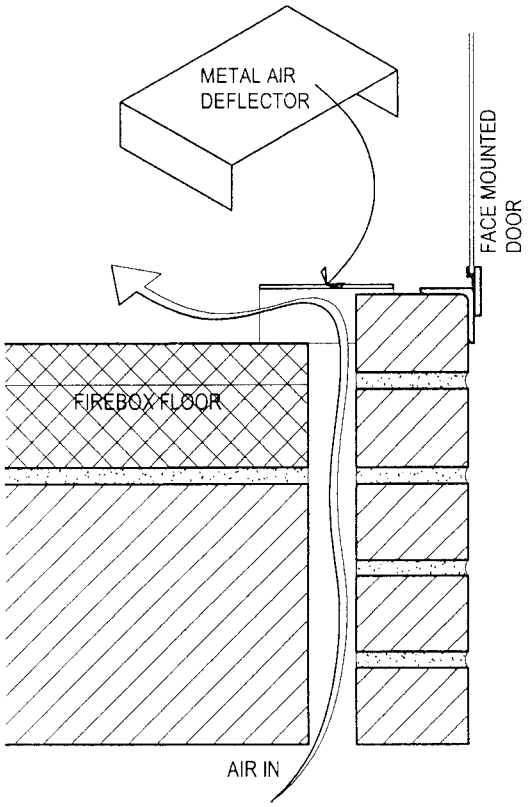
C. THRU FACE BRICK CLEAN-OUTS

SET BRICK IN INSULATION WRAP THEN POINT UP FACE JOINT BUT LEAVE RECESSED



OUTSIDE AIR OPTIONS

A. OUTSIDE AIR DIRECTED INTO FIREBOX



DOOR SUPPLIERS

Maine Wood Heat
254 Father Rasle Rd.
Norridgewolk, ME 04957
Ph. 207-696-5442

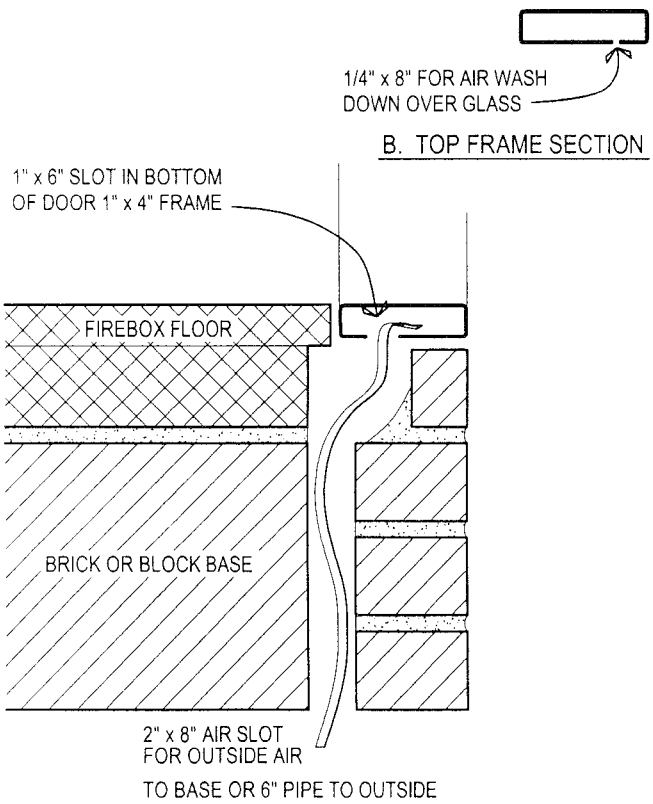
Canadian Kachelofen
405 Langille's Lake Rd.
RR #1 Blockhouse, Nova Scotia
Canada BOJ 1EO
Ph. 902-624-9583

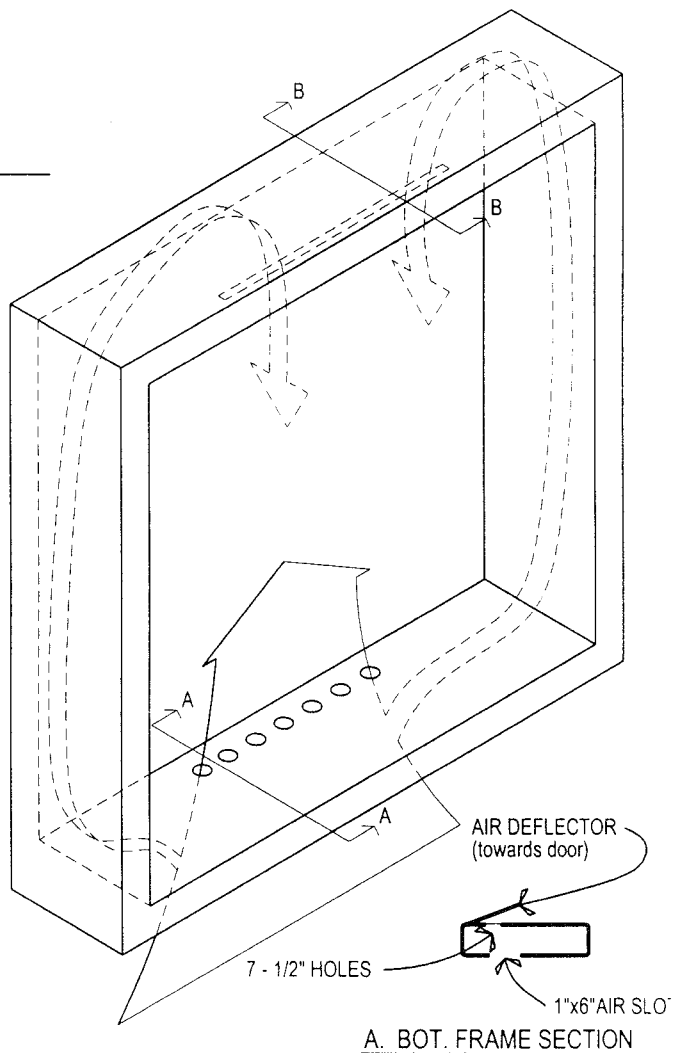
Temp-Cast
3324 Younge St.
Box 94059
Toronto, Ontario
Canada M4N 3R1
Ph. 416-322-5197

Masonry Stove Builders
RR5
Shawville, Quebec
Canada JoX2Y0
Ph. 819-647-5092

Lopez Quarries
111 Barbara Lane
Everett, WA 98203
Ph. 423-353-8963

B. OUTSIDE AIR DIRECTED INTO BOTTOM OF DOOR



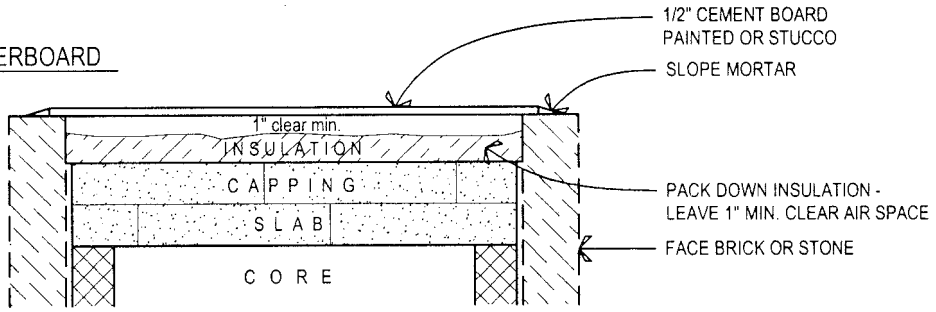


OPTIONS TO FINISH TOP (above capping slab)

