



TECHNOLOGY  
AHEAD

## POWER PLANTS AND INCINERATORS



# POWER PLANTS AND INCINERATORS

Making the most of scarce resources, preserving the environment, and using energy in an efficient way are the megatrends of our times.

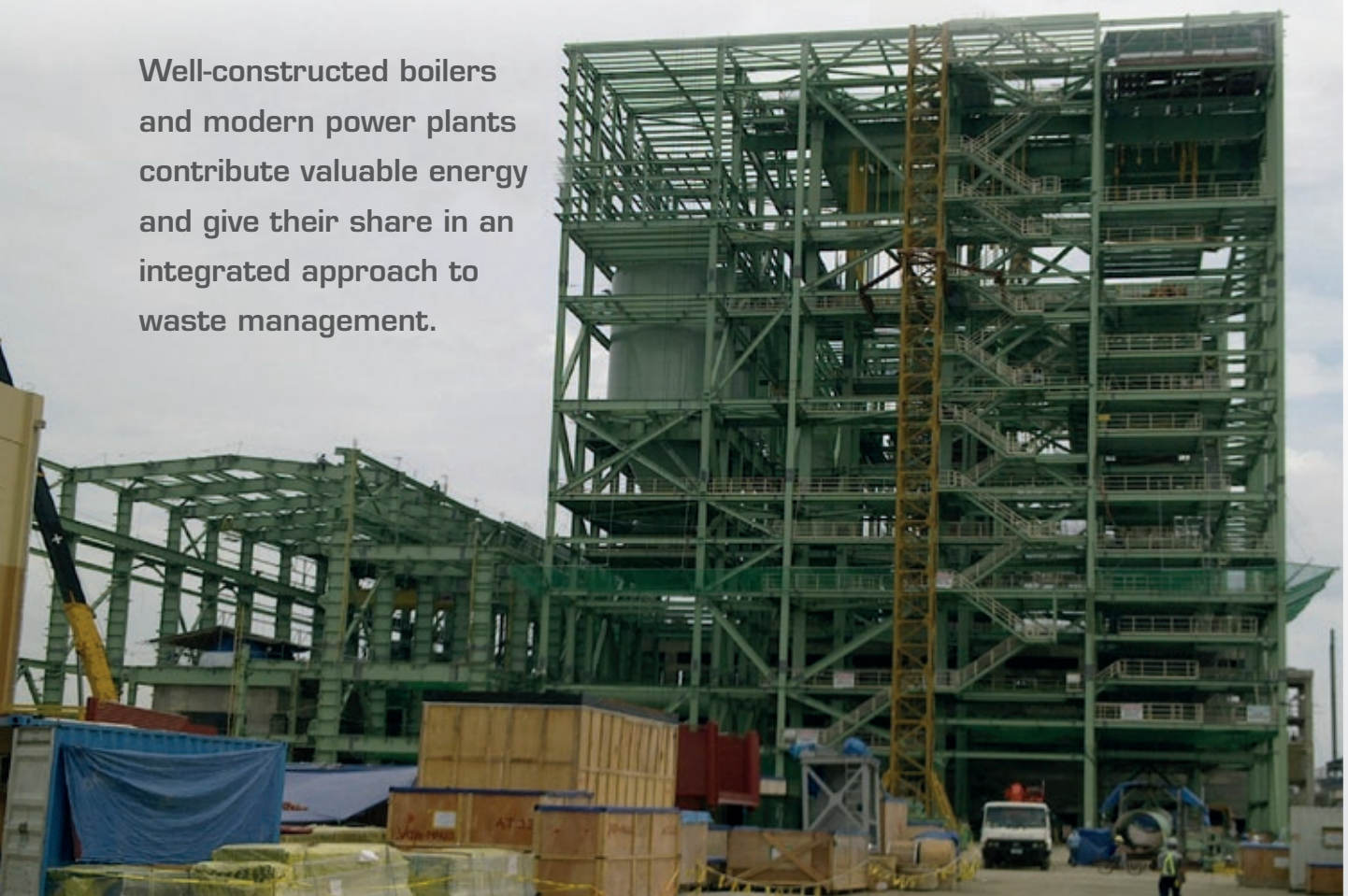
Fluctuating prices for fossile fuels, uncertainties about the usage of nuclear power, and the threat of climate change have led to a global rethinking of key questions.

- What are the best sources to provide energy, electricity, and heat?
- How can we regain and maintain economic growth without further damage to the environment?
- And finally, how do we ensure our standard of living for an ever growing population?



**Controlled incineration processes under technically optimized circumstances provide one part of the answer.**

Well-constructed boilers and modern power plants contribute valuable energy and give their share in an integrated approach to waste management.



The construction of modern, highly developed boilers is a technical challenge. For decades, boiler manufacturers have pushed the limits of technology, increased efficiency rates and allowed for a wide range of fuels.

The heart of the boiler, the firechamber, is one of the main components to ensure perfect combustion and optimal performance of the appliance. Boilers are lined with a wide range of high performance refractory lining to ensure smooth operations even in high temperatures and other adverse conditions.

As a response to the world demand of energy, more and more boilers for Power Plants are constructed. Industrialized nations have realized the benefits of local power generation and the use of CO<sub>2</sub>-neutral, renewable fuels as well as controlled waste incineration.

Refractory products used for power incinerators are developed with a range of adverse conditions to be considered:

- Abrasion resistance
- Thermal shock from sudden and large changes in temperature
- Heat transfer
- Resistance against alkali and other chemicals, mainly from the variety of fuels
- Corrosion

## Our services

Aside from the high quality and the proven reliability of our products we can support end users and engineering companies with vast knowledge of the application and technical services.

## Our solutions for

- Grates fired or stoker type for municipal waste
- Bubbling fluidized beds (BFB)
- Circulating fluidized beds (CFB)
- Pulverized coal fired boilers
- Biomass gasifiers
- Water cooled grates for biomass
- Rotary kiln incinerators
- Waste gas stacks and flares
- LEAF generators (Low emission alternative fuel)



Continuous measuring of technical data while testing in internal laboratory

## 1. Abrasion resistance

In the combustion process, various fuels are transformed into ashes and other residues potentially abrasive for the process equipment and refractory lining.

