



## Industrial Rotary Air Preheaters



Delivering Total Solutions



## Company Profile



Howden Australia  
a Service Provider  
to Heavy Industry  
In Asia Pacific  
and the Pacific Rim

The Howden Group has operated throughout the world for 150 years. With its activities coordinated on a regional and market basis, Howden Australia is the principal unit of the Howden Power division in the Asia-Pacific region and handles heavy to medium air and gas handling products for a range of industries.

The origin of the organisation, James Howden and Co. Ltd, was founded in Scotland in 1854 and grew up along with the steamship industry of Clydeside as a boiler, engine, heat transfer and draught plant supplier. The company's operations expanded over the years to become the major supplier of air and gas handling equipment to the Power Generation, Steel, Alumina, Cement, Mining, Oil and Gas, Paper Mill, Co-Generation Sugar Mill and generally most heavy industries.

Howden is currently the world's leading supplier of air and gas handling equipment and is the world's largest supplier of industrial fans. The company has by far the largest global installed base, and has grown by both internal development and acquisition. Key products from the following well-known air and gas handling companies are now incorporated within the Howden product range:

### Howden Product Range

Aerex Fans	Howden Fans	Stork Fans
Aerodyne Fans	Howden Heaters	Sturtevant Fans
Airtech Fans	Howden Process Compressors	Tallares Sanchez Luengo
American Blower	Howden Sirocco Fans & Heaters	(TSL) Elements
American Standard	James Howden Fans	Turbowerke Meissen Fans
Berry Fans	Joy Fans	Variax Fans
Buffalo Fans	Joy Green Fans	Ventilatoren Fans
Buffalo Forge Fans	Majax Fans	Ventilateurs Neu Fans
Burton Corblin Compressors	Meissen Fans	Voith Fans
Canadian Blower	Neu Fans	Wolf Fans
Carter Fans	Nordisk Fans	Westinghouse Sturtevant
Davidson Fans	Novenco Fans	Wheeler Fans
Donkin Fans	Pitstock Fans	
Donkin Blowers	Phoenix Fans	
Engart Fans	Powermax Fans	
Fantecnic Fans	Sheldon Fans	
Godfrey Blowers	Sirocco Fans	

And many more company  
names and brands.....

The 3,000 global Howden staff members are connected with modern communication systems and have personal contact with tens of thousands of end users and plant operators. Howden has focused specialised services and products, the largest installed base in the world with six generations of global applications experience. The company is a sure provider for any kind of air and gas handling, now and in the future.

R&D and administration of the core technology are entrusted to a number of "Centres of Excellence" in various locations around the world. Engineering of the Howden products for specific customer applications is done mainly on a local or regional basis and manufacture is carried out in the most cost-effective location depending on the installation site.

Howden Group companies have operated in Australia for more than 50 years. In addition to being the supplier of choice in the local market, Howden Australia is the major service provider and product supplier.

### Howden Australia Pty Limited

Howden Australia Pty Limited is the heavy to medium fan, air preheater and acoustic products division of Howden in Asia Pacific and the Pacific Rim with its Head Office in Sydney. Howden Australia offers a comprehensive package that includes customised engineering, project management, manufacture / supply/ service solution engineering and site management service. The Company employs a team of experienced professional mechanical and structural engineers who are fully conversant with modern design techniques including finite element analysis (FEA) and computer aided design (CAD). Specialised facilities are available in both Sydney and Melbourne for full-size and scale aerodynamic model testing. The Company also has equipment for stress, acoustic and vibration measurement. In addition to the above, on-site performance testing of equipment can be conducted to internationally recognised standards using portable equipment.

**Industries:** Power and Boilers; Alumina and Smelters; Steel and Smelters; PetroChemical Industry; Hard Rock and Coal Mining; Cement Production; Paper and Pulp; Co-Generation Sugar mills; Water Treatment; Heavy Industry and Process Plant

# Howden

Howden Australia

Howden Power North America  
US Toll Free Tel + 1 866 213 6237

Tel + 1 803 713 2336  
Tel + 61 2 8844 9100

Fax +1 803 713 2351  
Fax + 61 2 8844 9128





## Equipment Design and Selection:

An important issue when supplying new or retrofit equipment is the ability to assess the needs of the customer so that equipment packages that are best suited to these needs and give maximum cost recovery are offered.

Howden Australia engineers liaise closely with the customer and evaluate sites to obtain data and an in-depth understanding of the process. Using this knowledge together with available information on operating costs, the most cost-effective solutions are developed. In the case of retrofits this often means maximising the use of existing equipment and minimising the extent of new equipment supply.