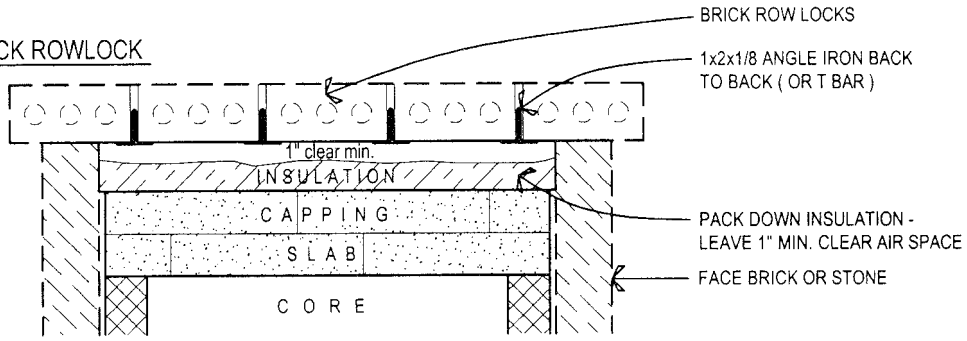
GENERAL NOTES

INSULATION CAN BE MFG. REFRACTORY OR PERLITE + LIME (3 TO 1 MIX) OR PERLITE + PORTLAND (6 TO 1 MIX)

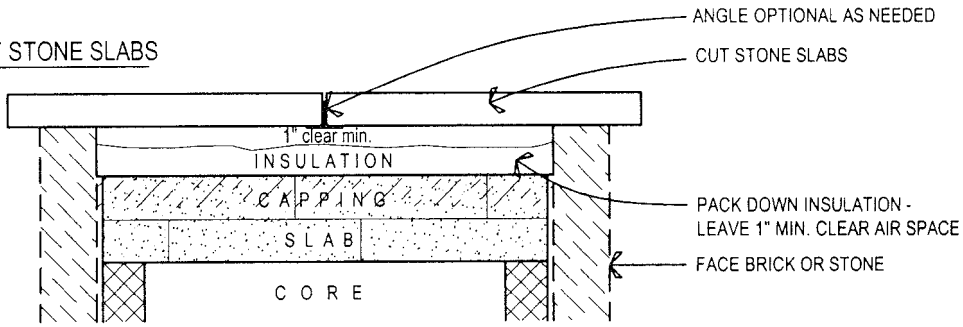
A. WONDERBOARD



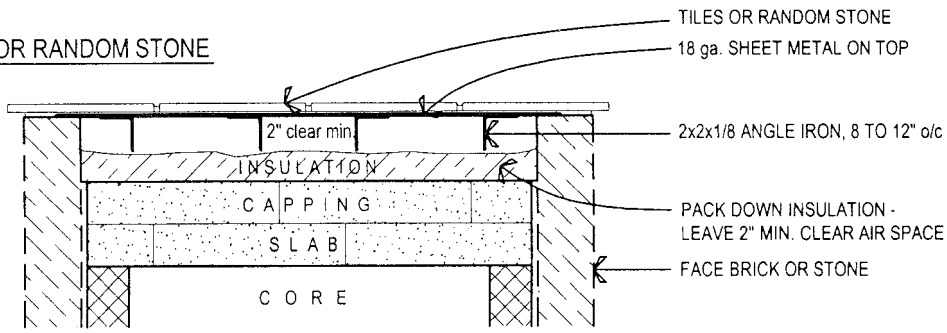
B. BRICK ROWLOCK



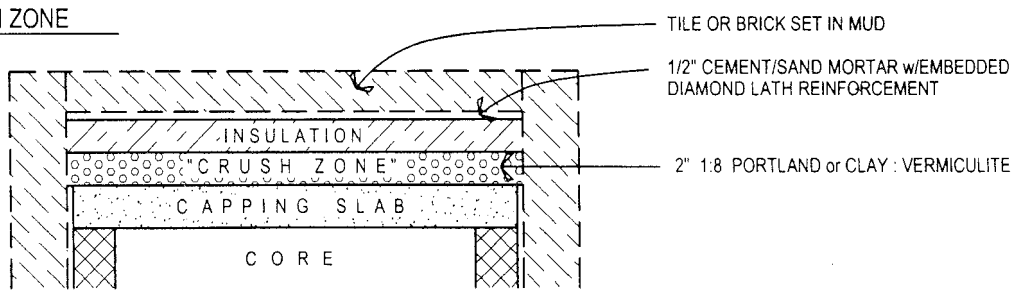
C. CUT STONE SLABS



D. TILE OR RANDOM STONE



E. CRUSH ZONE



ATR Engineering Masonry Heater Stabilization Report

In areas where seismic stability is required, there are two reports to look at. One dated 7-20-98, reported 11-07-97, and shows the basic fire heater types 1 – 5, all exceed resistance to tip over. See MOT (overturn) is less than the resistance dead load gravity force MRT.

Then on 3-11-99 the same five types were recalculated to include lateral co-efficiencies. The results were favorable but a little lower than the first calculations. See new M-2 MOT overturning moment # - FT is lower than the MR resisting moment # - FT by a safety factor of 1.19 to 1.64. However, in the first calculations the engineer recommended a post tension rod and channel iron system. In the second stability check he recommended a lighter flat iron and smaller rod should be plenty of over kill for stabilization where the inspector will not buy off on just the numbers. Easy enough to do and you would never have to worry about any liability. Remember the rods are not to be grouted in but free to expand from the heat. Your inspector may accept a Washington State report. If not you could use these and get a local engineer to draft a letter, with seal for your state, for a small fee.

ATR Engineering Inc.
9929 SW 206th CT
Vashon WA. 98070
(206) 463-5735

1 of 8 1-29-99
DRAFT
To Be Revised

7/20/98

TO:
Masonry Heater Association / WSCPA
c/o Lopez Quarries Masonry Heaters / Firecrest Fireplace Corp.
111 Barbara Lane
Everett WA. 98203

Attention: Mr. Jerry Frisch
Subject: Masonry Heater Stabilization / Supplemental to report dated 11/7/97

Dear Jerry,

This is a preliminary look at stabilizing the heaters and veneer using the concept of tension rods to "clamp" the firebox and veneer to the supporting base.

The preliminary analysis indicates that this is a feasible option the will satisfy the Seismic/Lateral stability requirements of 1634 of the 1997 Uniform Building Code (UBC) for Nonbuilding Structures.

To achieve the clamping action, rods are epoxy grouted into the concrete support base then tightened down onto a continuous plate system which transmits the tensile load from the rod into a uniform compressive stress in the firebox/veneer. Standard ASTM A307 rods can be used. The clamping plates should be stiff enough to evenly transfer the rod tension force into the masonry; for that reason I started by assuming a 3/8 plate thickness. Further analysis might show that thinner material could be used.

More work needs to be done on the exact detailing of the continuous top plate and the bolt through plate connection. You thoughts on this would be appreciated.

Please review this information with your association and let me know of their comments and suggestions.