Fluidized bed boilers also add sand into the furnace to promote combustion. The circulation of sand and ashes in the furnace is an important threat to the life of linings and demands optimal refractories to ensure the long lifespan of the furnace.

The lining must properly resist against abrasion at the operative temperature in order to ensure not only their own life but, in particular also protection of furnace water and steam pressure parts where they are installed.

For a specific rating against international requirements resistance of our materials is measured according to ASTM C704 in volume

loss ( $\text{cm}^3$ ) after standardized exposure to a stream of SiC abrasive ceramic sand. Materials used in boilers should show losses below  $15 \text{ cm}^3$ , and typically below  $10 \text{ cm}^3$  for BFB and CFB applications.

For very aggressive abrasion conditions special materials with losses as low as  $5 \text{ cm}^3$  are available; this can be reached through a balanced combination of aggregate (the coarse grains), matrix (the fine grains) and binding system.



Abrasion in a combustion chamber

## 2. Thermal shock

Uneven operating conditions of boilers and incinerators have a direct impact on the life span of the linings and the furnace in general.

While refractory suppliers always recommend stable conditions, these may not easily be kept within the boiler process.

Several parameters may affect thermal shock resistance.

- **High conductivity helps reduce gradients across linings which are at the origin of thermal stresses.**
- **Dimensional stability: materials with small temperature induced dimensional changes develop less thermal stresses.**
- **Strength helps resist stresses and generally helps withstand thermal shock induced stresses.**
- **Some aggregates can naturally absorb thermally induced cracks and shocks.**

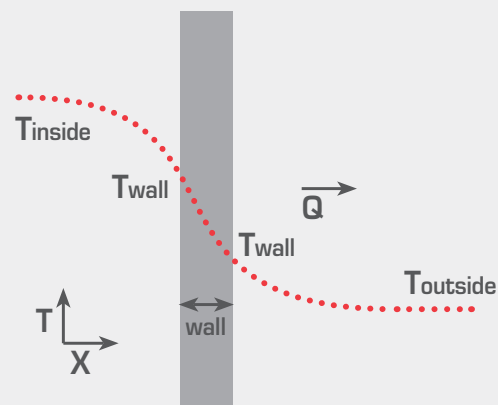
## 3. Heat transfer

Linings must comply with the design parameters of boilers and incinerators to ensure that the required heat flow can be extracted from the combustion.

Silicon carbide based materials are normally employed to reach thermal conductivity  $> 5 \text{ W/mK}$ . Values as high as  $12 \text{ W/mK}$  can be offered in case of need.

These values can be achieved by means of a high level of SiC.

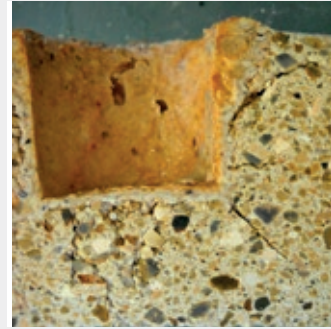
A recent trend is to replace thick and high SiC linings with thinner linings of high strength without SiC.



## 4. Resistance against alkali

Among the various corrosion drivers linked to the type of fuels alkali have become the most important because of the increasing use of wastes and new type of fuels: waste polymeric materials, biomass, paper, and industrial sludge are the most critical.

Alkali salts are easily vaporized at normal combustion temperature; in the vapor phase they can penetrate linings, attack them by forming new complex compounds which are normally molten and very sticky or precipitate in lower temperature layers/conditions with consequent local volume increase, degradation of strength and finally spalling of refractories.



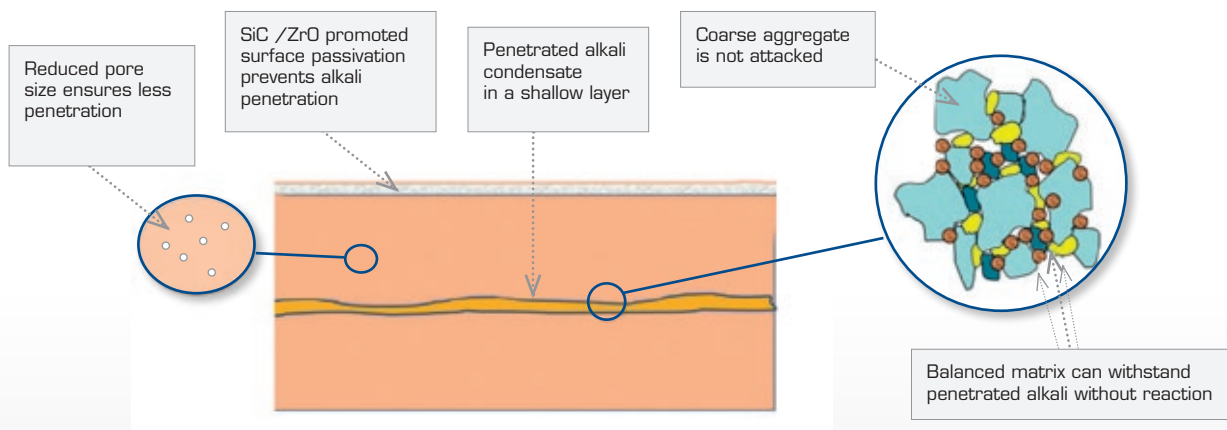
Refractory attacked by alkali

**Our alkali resistant materials are formulated to be only partially or not affected at all by alkali vapors in the combustion:**

1. Reduced open porosity to prevent penetration of alkali
2. SiC doped materials develop a partially oxidized glassy layer which reduces porosity
3. ZrO doped materials react in a controlled way with alkali and develop also a protecting glassy phase layer on the hot face
4. Refractories with a chemically balanced matrix can withstand alkali salts penetration without reacting or being attacked
5. Combinations of some of the above technologies



Refractory **NOT** attacked by alkali



## 5. Corrosion

**Several types of corrosion may affect furnaces in some areas depending on the type of fuel and on the operative conditions of combustion.**

Among others, the following factors are mainly responsible for chemical attacks:

- Carbon monoxide
- Fluorine
- Chlorine
- Sulfur
- Chemical processing wastes

## SOME KEY APPLICATIONS FOR COOLED PARTS

Membrane walls are widely used in several type of boilers. They do not need thermal insulation; pressurized steam or water run through pipes and extract heat from the combustion chamber and furnace ducts. Pipes often need protection against abrasion, they are therefore lined with one layer dense material resistant to abrasion. In order to ensure the designed heat flow linings must have limited thickness (30 – 70 mm) and the required thermal conductivity.