Howden Australia uses sophisticated computer programs, developed over many years, to select both fans and airheaters. This software makes it possible to quickly examine multiple solutions each with particular merits and thereby select the best equipment for the job. It should be noted that we custom engineer our products for each application and do not compromise performance in the interests of ease of engineering.

Proposal drawings may be prepared and detailed quotations submitted. These can include commercial evaluations for the purpose of purchase justification.

Feasibility studies are also carried out if required.

## Project Capability

Project capability extends from the supply of flange-to-flange items of equipment to complete turn-key installations. In the case of fans this might include silencers, ductwork, main drive motors, electrical switchboards and control panels, instrumentation and condition monitoring, civil works and associated buildings. Howden Australia also engineers and manages major rehabilitation works.

The project management function includes the following:

- **Planning and scheduling of resources and manpower using up-to-date computer techniques.**
- **Engineering, design, and drafting.**
- **Procurement**
- **Negotiation and control of sub-contracts.**
- **Manufacture and supply of equipment. Where appropriate re-work of existing equipment.**
- **Site Management and supervision of erection and commissioning.**

## Engineering

All products supplied by Howden Australia Pty Ltd are fully designed and drafted in our offices in Sydney. A team of highly qualified and experienced professional engineers use the latest computer based methods to ensure that the designs are optimal.

Key customer drawings can be supplied in AutoCADTM or DXF format. If necessary these can be transmitted by e-mail. In the formative stages of the design we encourage interactive information / drawing exchange with the customer to ensure that our equipment is integrated into the overall plant in the best possible way.

## Contract Management:

Contract administration for all contracts is carried out from our Sydney office. Procedures developed specifically to suit the Howden product range are used to optimise efficiency.

A competitive but fair approach is adopted with regard to sub-contractors. Sub-contractors are selected in every case on the basis of their ability to deliver a quality product or service on time and their prices must reflect an efficient operation.

New suppliers of materials and manufacturers of equipment, regardless of location, are checked to ensure they have a suitable quality system in place. Established suppliers with proven quality records are registered on the Howden approved vendor list and their performance is regularly reviewed. Where possible, suppliers and manufactures are selected to maximise the local content. Where the installation is outside Australia, certain critical items over which we require close control would be manufactured in Australia.

## Testing

### (a) Performance Test Facility

In addition to works and site contract fan performance testing of our own equipment, we are able to conduct on-site fan performance evaluation of existing equipment and to advise on any practical action which may be taken to improve the operation of a system. We can also undertake model testing for contract performance and development of fans to suit special applications and requirements within facilities located in Melbourne.

### (b) Flow Model Testing

When considering complex new plant layouts and designs an accurate knowledge of flow distribution and system resistance is important. In certain cases it may be necessary to use flow-modelling methods to determine this information. Our Melbourne laboratory is fully equipped to undertake complete model flow testing and optimisation of duct arrangements, silencer systems, mine shafts, drifts etc.

### (c) Acoustics

On-site investigations and testing: For various reasons – perhaps as a result of plant up-grading and expansion, increased noise may become a problem in air and gas handling systems. We are able to undertake environmental and in-duct investigations on-site and subsequently design absorptive, reactive/dissipative or fully reactive silencers to control noise to acceptable limits. Additionally we can design and supply acoustic insulation systems to limit break-out noise from casing and duct surfaces.

Laboratory investigations: The Melbourne facility has the capability to test full size modules of the largest silencers currently installed in the power industry. These tests can be carried out with flow where necessary, giving aerodynamic characteristics of the silencers as well as dynamic insertion losses at various passage velocities.

### (d) Rotary Air Preheater Testing

Site testing of Rotary Air Preheaters can be carried out to determine the thermal and aerodynamic (pressure drop and leakage) performance with the current operating conditions.



## Company Profile



Our Sydney office has sophisticated computer based engineering programs, which include a complex regenerative heat transfer program for Rotary Air Preheaters. This program has the capability to analyse the heat transfer and gas flow characteristics within a Rotary Air Preheater at full and part loads. The program is also able to calculate the gas analysis and physical properties resulting from the combustion of a wide variety of fuels burnt under different conditions.

Site test information is used to determine the actual operating conditions and performance of the Rotary Air Preheater. When refurbishment is being considered it is often the case that operating conditions or fuels have changed from the original design specification. In these circumstances this information is invaluable and can be used to optimise the heat transfer surface. Using this data the design improvements can be made which will increase the overall efficiency and life of the plant.