If you have any questions, please feel free to call.

Sincerely,

Arthur T. Rack

Arthur T. Rack P.E.
Principal

ATR Engineering Inc.
9929 SW 206th CT
Vashon WA. 98070
(206) 463-5735

3/11/99

TO:
Masonry Heater Association / WSCPA
c/o Lopez Quarries Masonry Heaters / Firecrest Fireplace Corp.
111 Barbara Lane
Everett WA. 98203

Attention: Mr. Jerry Frisch
Subject: Masonry Heater Stabilization / Supplemental to report dated 7/20/98

Dear Jerry,

I have revised the previous calculations to include the new Uniform Building Code lateral coefficients. I have also modified my previous calculations to include the resisting effect of the structures' dead load. As you can see in the attached calculation sheet the resistance to overturning is greater that the overturning caused by the lateral force, with a factor of safety (FS) greater than 1.0 in all cases. This satisfies the code requirement for stability. Although stability of the stoves is shown, I would like to suggest that we still use the details shown on drawings M-4 and M-5 with these modifications: (1) use a 1/4" flat plate in lieu of the previous channel and (2) use 1/4" diameter rods instead of 3/8" diameter. This will provide an extra factor of safety against workmanship and varying unit dead load weights for each stove type.

If you have any questions regarding this information, please feel free to call.

Sincerely,

A.T. Rack

Arthur T. Rack P.E.
President

New M2

file: masonOT

For: Masonry Heater Association / WSCPA
c/o Lopez Quarries Masonry Heaters / Firecrest Fireplace Copr.
111 Barbara Lane
Everett WA. 98203

Masonry Stove Types
1. Russian Multi-Flue
2. German Austrian
3. Finnish
4. Swedish
5. Small Grundofen

OVERTURNING MOMENT
ZONE 3

STABILITY CHECK

Mark	Firebox Weights (lbs)	Height (ft)	Width (inches)	Length (inches)	Lateral Seismic (lbs) V=% of Gravity 0.252	Mot Overturning Moment #-ft	Mr Resisting Moment #-ft	Factor of Safety FS= Mr/Mot
Type 1	20,000	7.25	36	72	5,040	18,270	30,000	1.64
Type 2	14,000	7.25	32	64	3,528	12,789	18,667	1.46
Type 3	12,500	7.25	36	48	3,150	11,419	18,750	1.64
Type 4	11,000	7.25	26	44	2,772	10,049	11,917	1.19
Type 5	9,000	5.00	24	34	2,268	5,670	9,000	1.59

Per 1997 Uniform Building Code / Seismic Zone 3
Lateral per 1629.6.8 for Non Building Structural Systems
Per 1634.3 for Rigid Structures
V=0.7 x Ca x I x W where Ca=0.36 / I=1.0

V= 0.252 W

Overturning and Stability Requirements Per 1605.2.2

JR Engineering Inc.
Consulting Engineer
9929 SW 206th Ct.
Vashon, WA 98070

phone: (206) 463-5735

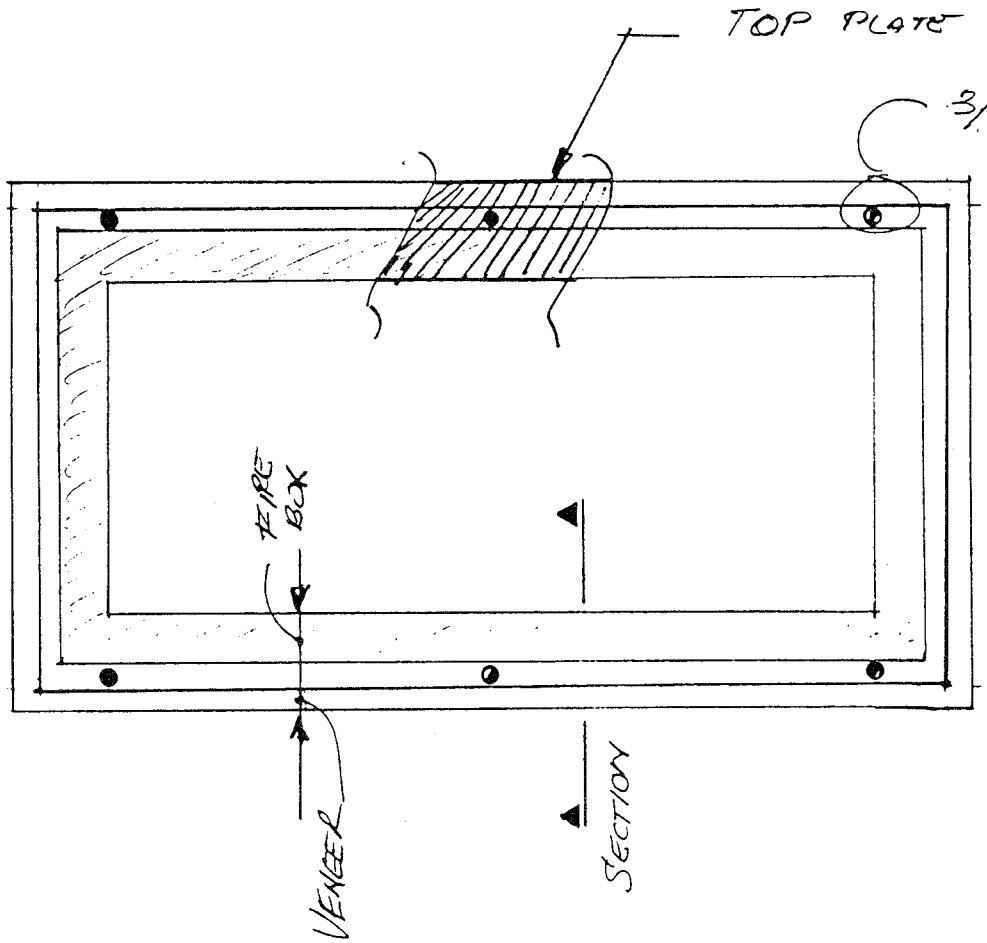
PROJECT

MASONRY HEATER ASSOCIATION

MASONRY STOVE STABILITY

Sheet No. M-4

Date 7/20/98



PLAN / ROD LAYOUT.