Linings must also be able to withstand the furnace burning conditions such as thermal shock, CO, chemical attacks, etc.



Gunning installation

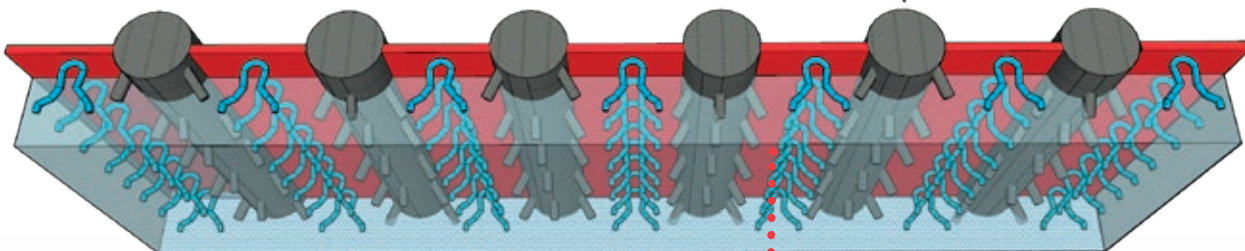
### 1. Roof and wall lining on membrane walls

Thin linings on water and steam cooled pipes are typically applied in different zones on walls or roofs of several types of boilers. Anchors are installed in the form of studs on pipes or small Y or V anchors welded on the fin in between.

Thin linings can be installed by casting self flow castables, by patching or by gunning. Gunning can be an option in the case of walls, but it becomes a preferred solution for roofs because of the convenient installation.

Typical applications involve medium to high alumina products, but also SiC materials are widely used in case high thermal conductivity and slag resistance are required.

Example of a membrane wall lining arrangement.



Seven offers a wide range of products for roof and wall lining on membrane walls:

- Seven Flow 65 NH CO
- Seven Flow 51 NM
- Seven Flow 75 NR
- Seven Flow 92 NB
- Seven Flow 70 ND
- Seven Gun 85 NX
- Seven Trow 85 CX -3
- Seven Flow 60 N SiC H -3
- Seven Patch 85 C SiC

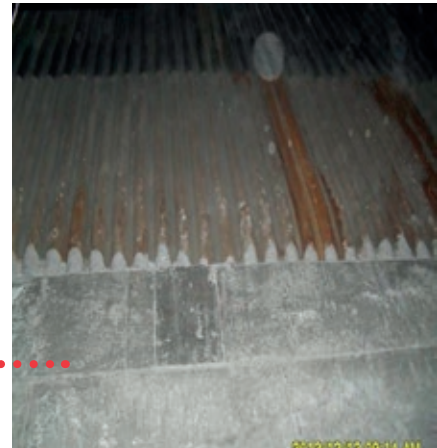


Lining by gunning of a membrane wall roof in an incinerator

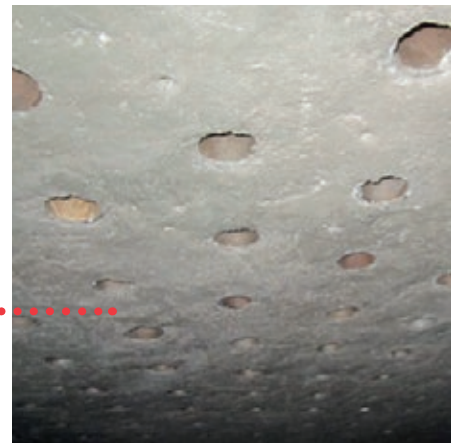
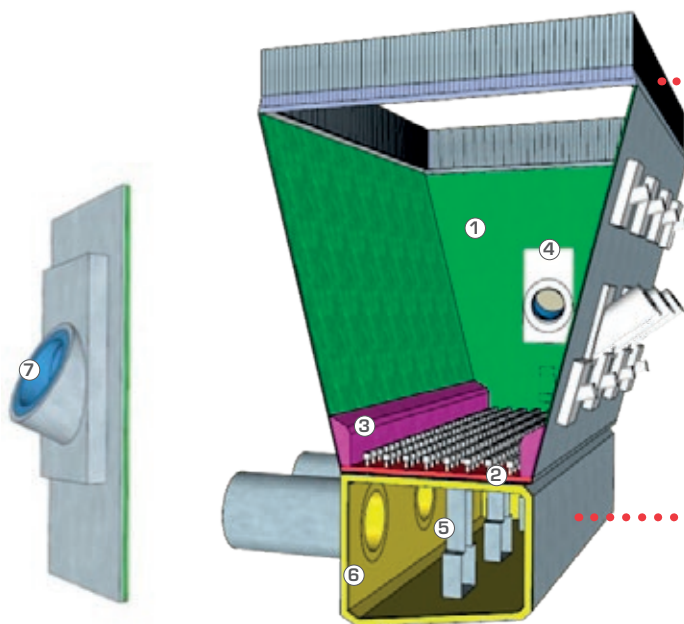
## 2. Fluidized bed combustion chambers

The lower combustion chamber is the area where both air, fuel, sand and limestone are injected into the fluidized bed. The ignition of the boiler is also initiated in this critical zone. Linings are therefore exposed to several types of stresses such as abrasion, thermal shock, reducing atmosphere and chemical attack. Linings in the lower combustion chamber range between 25 and 70 mm, and their construction as well as performance are key to optimal combustion conditions overall.

