Institute of Refractories Engineers

HEAT INSULATING REFRACTORIES

IRE Training Day
15 November 2018

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Heat Insulating Materials

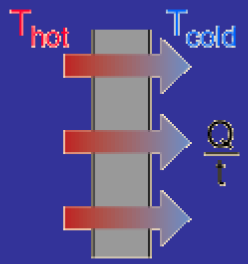
- WHY INSULATE
- HOW HEAT FLOWS
- HOW INSULATION WORKS
- TYPES OF INSULATION
- STEADY STATE AND TEMPERATURE CHANGE
- PROPERTIES
- EXAMPLES

Why Insulate?

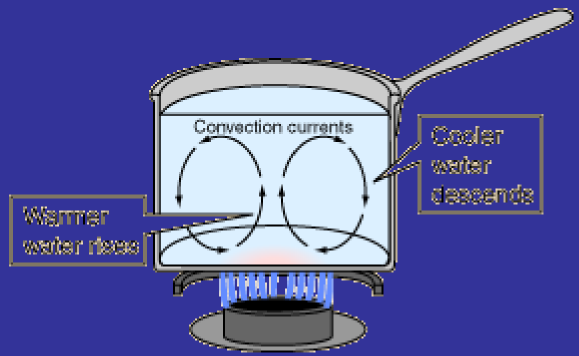
- Reduce Heat Flow to Shell/Outside
    - Acceptable Shell Temperature
    - Reduce Heat Loss – Fuel Saving
    - Control Cooling Rate
- Reduce Lining Weight
    - Less Energy To heat up Lining
        - Reduce Heat Up Energy Loss
        - Faster Heat Up/Cool Down
            - Cycle Time
            - Availability

How Heat Flows

Conduction



Convection



Radiation

How Insulation Works

- High Porosity
  - Air is less conductive than solid refractory
- Small Pore Size
  - Small pores limit convection
  - Pore surfaces stop once-through radiation
  - Very small pores STOP radiation

Types of Insulation

Insulating Castable/Gunning

Fibre Insulation

Insulating Firebrick

Microporous Insulation

Insulating Castable/Gunning

COMPOSITION
Cement Binder
Lightweight Aggregate eg
Expanded Clay
Vermiculite

WEIGHT
High – Density 1000-1500kg/m^3

INSULATION VALUE
Poor – Conductivity >0.5W/mK

PHYSICAL PROPERTIES
Good

COMMENT
Ease of Installation
Needs Anchorage

Insulating Firebrick

COMPOSITION
Refractory Grains
eg Chamotte
Combustible Particles
eg sawdust, EPS
Ceramic Bond

MAX TEMPERATURE 1500°C

WEIGHT
Medium – Density 600-1000kg/m^3

INSULATION VALUE
Low – Conductivity >0.2-0.5W/mK

PHYSICAL PROPERTIES
Medium

Insulating Firebrick - Production

Batch and Mix

Extrude - Oversize

Dry

Fire

Machine to Size

Insulating Firebrick - Properties

An INCREASE in Density ….