ATR Engineering Inc.
Consulting Engineer
9929 SW 206th Ct.
Vashon, WA 98070

phone: (206) 463-5735

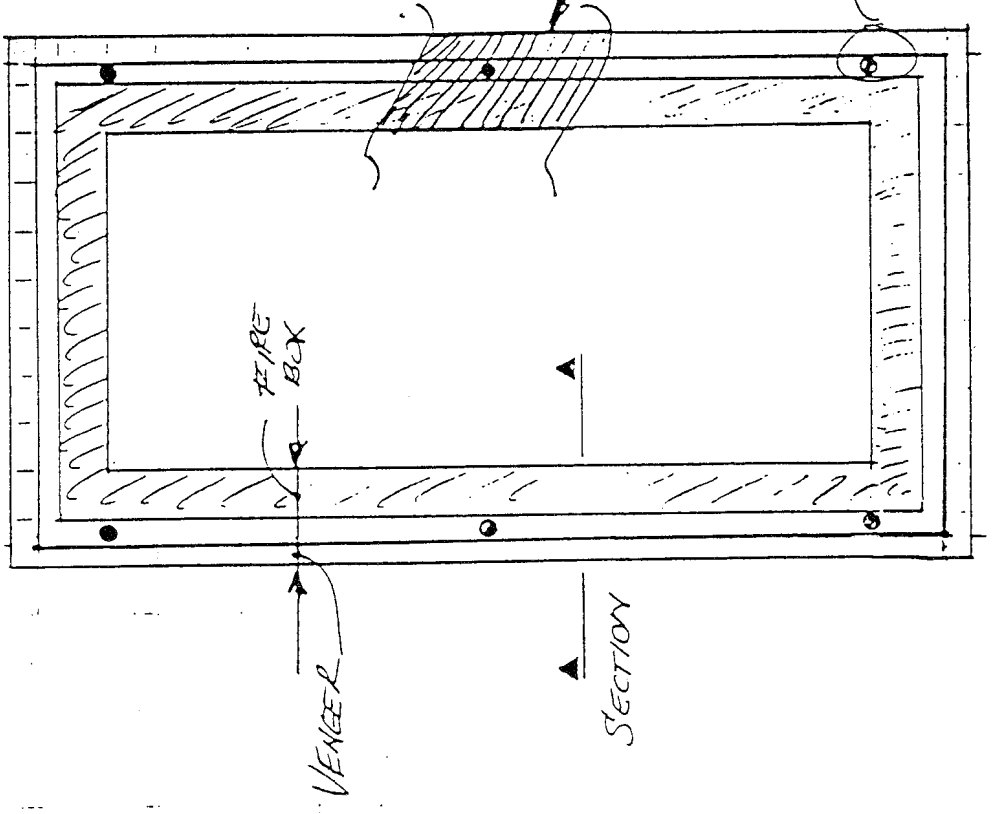
PROJECT

MASONRY HEATER ASSOCIATION

MASONRY STOVE STABILITY

Sheet No. M-4

Date 7/20/98



PLAN of ROD LAYOUT.

REVISED TO
4 - 1/4" RODS
W/ 1/4" FLAT PLATE ON TOP
See COVER LETTER - 3/11/99

ATR Engineering Inc.
Consulting Engineer
9929 SW 206th Ct.
Vashon, WA 98070

phone: (206) 463-5735

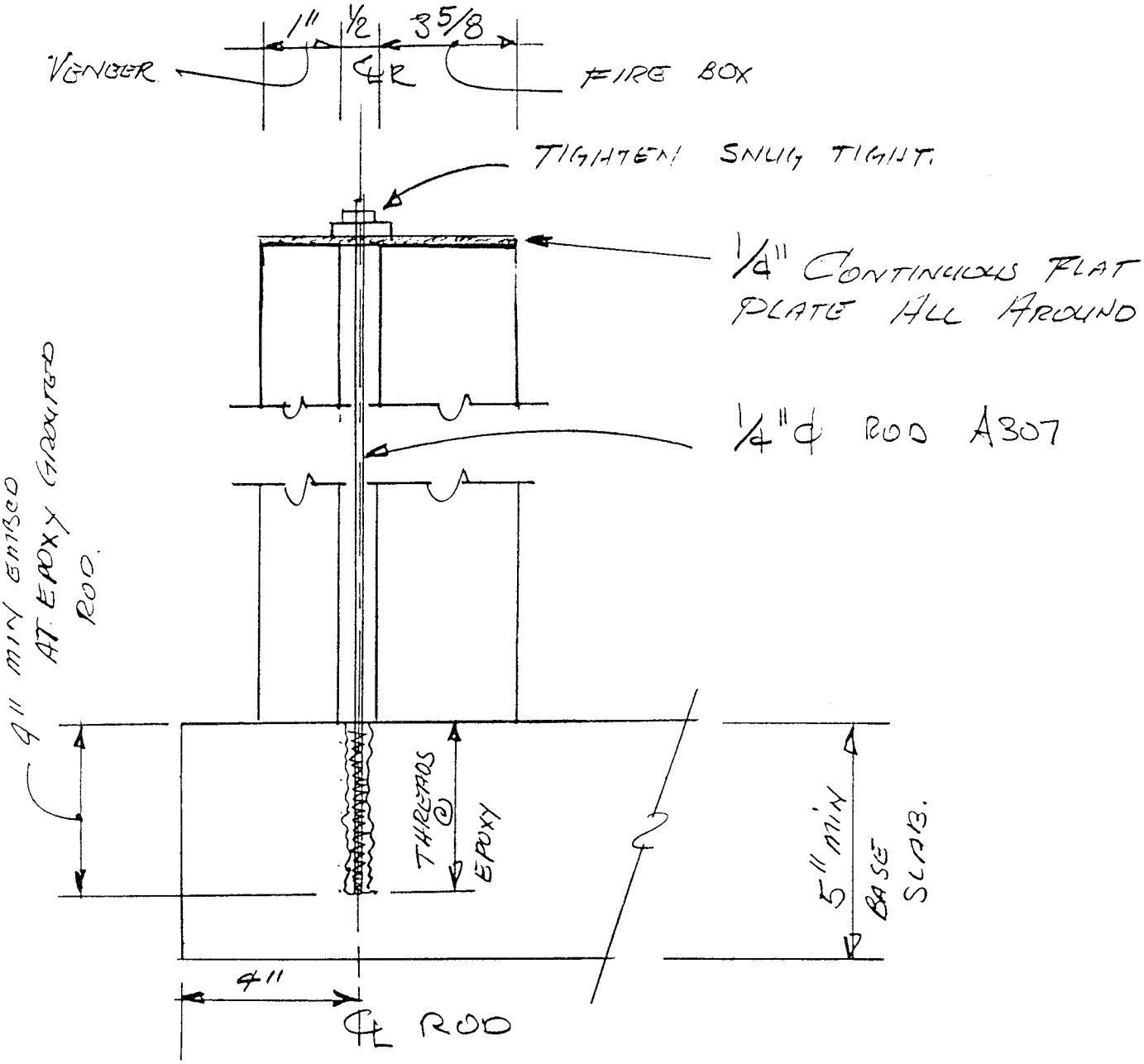
PROJECT

MASONRY HEATER ASSOCIATION

MASONRY STOVE STABILITY

Sheet No. M-5

Date 7/20/98



SECTION @ TENSION ROAD

NTS

REVISED 3/11/99

.(R Engineering Inc.
Consulting Engineer
9929 SW 206th Ct.
Vashon, WA 98070

phone: (206) 463-5735

PROJECT

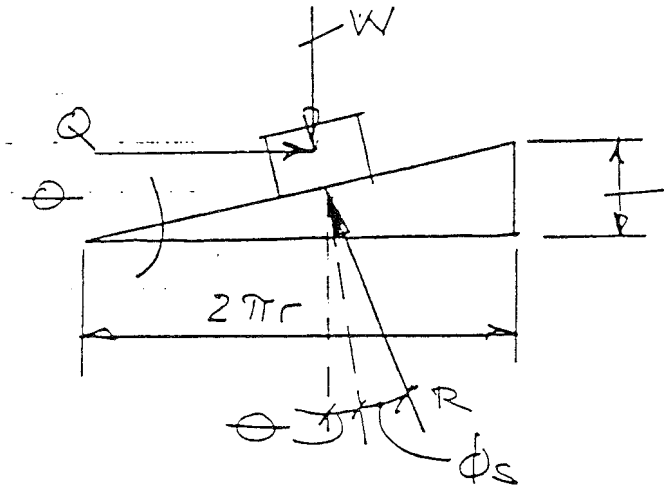
MASONRY HEATERS ASSOCIATION

TORQUE CALCULATIONS

Sheet No. MC

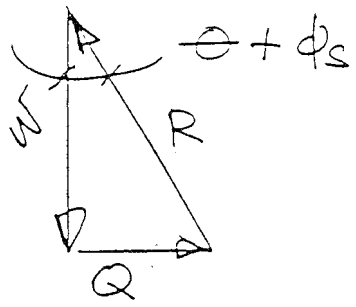
Date 7/20/98

FREE BODY DIAGRAM



SEE CALCULATIONS

THEN



ATR Engineering Inc. Consulting Engineer 9929 SW 206th Ct. Vashon, WA 98070 phone: (206) 463-5735	PROJECT MASONRY HEATER ASSOCIATION	Sheet No. MM
	TORQUE CALCULATIONS ON ROD	Date 7/22/98