In the air plenum that feeds the air nozzles there is only limited exposure to high temperature, thermal shock is a main concern and special attention should be placed upon the construction and installation.



Re-lined lower combustion chamber below free board



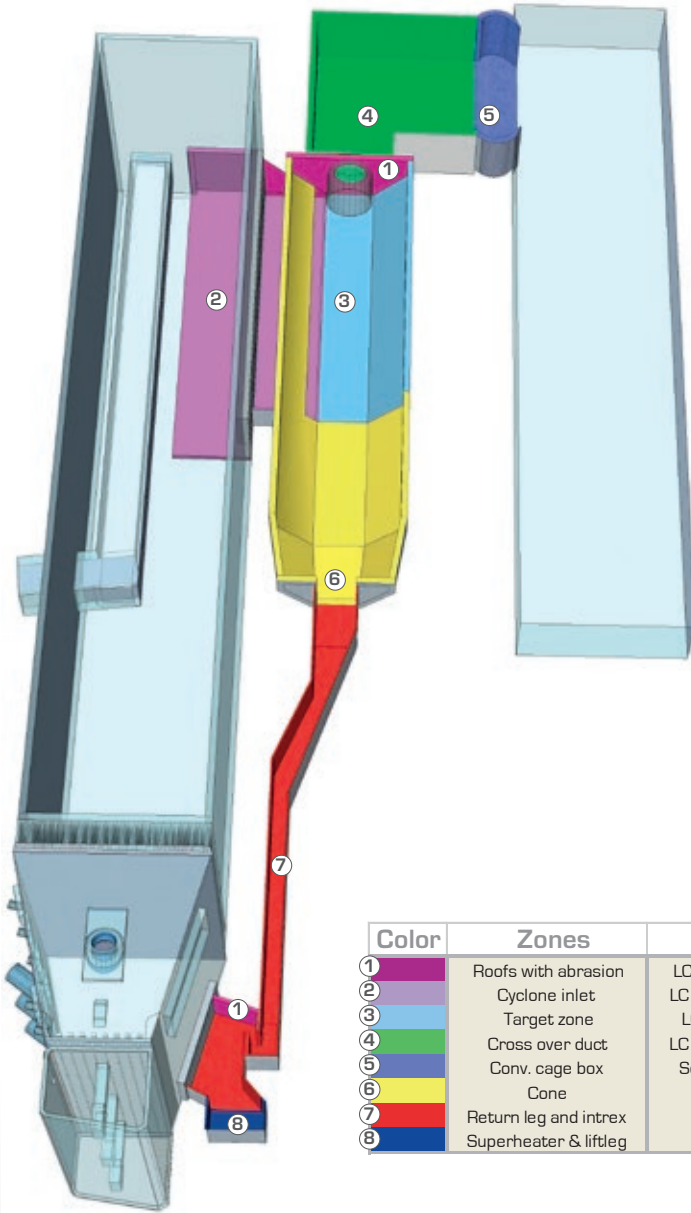
Roof of the air plenum

| Color | Zones                          | Material type                              | Attention to                |
|-------|--------------------------------|--|-----------------------------|
|       | Fuel feeding                   | LC or RC castable                          | abrasion, thermal shock, CO |
| ①     | Lower combustion chamber walls | Self flowing or patching                   | abrasion, thermal shock, CO |
| ②     | Hearth with nozzles            | RC or LC castable                          | abrasion, thermal shock, CO |
| ③     | Hearth corners                 | RC or LC castable                          | abrasion, thermal shock, CO |
| ④     | Burner                         | LC castable or plastic                     | abrasion, thermal shock, CO |
| ⑤     | Slag hopper                    | LC castable or plastic or dense bricks     | abrasion                    |
| ⑥     | Windbox                        | Medium weight insulating castable, plastic | thermal shock               |
| ⑦     | Backup insul. layer 2          | Insulating castable, density 0.7 - 0.8     | insulation                  |

| Seven products:          | Application areas  |
|--------------------------|--|
| Seven Flow 51 NM         | lower combustion chamber walls                               |
| Seven Flow 65 NH CO      | lower combustion chamber walls                               |
| Seven Cast 50/55 NM      | hearth with nozzles, hearth corners, fuel chute              |
| Seven Cast 80 NX         | fuel chute, hearth corners, hearth with nozzles, slag outlet |
| Seven Plast 70 CH CO     | burner, lower combustion walls                               |
| Seven Cast 70 NH         | burner   |
| Seven Cast 80 RX 5       | slag outlet  |
| Seven Flow 60 N SiC H -3 | walls  |
| Sevenlite 1300 HS P      | plenum   |

### 3. Compact separator, dipleg, intex

Cyclones are a challenging refractory application mainly because of abrasion and sometimes also alkali attack. Aside from the materials used, engineering and installation are key elements for good performance.



| Color | Zones                 | Material type                        | Attention to             |
|-------|-----------------------|--------------------------------------|--------------------------|
| ①     | Roofs with abrasion   | LC self flowing castable or gunning  | high abrasion, alkali    |
| ②     | Cyclone inlet         | LC self flowing castable or patching | high abrasion, alkali    |
| ③     | Target zone           | LC self flowing castable or patching | extreme abrasion, alkali |
| ④     | Cross over duct       | LC self flowing castable or gunning  | some alkali              |
| ⑤     | Conv. cage box        | Self flowing castable or gunning     | some alkali              |
| ⑥     | Cone                  | LC self flowing castable             | abrasion, alkali         |
| ⑦     | Return leg and intrex | LC self flowing castable             | abrasion, alkali         |
| ⑧     | Superheater & liftleg | LC self flowing castable             | abrasion, alkali         |