Decrease in Insulation Value

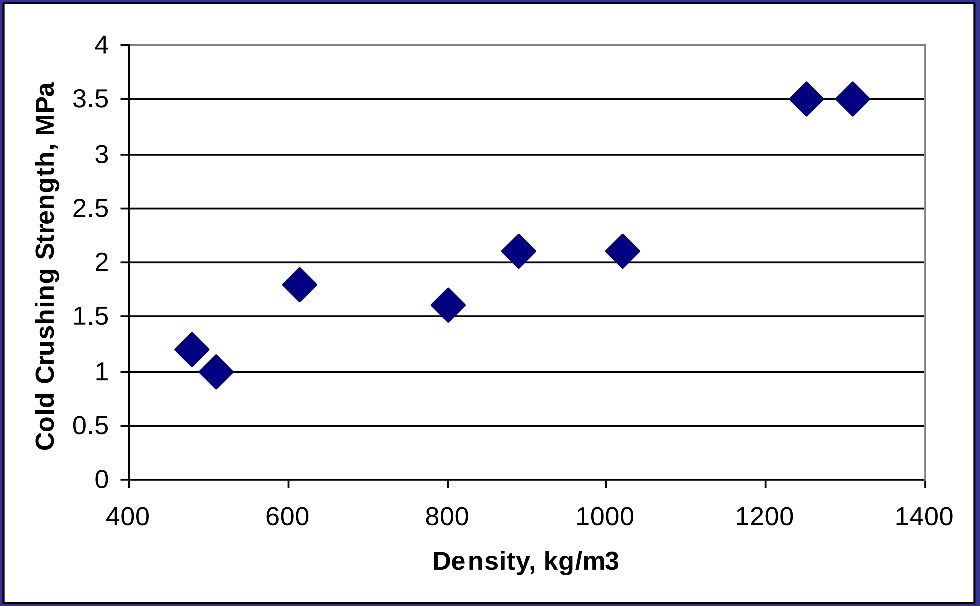
Increase in Strength

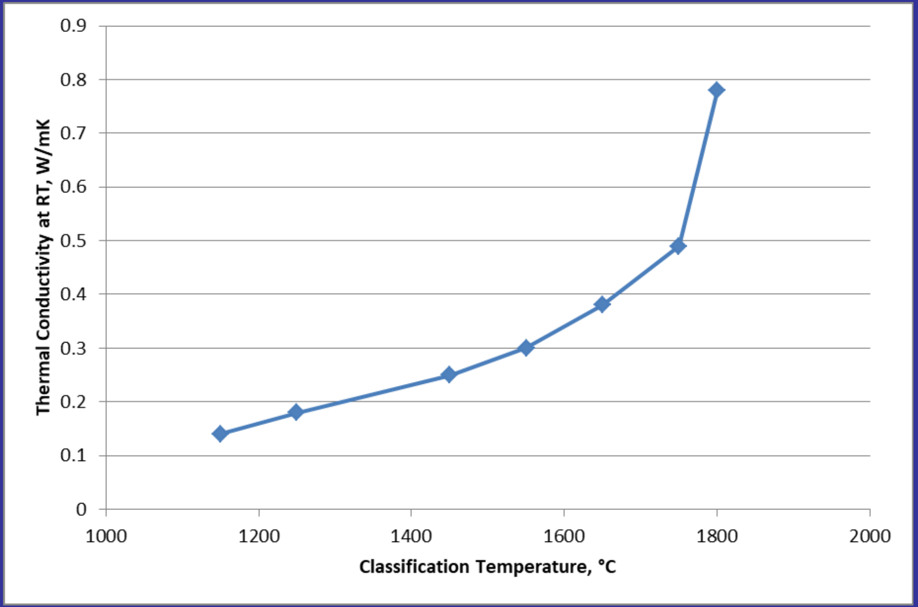
Increase in Max Temp

CLASSIFICATION TEMPERATURE

Defined by Shrinkage.

NOT Maximum Service Temperature





Fibre Products

RCF vs BODY SOLUBLE

- Health Issue
  - Substitution
  - Exposure Avoidance
  - Monitoring
  - Labelling
- Maximum Temperature