TORQUE ON RODS

@ 50 PSI WITH A = 783 IN² } R = 19,575# > 4000#

REDUCTION FACTOR = $\frac{4000^{\#}\ \text{REQ'D}}{19\,575^{\#}\ \text{PROVIDED}} = 0.204$

THEN 50 PSI × .204 = MIN PSI Rqd = 10.2 PSI

MIN CLAMPING FORCE > 10.2 PSI × A = 8,000#

EACH 3/8" ϕ ROD = 2376#/ROD

$\frac{8000^{\#}}{2376} = 3.4$ MIN USE 4 MIN. RODS.

CONVERT TORQUE TO CLAMPING FORCE

3/8" ϕ 16 THREADS / IN SINGLE THREADED. } SEE ⇨ DIAGRAM

PITCH = 1/16 = 0.063

LEAD = L = 1 × PITCH = 0.063

COEFFICIENT BETWEEN THREADS = μ_s = 0.30

LEAD θ $\quad \tan\theta = \frac{L}{2\pi r} = \frac{0.063\ \text{IN}}{2\pi(3/16)} = 0.053 \quad \theta = 3^\circ$

$\tan\phi_s = \mu_s = 0.30 \quad = \quad \phi_s = 16.7^\circ$

FORCE Q (Assumed)

Q(3/16 IN) = 30 #-FT.

$Q = \frac{30 \times 12}{3/16} = 1920^{\#}$

$W = \frac{Q}{\tan(\phi + \phi_s)} = \frac{1920^{\#}}{\tan 19.7^\circ} = 5362^{\#}$

REDUCE TORQUE TO $\frac{2376^{\#}}{5362^{\#}} \times 30^{\#}\text{-FT} = 13^{\#}\text{-FT}$ USE

Emissions Report

The emissions were tested on the Swedish Heater and the Blacksburg Grundofen. There were three other heaters tested by OMNI Testing, Beaverton, Oregon, in Washington State. Research Triangle Staff audited the tests for the EPA. That report lead to the EPA listing masonry heaters in their SIP – BACM – RACM – report recommending states could allow masonry heaters because of their clean burning characteristics. There is an effort ongoing to get a Standard ASTM Testing method for all masonry products that the EPA could reference.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504-8711 • (206) 459-6000

January 9, 1992

Thank you for the brochures and other information on Royal Crown European Fireplaces. Ecology's engineering staff has now reviewed the documents and specifications for your two basic designs, the rectangular one and the round one. Units built to the equivalent design of these two basic models can be sold as Washington State certified.

I apologize for the delay in responding to your request for a certification judgement. I trust this letter answers your questions. If you have any further concerns, please call me at (206) 459-6231.

Sincerely,

A. Fred Greef

A. Fred Greef
Wood Stove Coordinator
Air Quality Program

AFG:crp
cc: Mike Landon
Phyllis Baas

A REPORT ON THE PARTICULATE EMISSIONS PERFORMANCE OF MASONRY HEATERS – DEFINTION, DATA, ANALYSIS AND RECOMMENDATIONS

Prepared for: The Masonry Heater Caucus of the Hearth, Patio and Barbecue Association

Prepared by: Robert Ferguson
Ferguson, Andors & Company
P.O. Box 678
South Royalton, VT 05068

Date: February 13, 2008

The scope of this report is to provide the U. S. Environmental Protection Agency with chronologically organized information about the particulate emissions performance of masonry heaters as a defined product class and to provide conclusions and recommendations based on that information.

Table of Contents

Introduction

This White Paper is submitted by the Masonry Heater Caucus of the Hearth, Patio and Barbecue Association to support its request that the Office of Air Quality Planning and Standards (OAQPS) recognize that Masonry Heaters are a class of solid fuel heating devices that are inherently clean-burning and can be a viable emissions control option in PM-impacted areas. The White Paper has five parts:

- Background
  - Provides relevant background information on regulatory status, numbers installed annually, data sources, etc.
- Definition
  - Defines what comprises a clean-burning masonry heater including a list of critical features.
- Data
  - Summarizes the available North American emissions performance data.
- Conclusions
  - Summarizes our conclusions on emissions performance.
- Recommendations
  - A section containing our recommendations that includes procedures that can be used to provide assurances that masonry heaters built in the field include the critical elements identified in the definition of clean-burning masonry heater.

Background

Modern masonry heater designs originated in Europe and those designs have been in use for many decades, if not centuries. While masonry heaters are installed in relatively large numbers across Europe, they represent only a small niche in the solid-fuel burning market in the United States. Masonry heaters are site-built, often by individual masons, making it hard to provide a precise number of installed units. The Masonry Heater Caucus estimates that between 600 and 1,000 masonry heaters are installed in North America each year. This represents only a fractional percentage of all solid-fuel burning appliance sales and installations.

EPA's wood stove New Source Performance Standard (NSPS), 40 CFR Part 60, Subpart AAA, specifically exempts masonry heaters because the Regulatory Negotiation Committee recognized that they are inherently clean-burning due to their high burn rates and air-rich characteristics. This is explained in the preamble to the proposed regulations[1] as follows: "*The 800 kg cutoff was established as an easy means of excluding*

[1] Federal Register/Vol. 53, No. 38/February 26, 1988/Rules and Regulations/Page 5864. See Attachment 1.

high mass fast-burn wood-burning appliances known as "Russian stoves" or "European tile stoves." These devices typically operate at hot, fast burn rates and cannot be damped. It is also likely that they are incapable of meeting the 5 kg/hr minimum burn rate. The intent of the committee was to exempt from the standards these appliances which rely on clean-burning air-rich conditions and which have high combustion efficiencies."