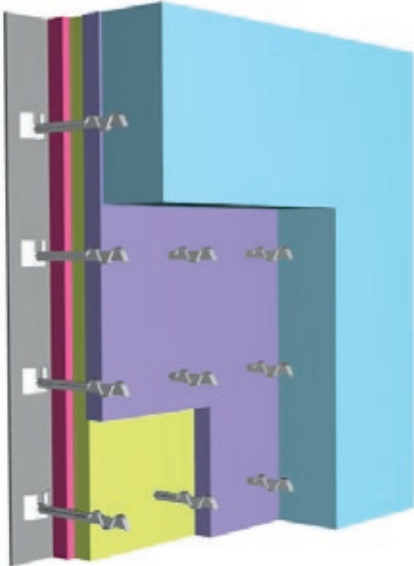
| Seven products:   | Application areas  |
|---|--|
| Seven Flow 75 NR  | target zone, separator inlet   |
| Seven Flow 92 NB  | target zone  |
| Seven Flow 51 NM  | inlet, cone, crossover duct, return duct, intrex, liftleg, convection cage |
| Seven Flow 70 ND  | inlet, cone, dipleg, intrex  |
| Seven Flow 60 N SiC H -3                                  | sloping walls, intrex  |
| Seven Gun 85 NX, Seven Gun 55 RM, Seven Gun 57 RH 01 V CO | roofs of inlet, separator and intrex, crossover duct, convection cage box  |
| Seven Gun 50 NM   | crossover duct, convection cage  |
| Seven Trow 85 CX -3                                       | roofs, corners, target zone, intrex  |
| Seven Cast 59 ND, Seven Cast 99 CF LCS                    | stripper cooler  |



# TYPICAL KEY APPLICATIONS FOR U COOLED PARTS

Despite the trend towards full membrane wall systems to extract more heat and thereby increase overall efficiency, traditional uncooled furnace shells are still widely used.

These are conditions where thick linings are needed; they normally feature multiple layers, dedicated anchoring, thermal insulation together with the typical properties to withstand the aggressive furnace atmosphere of boilers and incinerators.

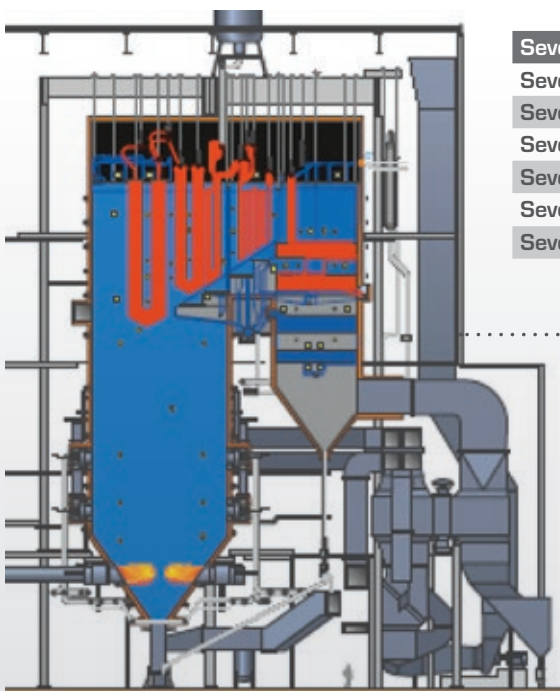


Seven Plast  
70 AKX

## 1. Furnace chamber of pulverized coal fired boilers

This type of furnace for coal burning dominates the electric power industry. Major coal fired plants have increasing size and their pressurized circuits are operated at increasing temperature and pressure.

Limited areas are protected by refractory linings. In any case their reliability is highly important as it may affect operations. The most demanding zones are the slag outlet and the burners where high thermal shock resistance is required.



| Seven products          | Application areas                     |
|-------------------------|---------------------------------------|
| Seven Plast 70 AKX      | burner throat, uncooled parts         |
| Seven Plast 70 CH CO    | burner throat, uncooled parts         |
| Seven Cast 38 RM 4      | uncooled parts, low thermal stress    |
| Seven Cast 75 RX 4      | uncooled parts with thermal stress    |
| Seven Patch 75/85 C SiC | cooled parts, thin linings over tubes |
| Seven Cast 57 N SiC 5   | slag outlet area                      |

Pulverized coal boiler improved

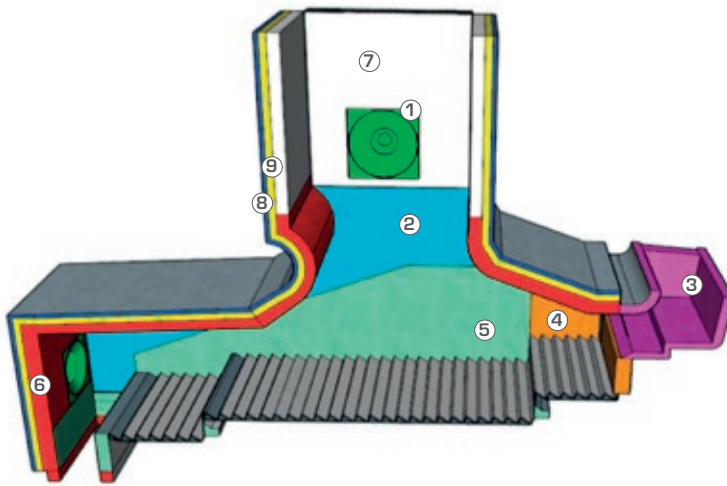
## 2. Stoker type and grate combustion chambers

Stoker and grate furnaces are typically used to produce energy from waste under strictly controlled conditions.

These incinerators are widely operated, especially for high capacities, and the optimal construction of the lining is a cornerstone to ensure optimal working conditions.

Several configurations are available according to the design of the different engineering companies.