### Site Management and Service

Howden Australia has a team of site Service Engineers who all have many years experience supervising the erection, commissioning and maintenance of all the Company's products. These engineers, while based in various locations around Australia are available to travel at short notice to locations anywhere in Asia-Pacific and the Pacific Rim area.

The Service Engineers are equipped with latest technology portable balancing and vibration monitoring equipment. In addition these engineers have laptop computers with general purpose software plus an industry standard scheduling package. The Service Engineers can relay data rapidly to the Sydney Head Office using modems.

Service Engineers have received specialist training in the componentry making up the Howden product. They are also familiar with the safety regulations, which are mandatory in major job sites and generally understand and comply with customer's reporting systems.

Most of our Service Engineers have direct experience managing large job sites both in Australia and in Asia-Pacific and the Pacific Rim region.

### Quality Assurance

Howden Australia operates a third party certified (Standards Australia, Quality Assurance Services) quality assurance system in accordance with ISO 9001:2000 (Licence No. QEC1849).

All quality assurance requirements normally nominated in customer's tender documents can be satisfied, including the supervision of work performed within the Howden Element Rolling Plant and those portions subcontracted out. The QA/QC systems currently in place are well established and supported by detailed records.

### QA System Auditing (Internal/External)

Howden Australia undergoes regular internal and independent third party QA system audits. Internal auditing is based on an annual schedule. Details of sub-contractors are maintained on a vendor database and vendors are required to complete capability questionnaires including details of their quality system development.

### Quality Assurance Support For Contracts

The Howden Australia QA system involves all company employees in an interactive manner. Additional to the dedicated QA/QC staff mentioned above each contract involves sales, contracts, design, manufacturing and administrative staff in a variety of standard procedures (SOPs). These include tender, contract and design reviews and inspections, non-conformance investigation and other activities directly related to each individual contract.

Special processes are detailed on drawings and where appropriate as written procedures. In the case of welding procedures, detailed welding procedures/specifications are prepared and welders qualified. A library of special process welding procedures is maintained.

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# Industrial Rotary Air Preheaters (Heat Exchangers)



## Rotary Air Preheaters

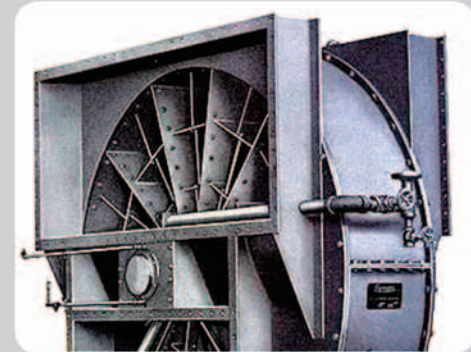
Since the invention of Rotary Air Preheaters, Howden designs, manufactures, installs and services them in all continents. They are custom optimised for the smallest to the largest conventional fossil coal, oil and gas power and steam plants.

Rotary Air Preheaters improve boiler efficiencies by 5 to 10 percent. Rotary Air Preheaters are designed to pre-heat the secondary and/or primary combustion air in exchange of cooling the passing exhaust gasses with the means of passing heat exchange plates called element plates which absorb and release energy.

Rotary Airheaters come in any layout and position to suit any site configuration:



Vertical Bisector Rotary Air Preheater (Secondary Air to Gas)



Horizontal Bisector Rotary Air Preheater

## Rotary Air Preheater Performance

The specification and evaluation of an Air Preheater consists of defining as a whole the performance parameters of thermal efficiency; overall leakage; maintain pressure drop; breakdown ratio; and required maintenance sequence, maintenance time and maintenance effort.

### Thermal Efficiency

The energy (heat transfer) exchange of boiler gases and fresh air by means of element plates of different profiles, materials and thickness that are compressed loaded in baskets (packs) and installed in the slow rotating Air Preheater rotor can be evaluated in efficiency of the heat transfer. Howden uses advanced electronic simulation programs to achieve the most practical efficiency of given design data or in case of major overhaul and upgrade access to actual fuel, ash and inlet conditions. Note: The most efficient and cheapest solution may not be a practical solution. Therefore the additional configurations shown below need to be considered.

