Advanced Technical Vision
Power Plants and Incinerators
Power Plants and Incinerators

DALMIA SEVEN is not only a new name, but a new promise: to bring tradition and innovation together for the purpose of serving the Indian market in an optimal and unprecedented way. It is a joint venture between Dalmia Refractories, India's trusted and leading refractory maker and Seven Refractories of Europe, a young European manufacturer, which unites innovative technology with multi-national experience across various refractory industries.

DALMIA SEVEN understands your specific requirements and serves them innovatively with the most advanced technology.

- 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?

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

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

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

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Controlled incineration processes under technically optimized circumstances provide one part of the answer.
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 CO2-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 (cm³) after standardized exposure to a stream of SiC abrasive ceramic sand. Materials used in boilers should show losses below 15 cm³, and typically below 10 cm³ for BFB and CFB applications.

For very aggressive abrasion conditions special materials with losses as low as 5 cm³ are available; this can be reached through a balanced combination of aggregate (the coarse grains), matrix (the fine grains) and binding system.

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 W/mK. Values as high as 12 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.

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

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

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

**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.

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.
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.

<table>
<thead>
<tr>
<th>Color</th>
<th>Zones</th>
<th>Material type</th>
<th>Attention to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuel feeding</td>
<td>LC or RC castable</td>
<td>abrasion, thermal shock, CO</td>
</tr>
<tr>
<td>2</td>
<td>Lower combustion chamber walls</td>
<td>Self flowing or patching</td>
<td>abrasion, thermal shock, CO</td>
</tr>
<tr>
<td>3</td>
<td>Hearth with nozzles</td>
<td>RC or LC castable</td>
<td>abrasion, thermal shock, CO</td>
</tr>
<tr>
<td>4</td>
<td>Hearth corners</td>
<td>RC or LC castable</td>
<td>abrasion, thermal shock, CO</td>
</tr>
<tr>
<td>5</td>
<td>Burner</td>
<td>LC castable or plastic</td>
<td>abrasion, thermal shock, CO</td>
</tr>
<tr>
<td>6</td>
<td>Slag hopper</td>
<td>LC castable or plastic or dense bricks</td>
<td>abrasion, thermal shock, CO</td>
</tr>
<tr>
<td>7</td>
<td>Windbox</td>
<td>Medium weight insulating castable, plastic</td>
<td>abrasion, thermal shock, CO</td>
</tr>
<tr>
<td>8</td>
<td>Backup insul. layer 2</td>
<td>Insulating castable, density 0.7 - 0.8</td>
<td>insulation</td>
</tr>
<tr>
<td>9</td>
<td></td>
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</tr>
</tbody>
</table>

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

### 3. Compact separator, dipleg, intex

<table>
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<th>Material type</th>
<th>Attention to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Roofs with abrasion</td>
<td>LC self flowing castable or gunning</td>
<td>high abrasion, alkali</td>
</tr>
<tr>
<td>2.</td>
<td>Cyclone inlet</td>
<td>LC self flowing castable or patching</td>
<td>high abrasion, alkali</td>
</tr>
<tr>
<td>3.</td>
<td>Target zone</td>
<td>LC self flowing castable or patching</td>
<td>extreme abrasion, alkali</td>
</tr>
<tr>
<td>4.</td>
<td>Cross over duct</td>
<td>LC self flowing castable or gunning</td>
<td>some alkali</td>
</tr>
<tr>
<td>5.</td>
<td>Conv. cage box</td>
<td>Self flowing castable or gunning</td>
<td>some alkali</td>
</tr>
<tr>
<td>6.</td>
<td>Cone</td>
<td>LC self flowing castable</td>
<td>abrasion, alkali</td>
</tr>
<tr>
<td>7.</td>
<td>Return leg and intrex</td>
<td>LC self flowing castable</td>
<td>abrasion, alkali</td>
</tr>
<tr>
<td>8.</td>
<td>Super heater &amp; liftleg</td>
<td>LC self flowing castable</td>
<td>abrasion, alkali</td>
</tr>
</tbody>
</table>

#### DS products:

<table>
<thead>
<tr>
<th>DS products</th>
<th>Application areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS Flow 75 NR</td>
<td>target zone, separator inlet</td>
</tr>
<tr>
<td>DS Flow 92 NB</td>
<td>target zone</td>
</tr>
<tr>
<td>DS Flow 51 NM</td>
<td>inlet, cone, crossover duct, return duct, intrex, liftleg, convection cage</td>
</tr>
<tr>
<td>DS Flow 70 ND</td>
<td>inlet, cone, dipleg, intrex</td>
</tr>
<tr>
<td>DS Flow 60 N SiC H -3</td>
<td>sloping walls, intrex</td>
</tr>
<tr>
<td>DS Gun 85 NX, DS Gun 55 RM, DS Gun 57 RH 01 V CO</td>
<td>roofs of inlet, separator and intrex, crossover duct, convection cage box</td>
</tr>
<tr>
<td>DS Gun 50 NM</td>
<td>crossover duct, convection cage</td>
</tr>
<tr>
<td>DS Trow 85 CX -3</td>
<td>roofs, corners, target zone, intrex</td>
</tr>
<tr>
<td>DS Cast 59 ND, DS Cast 59 CF LCS</td>
<td>stripper cooler</td>
</tr>
</tbody>
</table>
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.