Notwithstanding EPA's clear determination in the NSPS rulemaking that masonry heaters are inherently clean-burning, because of their high burn rates and air-rich characteristics, masonry heaters have had a difficult time getting accepted by SIP planners as viable control options for PM-impacted areas. In some jurisdictions, only NSPS-certified wood stoves have been allowed. While the intent may have been to eliminate "loop-hole" products as a means of improving air quality, the result for some product classes, including masonry heaters, has been to effectively ban a clean-burning alternative. Other areas have followed EPA's RACM/BACM guidance[2] and allowed NSPS-certified appliances, along with other appliances that have been shown to be "equivalent." [See also Renner memo[3].] However, these equivalency provisions, although written with good intent, are flawed in concept. The NSPS emission limits were based on Best Demonstrated Technology (BDT) for traditional wood-burning stoves and inserts and were supported with significant data from the Oregon woodstove certification program. These levels do not translate to appliances employing different technologies and, therefore, with different BDT. Masonry heaters are not designed nor do they operate like NSPS certified stoves or inserts. Moreover, the very different operating profiles for masonry heaters compared to woodstoves present difficult issues when attempting to make "equivalency" findings. The fuel load in a masonry heater is fully-consumed in a short period of time. This heats a large mass of refractory, which in turn discharges the stored heat over many hours. Woodstoves are also batch loaded, but the heat is delivered as the fuel load is consumed. The length of the burn depends on how the operator sets the air controls. When comparing emissions performance on a gram/hr basis, the masonry heater emissions must be averaged over the period of time that useful heat is being provided to the home in order to compare them with woodstoves on an "apples to apples" basis. Finally, the fact that air quality planning agencies frequently require costly case-by-case showings of "equivalency" has been an additional, significant obstacle to masonry heater builders.

We are presenting the results of masonry heater testing that has been conducted in North America, but it is important to recognize that considerable testing has also been conducted in Europe and that testing corroborates the clean-burning performance of masonry heaters as a class of products.

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[2] Technical Information Document for Residential Wood Combustion Best Available Control Measures, U. S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1992. See Attachment 2.

[3] Memo: F. H. Renner to Chief, Air Branch, Regions I – X, September 23, 1991, Interpretation of EPA's Guidance for Residential Wood Combustion Emission Control Measures. See Attachment 3.

Definition

It is also necessary to establish a way to determine what masonry heater designs should qualify for recognition in that class and for that the following definition is proposed.

"A masonry heater is a site-built or site-assembled, solid-fueled heating device constructed mainly of masonry materials or soapstone in which the heat from intermittent fires burned rapidly in its firebox is stored in its massive structure for slow release to the building. It has an interior construction consisting of a firebox and heat exchange channels built from refractory components."

Specifically, a masonry heater has the following characteristics:

- Site-built or site-assembled.
- A mass of at least 800 kg. (1760 lbs.).
- Tight-fitting fuel loading doors that are closed during the burn cycle,
- An overall average wall thickness not exceeding 250 mm (10 in.).
- Under normal operating conditions, the external surface of the masonry heater, except immediately surrounding the fuel loading door(s), does not exceed 110 C. (230 F.).
- The gas path through the internal heat exchange channels downstream of the firebox includes at least one 180-degree change in flow direction, usually downward, before entering the chimney.
- The length of the shortest single path from the firebox exit to the chimney entrance is at least twice the largest firebox dimension.
- A combustion air control that is designed to provide a high-fire burn rate only.
- A combustion air introduction system that directs the majority of the combustion air to the area in the firebox that is at or above the level of the fire.
- Constructed or installed by qualified masonry heater builders.

ASTM E-1602 "Standard Guide for Construction of Solid Fuel Burning Masonry Heaters" provides design and construction information for the range of masonry heaters most commonly built in the United States and can be used as the basis for determining whether a particular design qualifies for recognition as a masonry heater. A copy for reference purposes only is included as Attachment 5.

Data

A table showing the reports from testing in North America that provides data relevant to types of masonry heaters that meet the above definition is included as Attachment 6. The table includes a brief description of the test parameters and the average emission results. The data comprises the results from research studies, test method development efforts, and testing for certification to state masonry heater rules. The average particulate

performance is presented as emission factors (grams of particulate per kilogram of fuel burned). This format provides the best way to compare emissions from high-burn-rate, high-combustion-efficiency, intermittently-fired appliances. Emission rates, when available in the reports, have also been provided. However, as was briefly discussed in the Background section, emission rates (grams of particulate per hour) can be deceiving when evaluating intermittently fired high-mass appliances. One or two fires that last only a few hours can provide heat for a full twenty-four hour period. Emission rates should therefore be normalized over the period of time that heat is being provided by the masonry heater if they are to be used to compare different appliance types. The emission rates we are reporting here may not have been calculated using the same procedures in each case. Some values have been normalized, some have not. These differences should be taken into consideration when comparing individual values. We have also included ranges for data, as well as results from individual heaters when available in the reports.

The data that we are presenting represents all data from masonry heater testing in North America that we have been able to obtain with the exception of data from a test series conducted on four products from one manufacturer[4]. Please note that some additional reports have been issued that address sub-sets of testing results from the reports we have cited. Those reports have not been included if their data are contained within the cited reports. The table also includes a reference to the AP-42 emission factor for masonry heaters. Full references for each cited report are included in Attachment 7.

Report cover pages and extracted summaries or excerpts from the reports, when available, are included in Attachments 8 - 21. Copies of the full reports can be made available upon request.

Reference C (Attachment 10) is the report on the field testing of five heaters that represent a cross-section of the masonry heater designs that were being built across the country. This study from 1991-1992 was funded by Masonry Heater Association members. Ultimately, EPA was approached and agreed to monitor and audit this test program. In an EPA memorandum[5], Dr. Robert C. McCrillis presents his evaluation of the test results from the masonry heater test program. These results (which covered a broad range of heater designs) were used by EPA to calculate the 2.8 g/kg emission factor for masonry heaters that is listed in EPA's AP-42 document "Emission Factors from Residential Wood Combustion".

[4] These data were excluded because the tests were not conducted following a masonry heater test protocol but were instead generated using a fueling and operating protocol for factory-built fireplaces.
[5] Memo: R. C. McCrillis to D. Mobley, May 8, 1992, Masonry Heater Field Performance Data. See Attachment 4.

Conclusions

The test data support previous conclusions regarding the particulate emission performance of masonry heaters as a class and further defined as those designs that meet the criteria outlined earlier in this paper. Using a variety of test procedures, fueling protocols and fuel types, emission measurement methodologies, laboratory and in-situ measurements, the resultant average particulate emissions have ranged from 1.4 to 5.8 grams of particulate per kilogram of fuel burned. The average of the averages for this data is 2.9 g/kg. Again, the current AP-42 emission factor for masonry heaters is 2.8 g/kg. Note: We have not included the emission results for the Russian Heater cited in Reference B (Attachment 9). This heater was constructed by a mason inexperienced and untrained in masonry heater construction and the emission performance is considered as an outlier when compared to all other available data.

The low average particulate emissions from masonry heaters combined with the small number of annual installations justifies allowing masonry heater installations to continue without imposing undue burdens on the installers of these appliances. The cost associated with testing individual masonry heaters is simply prohibitive and does not represent a needed expenditure to protect air quality. Another means of satisfying air quality regulators is appropriate in this case.

Recommendations

Masonry heaters as a class should be accepted by EPA as clean-burning and EPA should give the appropriate guidance, in the form of a letter from the Office of Air Quality Planning and Standards, to state, local and tribal air quality regulators. That letter should recommend allowance of the installation and operation of qualified masonry heaters in PM-impacted areas as a viable strategy for PM reduction from Residential Wood Combustion (RWC). We suggest that the current AP-42 emission factor of 2.8 g/kg continues to be representative of the expected performance of masonry heaters as a class.

Qualified masonry heaters are defined as those in conformance with the masonry heater definition included in this paper.