Fibre Products

Bulk

Board

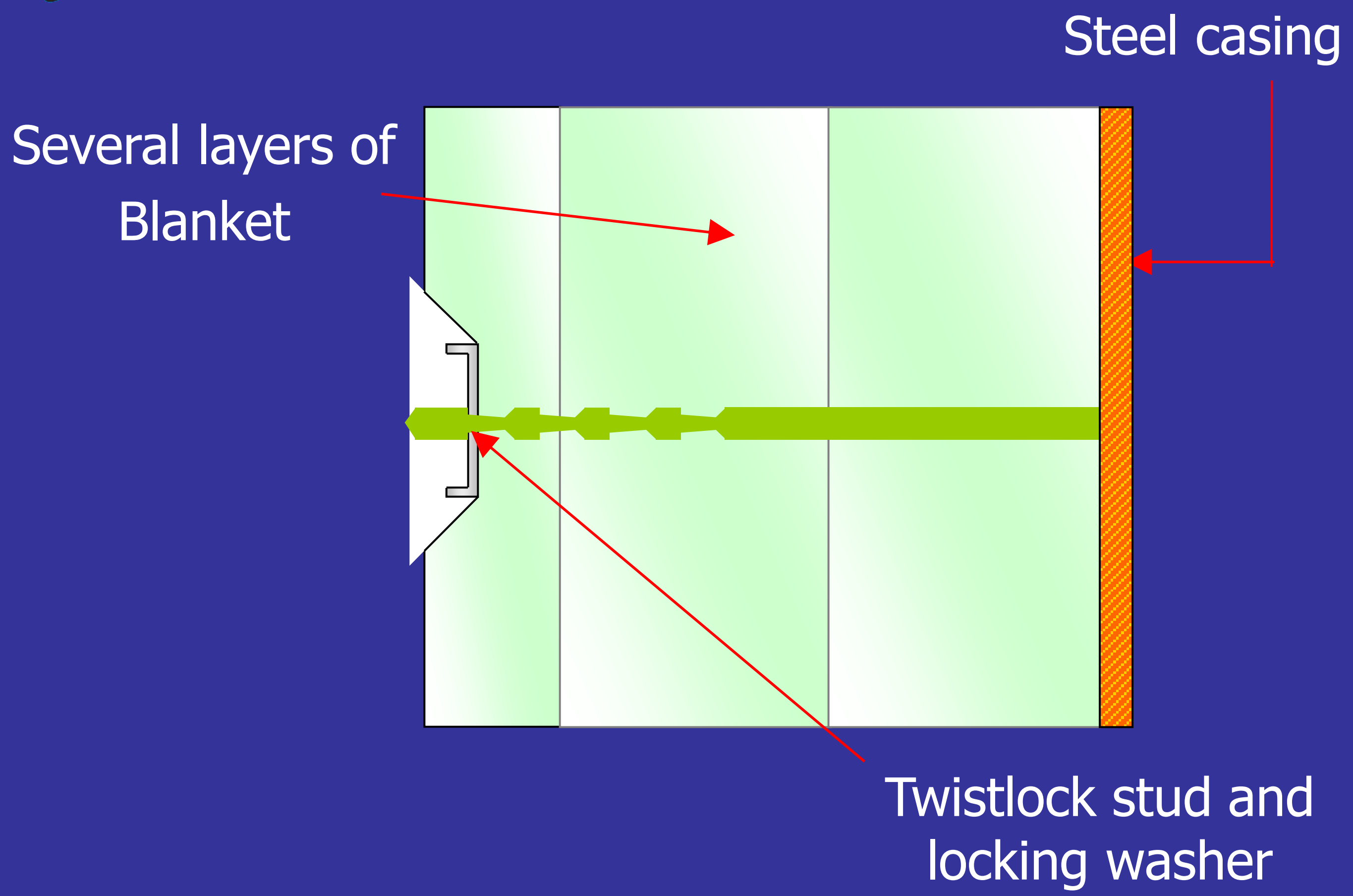
Blanket

Vacuum Formed

Modules

Paper

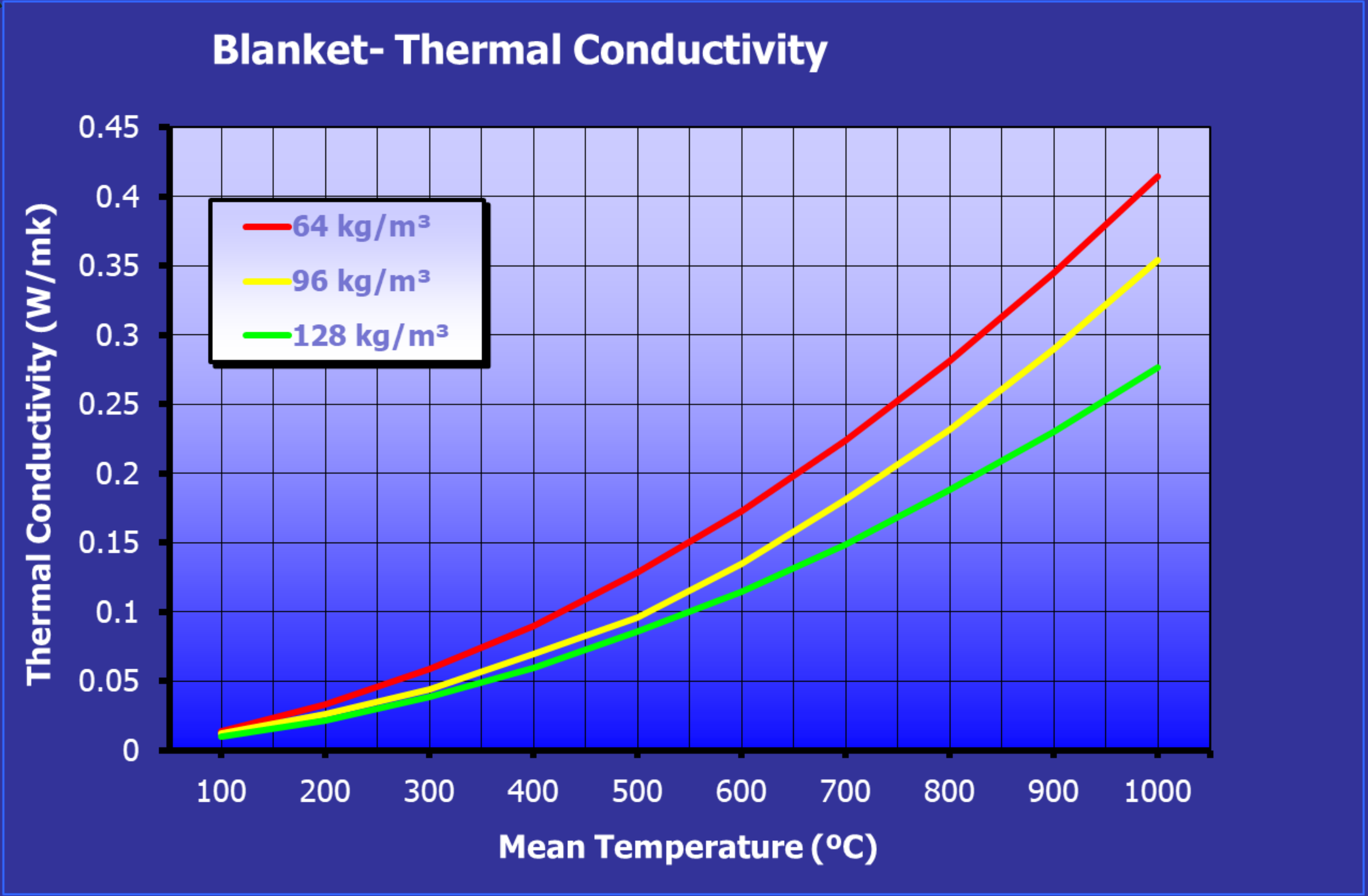
Layered Blanket Linings



Modules

- Engineered solution for high temperature requirements
- Anchorage located on cold face