### Maintain Pressure Drop:

The Rotary Air Preheater rotor or stator is packed with heating plates (element plates) as dense and close as practical. The air and gas flow and ash passes through with some friction that causes a normal pressure drop, between 1.6 InWG (inch watergauge) to about 6.0 InWG, subject to design configuration. A practical design of total element plate depth and profile combination should be such that the element plates can be cleaned in operation to maintain the designed pressure drop and at the same time maintain the possible lowest practical gas outlet temperature, which provides maximum boiler efficiency. The design is optimised to avoid unacceptable fouling and corrosion rates, that reduce the plant operation reliability and life cycle. Hence the most efficient element profile or depth combination may not be practical for dust, blockage and fouling conditions. In addition copied and wrongly manufactured element plates may be very inefficient or/ and sensitive to blockage and fouling.

High pressure drops cause higher air leakage and higher erosion and corrosion because the gas and air flows pass the lower resistant seal areas. Hence more maintenance, more frequent change of replacement spares and even unpredicted breakdowns are generally experienced.



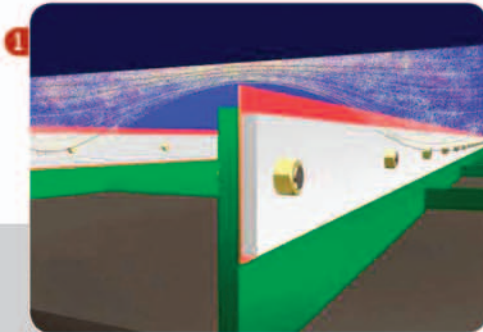
# Industrial Rotary Air Preheaters (Heat Exchangers)

## Modern and Upgraded Air Preheater Designs

### Rotary Air Preheater Seals

Fig: 1

Modern reliable Rotary Air Preheaters are designed with non-contact seals, because any contact sealing system such as the floating seals, brush seals or other contacts seal system is always potential for wear, erosion and corrosion with an early sign of increasing air-leakage, rotor wear and premature breakdowns. We also recommend replacing the non-contact seals (radial-, axial-, circumferential- (bypass), and hub-seals) every 5 years. The cost and effort is minor but ensure renewed sealing, because erosion, corrosion and temporary out of normal operation gas and airflows may leave rubbing marks and thinning.

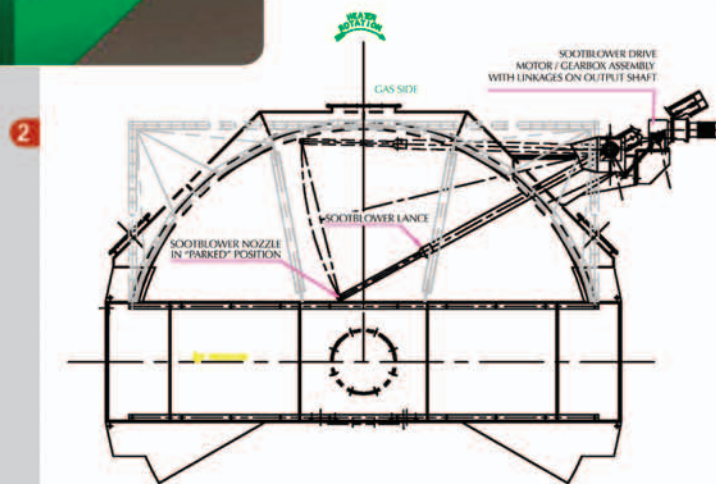


### Sootblowing and Washing

Fig: 2

Most plant operation conditions require frequent on-line cleaning of the element plates (once per shift or day or few days). A practical solution is sootblowing with dry superheat steam (minimum 212 DegF superheat equals to about 572 - 662 DegF deg cel steam temperature at minimum 145 PSI and maximum 174 PSI pressure) or with compressed air of similar pressures. The sootblowing method and mechanical design differs from the more common used boiler sootblowers in the way that the steam/ air has to be blown straight and vertical through the element plate depth of all layers. A single bank nozzle sootblower is far superior to a multi nozzle system, because the sootblow energy can be consolidated and focused deep into the element layers.

Our swing arm soot blower design has been proven to be very reliable and effective.



## Worthwhile Information to Keep

### HORIZONTAL ROTARY AIR PREHEATER ROTOR BALANCING

Rotating machines such as Rotary Air Preheaters have to be safely locked for any kind of routine and non-routine maintenance work. It is essential to work at all times in accordance with the operation and maintenance manual and procedures as well as engaging qualified technical Rotary Air Preheater Supervision.

After ensuring that all elements packs have been installed and have been wedged and welded into position it is necessary for the rotor to be balanced by carrying out the following procedure.