Conformance with the specified masonry heater design parameters should be confirmed and documented by an independent third party laboratory for each masonry heater design. This would be an engineering evaluation based on design drawings provided by the masonry heater builder or manufacturer. The conformance report would be applicable to each heater that is installed in accordance with the conforming design. Additional affirmations by the masonry heater installer or builder that the design as built in the field is in conformance with the design drawings could be considered if needed.

The complete White Paper Report to the EPA can be found at:

http://mha-net.org/docs/codes/astm/2008.02.13%20HPBA-MHA-EPA%20White%20Paper.pdf

Masonry Heater Association Of North America

HOMEOWNERS SAFETY MANUAL
and
BURNING GUIDE FOR MASONRY HEATERS

Before using your masonry heater, please read these instructions carefully - failure to do so may bring about potentially hazardous conditions. Points you should know when using your masonry heater.

A. USE ONLY WITH DOOR CLOSED.

B. DO NOT USE A GRATE OR ANDIRONS.

C. IN NEW MASONRY HEATERS THE ENTIRE CHIMNEY INSTALLATION SHOULD BE INSPECTED REGULARLY (ON A MONTHLY BASIS) UNTIL A CLEANING CYCLE IS DETERMINED.

D. WHEN CLEANING A CLASS 'A' METAL CHIMNEY USE A POLY OR NYLON TYPE BRUSH. DO NOT USE A METAL BRUSH.

E. FLAMMABLE LIQUIDS MUST NOT BE USED TO START FIRES.

F. WHEN CLEANING THE ASHES OUT OF YOUR MASONRY HEATER, BE SURE AND USE A METAL CONTAINER FOR ASHES AS AN ADDED SAFETY MEASURE. DO NOT STORE ASHES ON COMBUSTIBLE SURFACE.

G. MAINTENANCE AND SAFE OPERATIONS ARE THE HOMEOWNERS RESPONSIBILITY.

H. INSTALL SMOKE ALARMS AND CO. DETECTORS FOR ADDED PROTECTION.

WARNING:
Before starting the fire, check damper for proper position. On masonry heaters where there is no damper, but an airtight fire door to stop air flow, do not close this type of door until the wood is totally burned and only glowing embers remain. No flames should be visible. Once the airtight (damper) door is closed it should remain closed until the next firing at least 6 hours later (minimum). If this procedure is not followed, a gas explosion can occur, resulting in expensive rebuilding of the heater and possible personal injury. Some masonry heaters have this type of damper/door. If your masonry heater has a combustion air control, never close before fuel is totally consumed.

NOTE: You could help the drying out process by using an electric fan or heater directed into the firebox starting 2 or 3 days after the masonry heater is installed. Leave the damper open fully during dry out and curing/break in period.

ADDITIONAL INSTRUCTIONS:

1. Wait at least 30 days to start using your new masonry heater, unless your installer specifies otherwise. You should have 8 to 10 small fires to cure and slowly dry out any moisture present. (This precaution should be taken annually at the start of every heating season).

   WARNING: DO NOT EXCEED 10 PERCENT OF FULL LOAD (as specified by manufacturer) ON THE FIRST 8 TO 10 FIRES. Then increase load by 5 percent on each of the next 8 fires. On the next fires, increase each by 10 percent until you reach the 100 percent maximum that the masonry heater was designed for. If during this break-in period you notice moisture (damp areas on surface or sweat appearing in mortar joints) skip 1 or 2 fires to avoid a steam explosion. You should not feel any heat on the surface during the first 12 to 15 fires. If you do, you may be over firing.

   NOTE: First open the damper. It is not a bad idea to check draft with a single match held at the lintel. If it is drafting into the room, turn off any fans or open a window or door for a brief time. When chimney is drafting up properly, there should be no smoke back or spillage problems. On outside chimneys or new masonry heaters with first startup fires, it may be necessary to heat the flue via the cleanout at the chimney base. Some basement masonry heaters may have a bypass damper, which should be open for start up to preheat flue and enhance draft.

2. **After the break-in period, try a top down burn.** (A clean burn start up procedure - yes, just the opposite of what we are used to.)

   Place one piece of wood approximately 2" x 2" in diameter on bottom parallel to door.

   Criss cross three pieces of wood approximately 4" to 5" in diameter on top of the first piece (log cabin style). See Section 4 for Tee Pee Style (with grain end facing door).

   Lay two pieces approximately 3" to 4" in diameter on top of the second layer, but parallel to the first layer. This will be approximately 20 to 26 pounds of base wood (assuming a medium to large heater).

   Next, crumple two or three pages of newspaper and place on top of third layer. Using 3 to 4 pounds of small 1/2" to 1" in diameter kindling, criss cross the kindling on top of paper fairly close together allowing enough room for air flow (log cabin style).

   Using one full page of newspaper, make a torch approximately 23" to 28" long. Light torch and hold up flue. This will enhance the draft. When the torch burns down, use it as the match to start the fire.

You will also find that wood laid criss cross will produce more heat then layered wood placed parallel to one another.

3. After the first start up phase, larger wood may be used keeping in mind the criss cross (log cabin style) gives more heat. Maximum wood size recommended is 6" to 7" in diameter. All wood should have one or more split sides (no rounds).

4. On smaller fireboxes, anything less than 18" x 18", a Tee Pee style fire works best. Stand wood on end using smaller pieces - i.e. cut log cabin style wood as described above into 1/2 or 1/3 of its size. Stand wood in rear of firebox and kindle the front and top for best results. See MFG/builder specifics for maximum fuel load usually 12 to 20 pounds.

5. Your masonry heater will burn virtually creosote free when using well-seasoned (15 to 20 percent) dry wood of proper size. Only through your own neglect will you ever experience creosote buildup. If you discover creosote in your flue, immediately cease to use your present fuel. Have your chimney cleaned if heavy deposit has resulted and then use only well seasoned dry wood. For your own safety, remember only you can prevent a hazardous situation from developing.

   DO NOT RELOAD IF MORE HEAT IS NEEDED IN A 24-HOUR CYCLE. WAIT 8 TO 12 HOURS THEN HAVE A SECOND FIRE, OR 3 FIRES IN A DAY - ONE EVERY 8 HOURS.

6. Remember to clean and inspect your heater annually (minimum) as well as the flue. It is recommended that you have a chimney cap installed for rain and snow protection. It is recommended that when not in use you leave the damper in the open position (or remove is possible) as not to freeze (rust) closed. Also, remove all ashes at the end of the heating season as they draw dampness that is harmful to the metal and masonry parts, and may cause an undesirable odor.

   If you have questions - consult with your manufacturer/builder.

WARNING - SPECIAL NOTE:

YOUR WARRANTEE WILL BE VOID IF YOU USE YOUR NEW HEATER TO DRY OUT AN UNFINISHED NEW HOME UNDER CONSTRUCTION.

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Definitions

The following definitions have been adapted from those presented in ASTM E 1602.

Approved - acceptable to the authority having jurisdiction.

Authority - having jurisdiction the organisation, office, individual, or agent thereof, who is responsible for approving construction, matertals,equipment, installation, procedure, etc.

Bypass damper - a valve or plate that provides a direct path to the chimney flue for the flue gases .or portion thereof.

Capping slab- a horizontal refractory barrier covering the top of the heater that provides a seal., insulation and allowance for expansion of the core.