- Higher gas velocity resistance

Fibre Products



Calcium Silicate

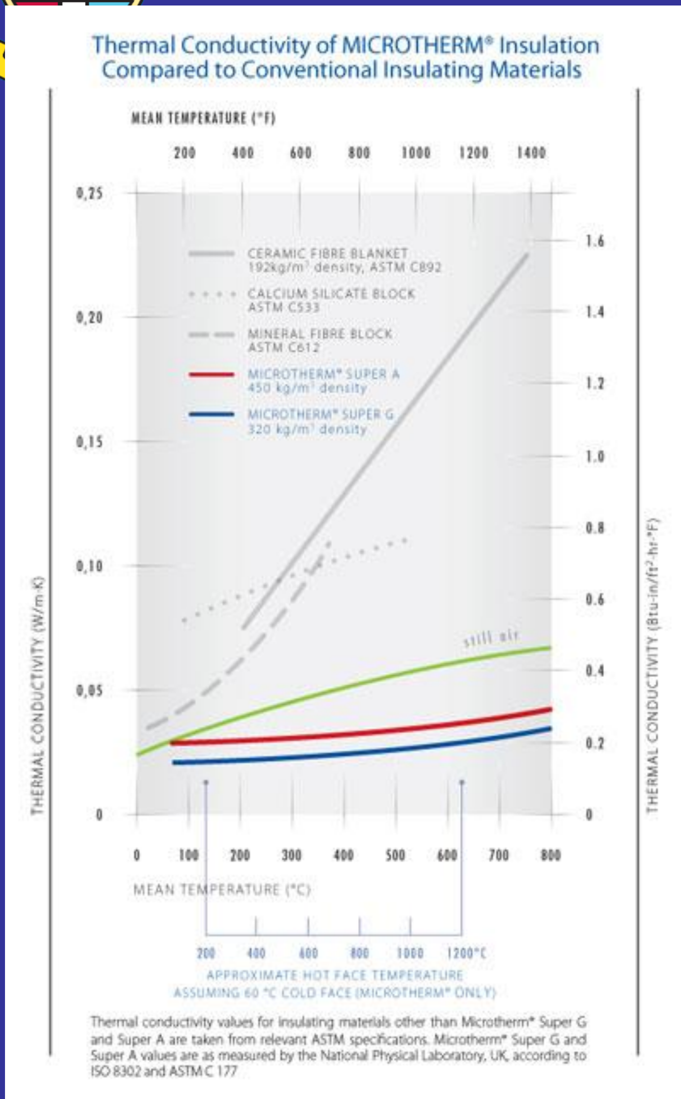
- Rigid Board
- Max Service Temperature of 1000°C
- Easy to cut
- Low cost for insulation value
- Can be machined for complex shapes