High SiC content and low porosity materials are normally recommended by the engineering companies especially to reduce the sticking in the grate transition or on the walls and also to ensure heat extraction. Other possible issues in the lower part of the combustion chamber are abrasive wear and water steam while alkali attack may appear in the linings above.



| Color | Zones                         | Material type                                   | Attention to                          |
|-------|-------------------------------|---|---------------------------------------|
| ①     | Burner throats                | Plastic or LC castable                          | high temperature, thermal shock       |
| ②     | Combustion chamber walls      | LC castable with or without SiC or SK 34 bricks | alkali attack, thermal shock          |
| ③     | Fuel chute                    | LC castable                                     | abrasion                              |
| ④     | Preheating chamber            | LC castable with SiC                            | thermal shock, sticking               |
| ⑤     | Grate transition              | LC castable with high SiC                       | slag sticking, abrasion, thermal flow |
| ⑥     | Combustion chamber roof; neck | LC castable or gunning with or without SiC      | alkali attack                         |
| ⑦     | Upper walls                   | LC castable or gunning with or without SiC      | alkali attack                         |
| ⑧     | Backup insulation, 2nd layer  | Insulating castable, density 0.7 - 0.8          | insulation                            |
| ⑨     | Backup insulation, 3rd layer  | Thermo insulating board                         | insulation                            |



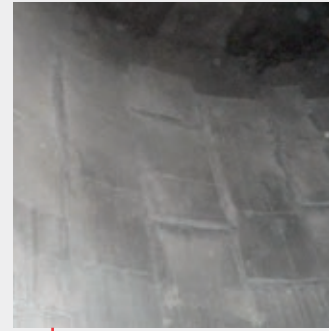
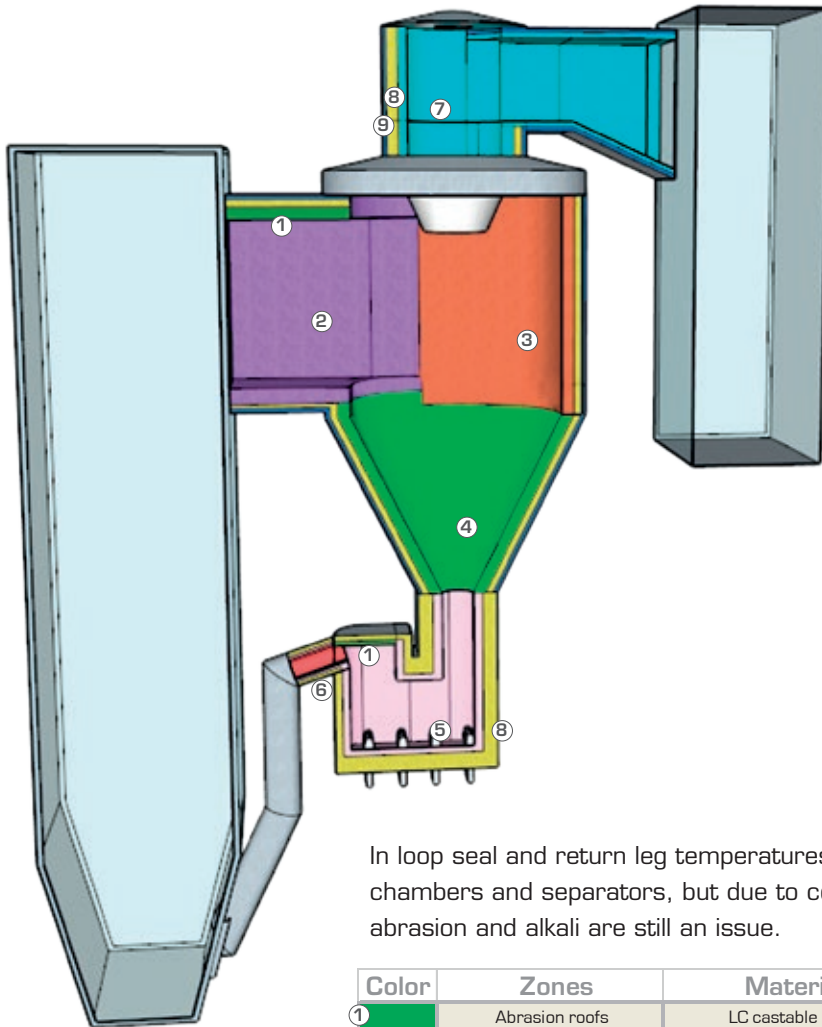
Partial re-lining of a grate combustion chamber.

Notice: smaller and newer units especially for biomass applications are mostly built by cooled parts where thin linings are applied to ensure protection of pipes against chemical attack, slag and abrasion, but also to ensure the required thermal flow.

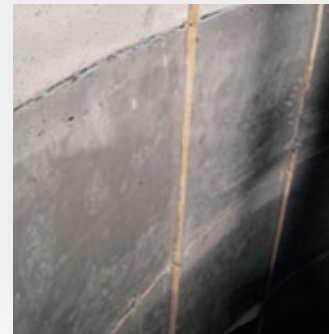
| Seven products:          | Application areas   |
|--------------------------|---|
| Seven Cast 80 NX         | fuel chute, grate transition zone exit side                   |
| Seven Cast 50/55 NM      | fuel chute, side wall, upper walls, sometimes preheating zone |
| Seven Gun 50 RM 5        | upper walls   |
| Seven Flow 35 N SiC M -3 | upper walls, side walls                                       |
| Seven Cast 65 N SiC -3   | grate transition zone   |
| Seven Brick 90 K SiC     | grate transition zone   |
| Seven Cast 30 N SiC B    | preheating zone wall  |
| Seven Cast 30 N SiC D    | preheating zone wall  |
| Seven Plast 70 CH CO     | burner throat   |
| Seven Cast 70 NH         | burner throat   |
| Seven Cast 65 ND/ NX     | roof and neck   |
| Seven Flow 50 ND 51 Z    | roof and neck   |
| Seven Cast 50 ND 15 Y    | roof and neck   |
| Seven Gun 57 RH 01 V CO  | roof, neck and side walls                                     |

### 3. Cyclones, loop seal and return leg with thick linings

The older generation of separators in CFB are uncooled and lined with thick linings either by bricks or monolithic refractories. Even though membrane walls become more and more popular, several traditional cyclones are still built and regularly operated nowadays.