Cleanout opening - an access opening in a flue passageway of the heater or chimney that is designed to allow access to the flue for purposes of inspecting for and removing accumulated deposits.

Damper - an adjustable valve or plate for controlling draft or the flow of gases, including air.

Firebox (fire chamber) - that portion of the masonry heater that is designed for containing and burning the fuel charge.

Gas slot- a small fixed opening that permits some unburned flue gases to bypass downdraft flue channels.

Hearth extension- the noncombustible surface applied to the floor area extending in front of and beyond each side of the fuel loading-door of the heater; also applies to the floor beneath a heater or beneath an elevated overhanging heater hearth.

Heater base - that portion of the support for the heater between the heater and the foundation that is below the firebox or the heat exchange area.

Heat-exchange channel - a chamber or passageway between the firebox and the chimney flue in which heat in the flue gases is transferred to the surrounding masonry.

Kachel - a structural square or rectangular masonry heater tile with a hollow back.

Masonry heater - see MHA Masonry Heater Definition, below

Mortar, masonry - a mixture of Portland cement (or equivalent), a plasticizer, sand and sufficient water to form a workable consistency.

Mortar, refractory - mortar consisting of fire clay (heat setting) or fire clay and sodium silicate (air setting).

Mortar, soapstone refractory -a mixture of powdered soapstone and sodium silicate.

Non-combustible material - a material that, in the form in Which it is used and under the conditions anticipated, does not ignite, burn, support combustion, or release flammable vapours when subjected to fire or heat.

Soapstone - a variety of natural stone (hydrated silica of magnesium) that is suitable for high-temperature applications in masonry heaters.

Wing wall - a non-combustible " lateral projection from the exterior wall of a masonry heater for use in bridging the space between a heater and a combustible partition wall".

Definitions taken from the MHA Heater Mason's Reference Manual

Conversion Factors

Multiply this	by this	to get this	
British thermal unit (Int.)	1055.06	joule	J
Btu per cubic foot	37.2591	kilojoule per metre^3	*kJ/m^3*
Btu per cubic foot Degrees F.	67.0661	kilojoule per cubic metre °C	kJ/(m^{30}C)
Btu per pound	2.326	kilojoule per kilogram	kJ/kg
Btu per pound of	4.1868	kilojoule per kgOC	kJ/kgOC
centimetre	0.39370	inch	
centimetre of water (4°C)	98.06378	pascal	Pa
cord (stacked volume 128ft^3) (solid volume 71 - 85 ft3)	3.6246	cu. metre (stacked volume) (solid volume 2.0 - 2.4 m^3)	m^3
cubic centimetre	0.06102	cubic inch	
cubic centimetre	0.001	litre	L
cubic foot	0.028317	cubic metre	m^3
cubic foot	28.31685	litre	L
cubic foot per hour	28.31685	litre per hour	Uh
cubic foot per minute	0.4719474	litre per second	Us
cubic foot per second	0.2831685	cubic metre per second	m^3/s
cubic foot per second	28.31685	litre per second	Us
cubic inch	16.387064	cubic centimetre	cm^3
cubic inch	16387.064	cubic millimetre	mm^3
cubic metre	0.2759	cord	
cubic metre	1.3080	cubic yard	
cubic metre	35.3147	cubic foot	
cubic metre	219.97	gallon	
degree (angle)	0.017453	radian	rad
degree (temperature)	see end of this table		
foot	0.3048	metre	m
foot	304.8	millimetre	Mm
foot	304.8	millimetre	mm

foot of water (4°C)	2.98898	kilopascal	kPa
foot	304.8	millimetre	mm
foot of water (4°C)	2.98898	kilopascal	kPa
foot per minute	0.00508	metre per second	*m/s*
foot per second	0.3048	metre per second	*m/s*
gallon (imperial)	4.54609	litre	L
gallon (US)	3.785412	litre	L
gallon per minute	0.075768	litre per second	LIs
horsepower (boiler)	9.80950	kilowatt	kW
horsepower (boiler)	33461	Btu	Btu
horsepower (electric)	746	watt	W
horsepower (electric)	0.746	kilowatt	kW
horsepower (550 ft Ibis)	0.74569	kilowatt	kW
horsepower hour	2.68452 .	megajoule	MJ
inch	2.54	centimetre	cm
inch	0.0254	metre	m
inch	25.4	millimetre	mm
inch of water (4°C)	0.249	kilopascal	KPa
joule	0.0009478	Btu(international)	
joule	0.2778×10^{6}	kilowatt hour	kWh
joule per litre	0.026839	Btu per cubic foot	
kilogram	2.20462	pound	
kilojoule per cubic metre	0.026839	Btu per cubic foot	
kilojule per cubic metre	0.004309	btu per gallon	
kilojule per kilogram	0.429923	Btu per pound	
kilolitre	35.315	cubic foot	

kilolitre	219.969	gallon	
kilometre	0.621371	mile	
kilometre per hour	0.277778	metre per second	m/s
kilopascal	0.2953	inch of mercury(O°C)	
kilopascal	4.01474	inch of water(4 0c)	
kilowatt	1.34048	horsepower (electric)	
kilowatt hour	3412	Btu(international)	
kilowatt hour	3.6	megajoule	MJ
litre	0.035315	cubic foot	
litre	0.219969	gallon	
titre per second	2.11888	cubic foot per minute	
litre per second	13.1982	gallon per minute	
metre	39.370	inch	
metre	3.28084	foot	
metre	1.0936	yard	
mile	1.609344	kilometre	km
millimetre	0.03937	inch	
ounce-force per square inch	0.430922	kilopascal	kPa
pint	0.568261	litre	L
pound	453.59237	gram	g
pound	0.45359	kilogram	kg
pound per cubic foot	16.01846	kilogiam per cubic metre	kglm^3
pound per cubic inch	27.67990	gram/cubic centimetre	glcm^3
pound per cubic inch	27.67990	kilogram per litre	kg/L
pound per cubic yard	0.593276	kilogram per cubic metre	kg/m3
pound per hour	0.453592	kilogram per hour	kg/h

pound-force per square foot	0.04788	kilopascal	kPa
pound-force per square inch	6.894757	kilopascal	kPa
quart	1.136522	litre	L
quart (US)	0.946353	litre	L
square centimetre	0.1550	square inch	
square centimetre	0.0001	square metre	m^2
square centimetre	100	square millimetre	mm^2
squ.~re foot	0.0929030	square metre	m^2
squ~re inch	6.4516	square centimetre	cm^2
square inch	645.16	square millimetre	mm^2
square metre	10.7639	square foot	
square metre	1.19599	square yard	
square millimetre	0.001	square centimetre	cm^2
square millimetre	0.001550	square inch	
square yard	0.8361274	square metre	m^2
ton - long (2240 pounds)	1.016046	tonne or metric ton	
ton - short (2000 pounds)	0.907184	tonne or metric ton	
watt hour	3.600	kilojoule	kJ
watt,hour	3.412	Btu(international)	
watt per square foot~,:	10.76391	watt per square metre	Wfm^2
yard	0.9144	metre	m

TEMPERATURE CONVERSIONS

degree Celsius	(oG X 1.8) + 32 ::: degree Fahrenheit
degree Fahrenheit	(OF - 32) X .555 ::: degree Celsius

Conversion Factors taken from the Masonry Heater Association's Heater Mason's Reference Manual.