Foamglass

- Closed cell glass foam
  - Good insulation value
  - Acid resistant & impermeable
- Low Max service temp – approx 450°C
- Special adhesives to use

- Often used as external cladding/lagging

Microporous Materials

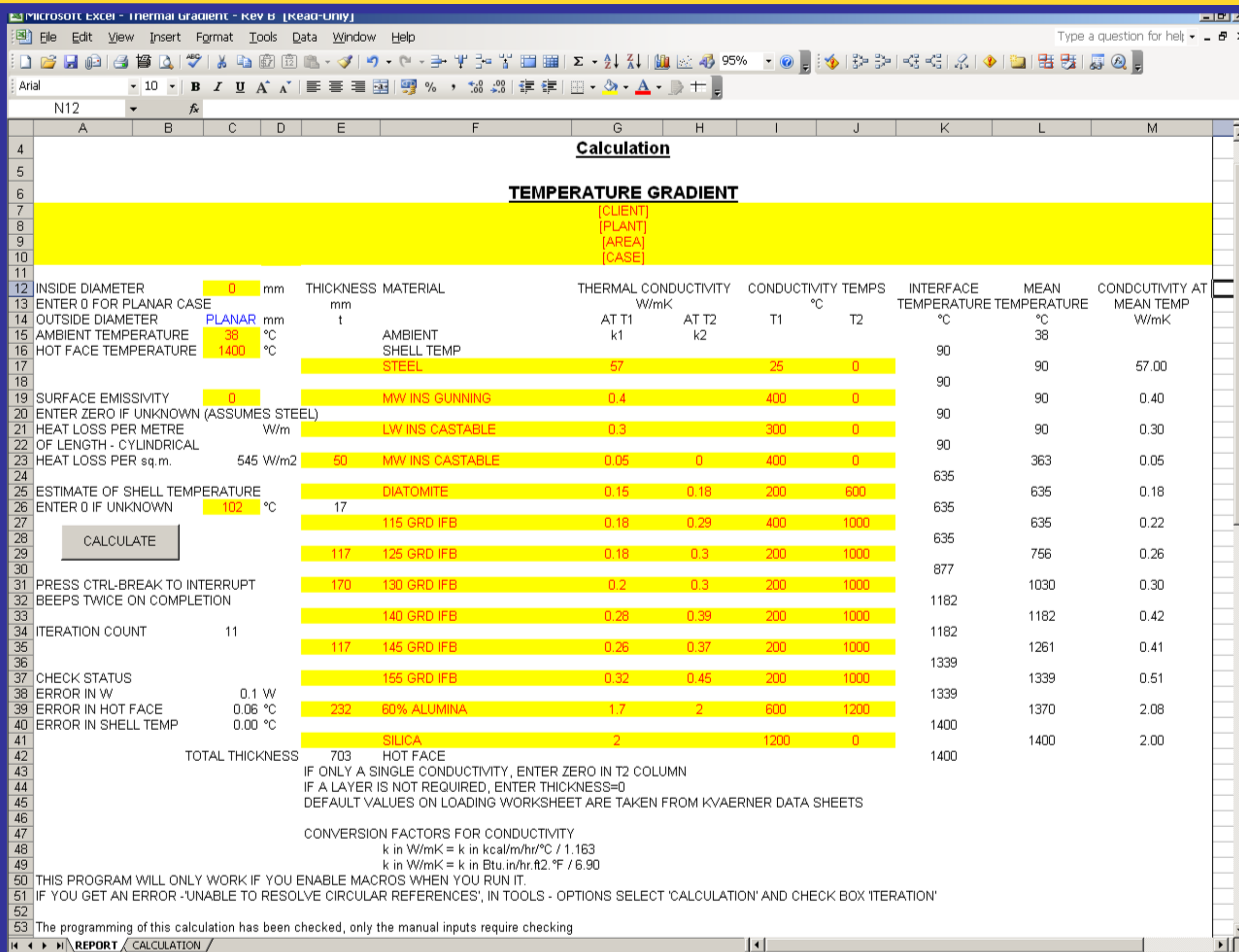


- Temperature vs Thermal Conductivity
- Installation
    - Bending & Cutting, Water