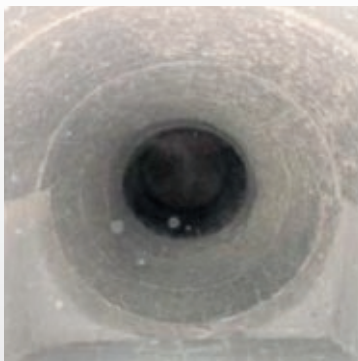
Upper cyclone



Lining of the cyclone

In loop seal and return leg temperatures are lower than in combustion chambers and separators, but due to concentration of sand and ashes abrasion and alkali are still an issue.

| Color | Zones                        | Material type                        | Attention to             |
|-------|------------------------------|--------------------------------------|--------------------------|
| ①     | Abrasion roofs               | LC castable or gunning               | high abrasion, alkali    |
| ②     | Inlet walls                  | LC castable or plastic               | high abrasion, alkali    |
| ③     | Target zone                  | LC castable, plastic or dense bricks | extreme abrasion, alkali |
| ④     | Cone                         | RC or MC castable                    | abrasion, alkali         |
| ⑤     | Loop seal                    | RC or MC castable                    | abrasion, alkali         |
| ⑥     | Return leg                   | RC or MC castable                    | abrasion, alkali         |
| ⑦     | Outlet duct                  | RC castable or gunning               | some alkali              |
| ⑧     | Backup insulation, 2nd layer | Castable density 0.7 - 0.8           | insulation               |
| ⑨     | Backup insulation, 3rd layer | Thermo insulating board              | insulation               |

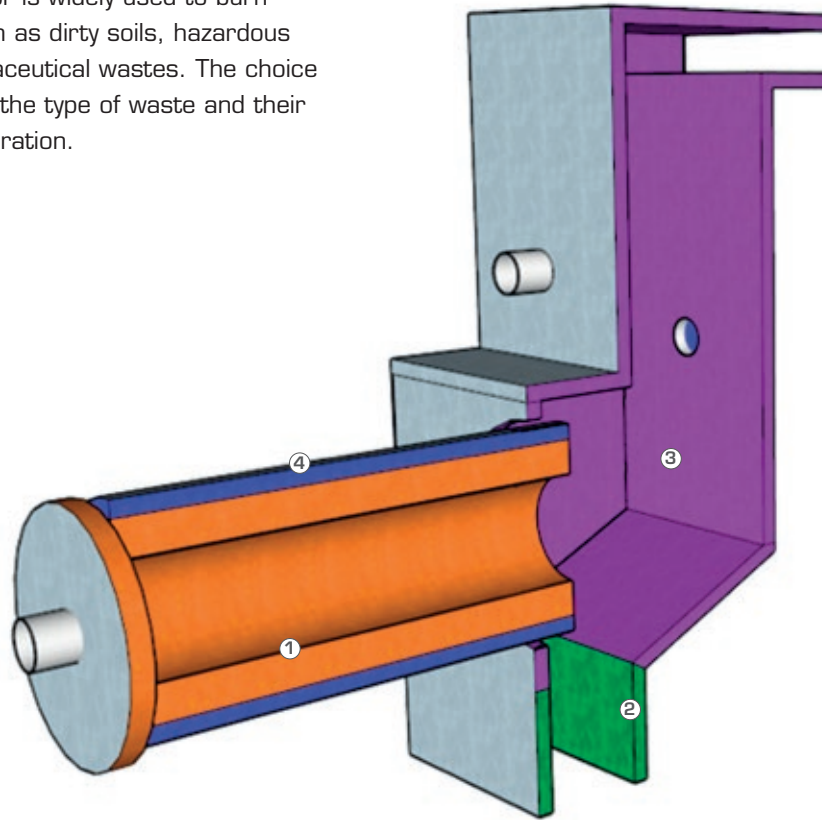


From cyclone to loop seal

| Seven products  | Application areas                              |
|---|--|
| Seven Cast 80 NX  | inlet walls, target zone, loop seal            |
| Seven Cast 52 RM  | inlet floor, cone, loop seal, outlet duct      |
| Seven Cast 50 NM  | inlet floor, cone, loop seal, return leg       |
| Seven Cast 58 NM  | roof, cyclone inlet, cyclone drum              |
| Seven Cast 43 RM 5 -10  | outlet duct                                    |
| Seven Gun 85 NX,<br>Seven Gun 55 RM,<br>Seven Gun 57 RH 01 V CO | roofs, inlet walls, cyclone drum, cyclone exit |
| Seven Gun 47 RM 5   | roofs, outlet duct                             |
| Seven Trow 85 CX -3   | target zone, high abrasion                     |
| Seven Plast 70 CH CO  | cyclone drum, inlet, exit, loop seal           |

#### 4. Kilns of rotary type incinerators

This type of incinerator is widely used to burn industrial wastes such as dirty soils, hazardous materials and pharmaceutical wastes. The choice of linings depends on the type of waste and their behavior during incineration.



| Color | Zones                     | Material type                      | Attention to            |
|-------|---------------------------|------------------------------------|-------------------------|
| ①     | Combustion rotary chamber | LC or UC castable                  | chemical corrosion      |
| ②     | Ash hopper                | RC castable                        | thermal shock, abrasion |
| ③     | Outgas duct               | Insulating castable                | insulation, strength    |
| ④     | Insulation                | Insulating castable or gunning mix | insulation, strength    |

| Seven products        | Application areas           |
|-----------------------|-----------------------------|
| Seven Cast 88 NR 03 W | rotary kiln, waste gas duct |
| Seven Cast 50 ND 15 Y | rotary kiln                 |
| Seven Cast 75 NR 04 Y | rotary kiln                 |
| Seven Shot 50 ND 15 Y | rotary kiln, waste duct     |
| Seven Shot 51 NH 01 X | rotary kiln, waste duct     |
| Seven Cast 50 NM      | slag hopper                 |