1. Spin the rotor by hand in order to allow the heaviest sector to fall by its own weight to the bottom vertical centre line.
2. Mark top dead centre container, ie the sector of the rotor diametrically opposite the heaviest sector.
3. Check out of balance position by repeating Steps 1 and 2 two or three times.
4. Turn the rotor by hand through 90 degs so that the marked sector is on the horizontal centre line.
5. Lock rotor in this position.
6. Fit a 110 Lbs spring balance between one of the centre section flange bolt holes and an axial seal bolt hole on the rotor shell.
7. Unlock the rotor.
8. The weight shown on the spring balance is then the weight required diametrically opposite the heavy portion to balance the rotor. Weights in the form of flats or plates should be welded on the outside of the rotor shell plates clear of cold element packs. Allowance should be made for the weight of weld when selecting balance weight.
9. Balance rotor to within 5.5 Lbs .
10. Repeat the procedure above and refit spring balance. Check that reading is within the out of balance tolerance.

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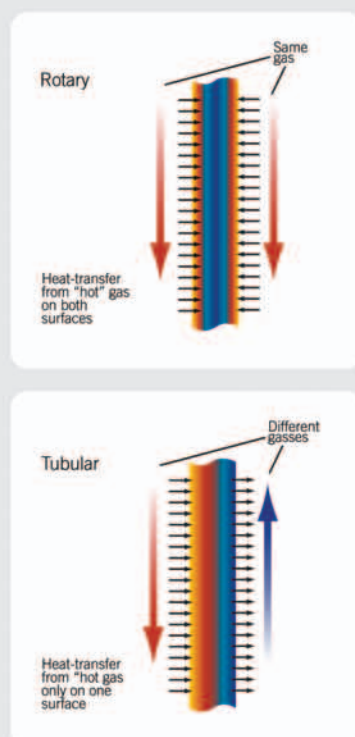
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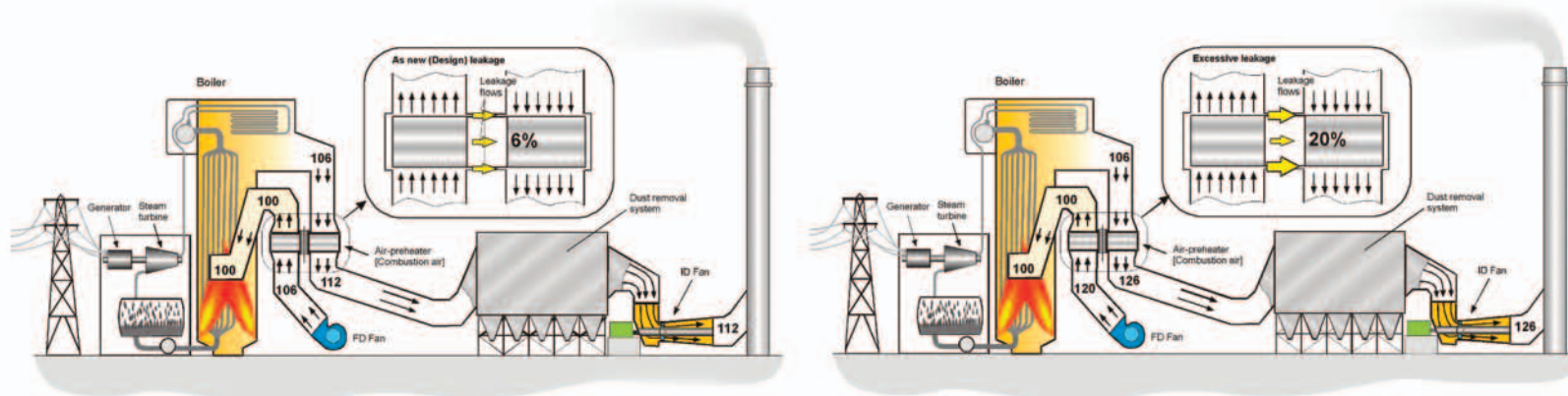




### Selecting a Rotary Air Preheater or a Tubular Air Preheater

Boilers and steam generators are much larger than years gone by. Fuel cost increases and a social request of reducing environmental burdens suggest reducing inefficiency. Tubular Air Preheater is a static equipment which needs to be laid out to higher cold end mean metal temperature to avoid the excessive time consuming and costly corrosion repairs. The Rotary Air Preheater design is very narrow in depth with very effective sootblow or compressed air cleaning features which reduces the corrosion and fouling rate, hence lower mean cold end metal temperatures are manageable which increases the airheater effectiveness—increases the boiler efficiency—consequently reduces fuel consumption and maintenance time and cost. A Rotary Air Preheater in most applications will be very much smaller in size and cheaper to manufacture, install and requires less foundation and support material. The reason for this is simple. With a Rotary Air Preheater (regenerative type), both sides of the heat-transfer plates are used for active heat-transfer (either heat in or out), and the same plates are used in both sides of the Rotary Air Preheater.