Heat Flow Calculation

- Predict shell temperature
- Confirm each layer is not ‘overheated’ in multi layer linings
  - Need to consider changes in conductivity with temperature
  - Need to consider varying service conditions
  - Need to consider worn linings

Heat Flow Calculation



Microsoft Excel - Thermal Gradient - Rev B [Read-Only]

File Edit View Insert Format Tools Data Window Help

N12

Calculation

TEMPERATURE GRADIENT

[CLIENT]
[PLANT]
[AREA]
[CASE]

	A–B	C	D	E	F	G	H	I	J	K	L	M
12	INSIDE DIAMETER	0	mm	THICKNESS	MATERIAL	THERMAL CONDUCTIVITY		CONDUCTIVITY TEMPS		INTERFACE	MEAN	CONDCUTIVITY AT
13	ENTER 0 FOR PLANAR CASE			mm		W/mK		°C		TEMPERATURE	TEMPERATURE	MEAN TEMP
14	OUTSIDE DIAMETER	PLANAR	mm	t		AT T1	AT T2	T1	T2	°C	°C	W/mK
15	AMBIENT TEMPERATURE	38	°C		AMBIENT	k1	k2				38	
16	HOT FACE TEMPERATURE	1400	°C		SHELL TEMP					90		
17					STEEL	57		25	0		90	57.00
18										90		
19	SURFACE EMISSIVITY	0			MW INS GUNNING	0.4		400	0		90	0.40
20	ENTER ZERO IF UNKNOWN (ASSUMES STEEL)									90		
21	HEAT LOSS PER METRE		W/m		LW INS CASTABLE	0.3		300	0		90	0.30
22	OF LENGTH - CYLINDRICAL									90		
23	HEAT LOSS PER sq.m.	545	W/m2	50	MW INS CASTABLE	0.05	0	400	0		363	0.05
24										635		
25	ESTIMATE OF SHELL TEMPERATURE				DIATOMITE	0.15	0.18	200	600		635	0.18
26	ENTER 0 IF UNKNOWN	102	°C	17						635		
27					115 GRD IFB	0.18	0.29	400	1000		635	0.22
28	CALCULATE									635		
29				117	125 GRD IFB	0.18	0.3	200	1000		756	0.26
30										877		
31	PRESS CTRL-BREAK TO INTERRUPT			170	130 GRD IFB	0.2	0.3	200	1000		1030	0.30
32	BEEPS TWICE ON COMPLETION									1182		
33					140 GRD IFB	0.28	0.39	200	1000		1182	0.42
34	ITERATION COUNT	11								1182		
35				117	145 GRD IFB	0.26	0.37	200	1000		1261	0.41
36										1339		
37	CHECK STATUS				155 GRD IFB	0.32	0.45	200	1000		1339	0.51
38	ERROR IN W	0.1	W							1339		
39	ERROR IN HOT FACE	0.06	°C	232	60% ALUMINA	1.7	2	600	1200		1370	2.08
40	ERROR IN SHELL TEMP	0.00	°C							1400		
41					SILICA	2		1200	0		1400	2.00
42	TOTAL THICKNESS			703	HOT FACE					1400		

IF ONLY A SINGLE CONDUCTIVITY, ENTER ZERO IN T2 COLUMN
IF A LAYER IS NOT REQUIRED, ENTER THICKNESS=0
DEFAULT VALUES ON LOADING WORKSHEET ARE TAKEN FROM KVAERNER DATA SHEETS

CONVERSION FACTORS FOR CONDUCTIVITY
k in W/mK = k in kcal/m/hr/°C / 1.163
k in W/mK = k in Btu.in/hr.ft2.°F / 6.90

THIS PROGRAM WILL ONLY WORK IF YOU ENABLE MACROS WHEN YOU RUN IT.
IF YOU GET AN ERROR -'UNABLE TO RESOLVE CIRCULAR REFERENCES', IN TOOLS - OPTIONS SELECT 'CALCULATION' AND CHECK BOX 'ITERATION'

The programming of this calculation has been checked, only the manual inputs require checking

REPORT / CALCULATION

General Comments

- Consider Maximum Temperature
- Thermal Conductivity Value at Temperature
- Available Thickness
- Strength Requirements
- Chemical Attack – Hydrogen, Alkali

Thank You For Your Attention