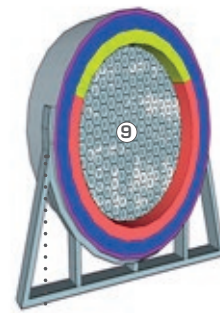
Seven Refractories packaging machine

## 5. Combustion chambers of flue gas incinerators

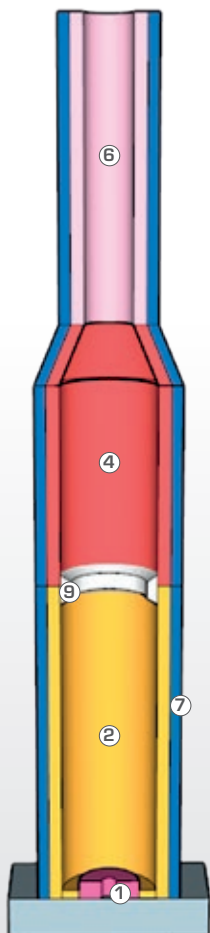
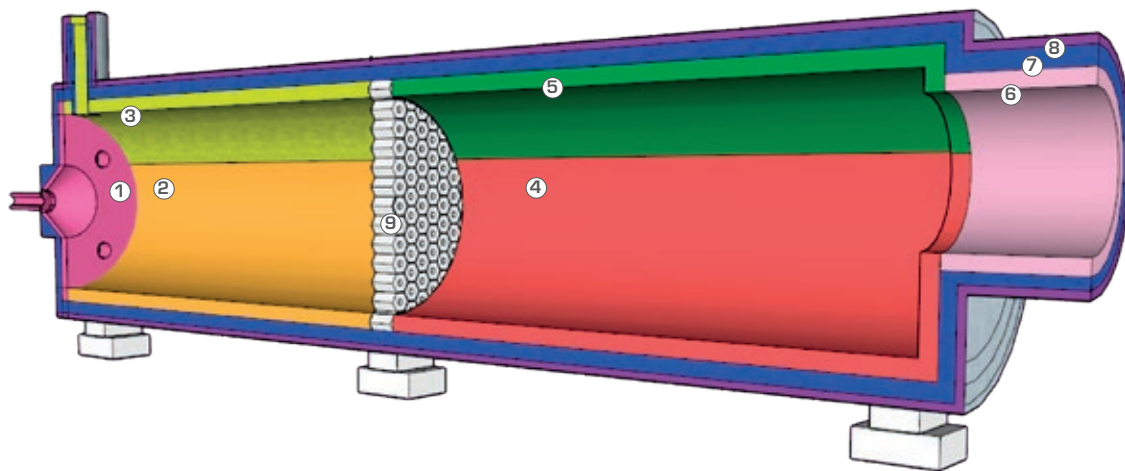
Gaseous subproducts of industrial processes must be properly burnt and treated to avoid dangerous emissions. The additional controlled and monitored incineration of flue gas is therefore a common practice for environmental reasons. Dangerous chemicals can be transformed to harmless oxides in this kind of equipment, and the concentrations of dioxins and NO<sub>x</sub> are reduced to safe levels.

This type of incinerator can have different configurations, their combustion chambers are normally static drums, which do not rotate. In the graphs, a horizontal and a vertical configuration are depicted.

The choice of linings depends mainly on the type of chemical contained in the flue gases.



Detail baffle wall



| Color | Zones                                | Material type                      | Attention to                 |
|-------|--------------------------------------|------------------------------------|------------------------------|
| ①     | Burner throat                        | Plastic or LC castable             | thermal shock                |
| ②     | Combustion chamber                   | LC castable, gunning mix, plastic  | abrasion, chemical corrosion |
| ③     | Roof before baffle                   | Gunning mix or plastic             | abrasion, chemical corrosion |
| ④     | Post combustion chamber after baffle | RC or LC castable                  | abrasion, chemical corrosion |
| ⑤     | Roof after baffle                    | Gunning mix or plastic             | abrasion, chemical corrosion |
| ⑥     | Outgas duct                          | Insulating castable                | insulation                   |
| ⑦     | Insulation (2nd layer)               | Insulating castable or gunning mix |                              |
| ⑧     | Insulation (3rd layer)               | Insulating board                   |                              |
| ⑨     | Baffle wall                          |                                    | thermal shock                |

| Seven products                        | Application areas                       |
|---------------------------------------|---|
| Seven Plast 70 AKX                    | burner throat, combustion chamber, roof |
| Seven Cast 65 NX                      | combustion chamber, baffle wall         |
| Seven Cast 70 NH                      | baffle wall, burner throat              |
| Seven Cast 52 RM                      | combustion chamber after baffle         |
| Seven Gun 60 ND                       | roof before baffle                      |
| Seven Gun 47 RM 5,<br>Seven Gun 55 RM | roof after baffle                       |
| Sevenlite 1300, 1100 LD               |   |

Aggressive applications for fluoride and/or chloride wastes:

Seven Cast 98 UR  
 Seven Plast 90 AKR  
 Seven Brick 99 KR (99% alumina)  
 Seven Cast 95 RBB LW

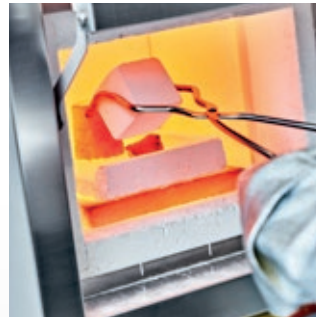
# RESEARCH AND SUSTAINABLE DEVELOPMENT

Seven Refractories has incorporated environmental concerns about climate change in its innovative approach to the market; not only in making our factory more electrically independent by using renewable energy sources, but in the entire manufacturing process cycle and quality control.



**Respect of the environment is a core value of Seven Refractories.**

Selection of the raw materials, dedicated and oriented research, composition architecture and on the field technical experts are the key-points for outstanding efficiency and reliability of the refractory linings, excellent control of the thermal load distribution and low product variability in time.



TESTING



PRODUCTION



# SERVICES PROVIDED

- Preliminary study and investigation for the entire project
- Design and architecture including bill of materials and thermal calculation
- Full range of products for lining and maintenance
  - Regular, low, ultra-low and no-cement castable
  - Regular and dense low-cement gunning mix
  - Ramming
  - Shotcreting
  - Self flowing
- Supply of mixers, gunning machines, pumps, etc.
- Training on mixing, gunning and maintenance techniques
- Training on equipment usage
- Supervision and monitoring by experienced technicians
- Global research & development
- Technical advice by experts
- Monitoring and targeting of results



05-2019

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