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.

<table>
<thead>
<tr>
<th>DS products</th>
<th>Application areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS Plast 70 AKX</td>
<td>burner throat, uncooled parts</td>
</tr>
<tr>
<td>DS Plast 70 CH CO</td>
<td>burner throat, uncooled parts</td>
</tr>
<tr>
<td>DS Cast 38 RM 4</td>
<td>uncooled parts, low thermal stress</td>
</tr>
<tr>
<td>DS Cast 75 RM 4</td>
<td>uncooled parts with thermal stress</td>
</tr>
<tr>
<td>DS Patch 75/85 C SiC</td>
<td>cooled parts, thin linings over tubes</td>
</tr>
<tr>
<td>DS Cast 57 N SiC 5</td>
<td>slag outlet area</td>
</tr>
</tbody>
</table>
Stoker type and grate combustion chambers

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

These incinicators 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.

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

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**DS products:** | **Application areas**
---|---
DS Cast 80 NX | fuel chute, grate transition zone exit side
DS Cast 50/55 NM | fuel chute, side wall, upper walls, sometimes preheating zone
DS Gun 50 RM 5 | upper walls
DS Flow 35 N SiC M -3 | upper walls, side walls
DS Cast 65 N SiC -3 | grade transition zone
DS Cast 30 N SiC B | preheating zone wall
DS Cast 30 N SiC D | preheating zone wall
DS Plast 70 CH CO | burner throat
DS Cast 70 NH | burner throat
DS Cast 65 ND/ NX | roof and neck
DS Flow 50 ND 51 Z | roof and neck
DS Cast 50 ND 15 Y | roof and neck
DS Gun 57 RH 01 V CO | roof, neck and side walls
DS 1000 | insulating back layer

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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.

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

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

### DS products Application areas

- DS Cast 80 NX: inlet walls, target zone, loop seal
- DS Cast 52 RM: inlet floor, cone, loop seal, outlet duct
- DS Cast 50 NM: inlet floor, cone, loop seal, return leg
- DS Cast 58 NM: roof, cyclone inlet, cyclone drum
- DS Cast 43 RM 5 -10: outlet duct
- DS Gun 85 NX, DS Gun 55 RM, DS Gun 57 RH 01 V CO: roofs, inlet walls, cyclone drum, cyclone exit
- DS Gun 47 RM 5: roofs, outlet duct
- DS Trow 85 CX -3: target zone, high abrasion
- DS Plast 70 CH CO: cyclone drum, inlet, exit, loop seal
- DS 1000: insulating back layer
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.

<table>
<thead>
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<th>Material type</th>
<th>Attention to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Combustion rotary chamber</td>
<td>LC or UC castable</td>
<td>chemical corrosion</td>
</tr>
<tr>
<td></td>
<td>Ash hopper</td>
<td>RC castable</td>
<td>thermal shock</td>
</tr>
<tr>
<td></td>
<td>Outgas duct</td>
<td>Insulating castable</td>
<td>abrasion</td>
</tr>
<tr>
<td></td>
<td>Insulation</td>
<td>Insulating castable or</td>
<td>insulation, strength</td>
</tr>
<tr>
<td></td>
<td></td>
<td>gunning mix</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DS products</th>
<th>Application areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS Cast 88 NR 03 W</td>
<td>rotary kiln, waste gas duct</td>
</tr>
<tr>
<td>DS Cast 50 ND 15 Y</td>
<td>rotary kiln</td>
</tr>
<tr>
<td>DS Cast 75 NR 04 Y</td>
<td>rotary kiln</td>
</tr>
<tr>
<td>DS Shot 50 ND 15 Y</td>
<td>rotary kiln, waste duct</td>
</tr>
<tr>
<td>DS Shot 51 NH 01 X CO</td>
<td>rotary kiln, waste duct</td>
</tr>
<tr>
<td>DS Cast 50 NM</td>
<td>slag hopper</td>
</tr>
<tr>
<td>DS 1000</td>
<td>insulating back layer</td>
</tr>
</tbody>
</table>

Seven Refractories packaging machine
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 NOx 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.

Aggressive applications for fluoride and/or chloride wastes:
DS Cast 98 UR
DS Plast 90 AKR
DS Cast 95 RBB LW
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.
**Services Provided**

- Preliminary study and investigation for the project edition
- Design and architecture, bill of materials, 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
  - Grouting, patching and dry vibrating products
- Supply of mixer, gunning machines, pump, etc.
- Supervision and monitoring by experienced technicians
- Global Research & Development
- Monitoring and targeting of results
- Technical advice from experts

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