With a tubular type, only one side of the tube surface is used for the heat input, with the other side only being used for heat output. This effectively means that a Tubular Air Preheater requires significantly more surface area. Only a limited amount of heat energy can be stored and released through a surface area per time unit. Additional advantages stem from the fact that with a Rotary Air Preheater regenerative type, where the thermal energy is stored within the mass of the heat-transfer plates build up of dust on the surfaces will have a minimal effect on the Rotary Air Preheater thermal performance. This is due to the fact that the dust has mass and will also store thermal energy in much the same way that the metal in the heat-transfer plate will. With a tubular type, however, the heat transfer is by conduction from say the outside of the tube to the inside. That means that the heat transfer will take place through any dust layer before it can flow across the tube wall. In this type of heater the dust will act as an additional resistance to heat-transfer and will reduce the Rotary Air Preheater performance.



### Rotary Air Preheater Leakage Control

Although air to gas leakage cannot be prevented on a Rotary Air Preheater (heat-exchanger), it is important to keep it as low as possible. The main reason is that leakage results in additional fan power. To help understand this, the above diagrams have been prepared. The first shows a simple oil-fired boiler with an FD and ID fan, and a Rotary Air Preheater with 6% leakage. (This is a typical design level for a new Rotary Air Preheater). The diagram shows that for the full output of the boiler 100 mass-flow unit of air are required in the furnace. Because of the leakage from air to gas of 6%, or in this case to 6 mass-flow units, the FD fan has to provide a mass-flow of 106 units. Because fuel is being added and burnt in the furnace the returning

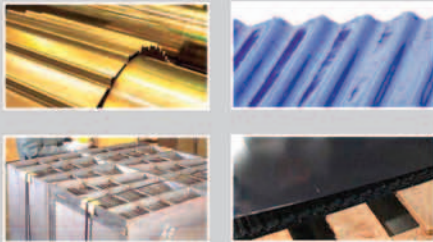
exhaust gas will be a slightly higher mass-flow, in this case 106 units. As the gas passes through the heater a further 6 mass-flow units are added resulting in 112 units entering the duct and eventually the ID fan. If the Rotary Air Preheater leakage is now 20% due say to some degradation of the Rotary Air Preheater sealing system, then to produce 100 mass-flow units of air into the furnace, the FD fan must generate 120 units. In addition the ID fan must handle a mass-flow of 126 units, and increase in mass flow of through the fan of 11%. The fan absorbed power will increase much more than this as the additional volume flow means that the fan will have to generate additional static pressure. In this case, for example the fan absorbed

power could increase by around 30% !!! To achieve the same boiler mass-flow of 100 the FD fan must increase its output by 14 units ...this will in turn result in an additional 15% in absorbed FD fan power.

With large boiler fans, absorbing say 2 MW each, the additional absorbed power in the above case would be around 900kW or 0.9 MW. Based on a cost of 20 US cents per kW hour and on an 8,000 hours per year plant operation, this equates to a staggering cost of \$ 1,440,000 per year. The above case of the leakage increasing to 20% is probably unlikely, however it does highlight the penalty in fan power and cost when the leakage increases.



# Element Plates (Heat Exchanger Plates)



## Element Plates (Heat Exchange Plates)

Rotary Air Preheater dimensions arrive from a practical solution of air, gas and ash input and the wanted output, for which Howden has the unrivalled experience and tools.

Element plate selection/ evaluation has to consider the quantity of layers, the layer depth, profile and layer combination, the material the basket design (container) and the plate material, the Rotor dimension, rotation speed; air-, gas-, ash-contents and pressures and volume.

The best practical solution is one where the outlet temperatures, pressures and velocities can be met and maintained. For obvious reasons to achieve and maintain best boiler efficiency the lowest gas outlet temperature, highest air outlet temperature, lowest pressure drop through the element layers are desired. However there are the limits of hot end fouling (large ash partial lock and block the plate passing) and cold end fouling (insufficient ash being resent in the flue gas to absorb the condensing acid arising from the sulphur in the fuel and/ or due to the high sulphur and moisture in oil or coal fuel in combination with very low combined cold end temperatures).

## Element Plate Material

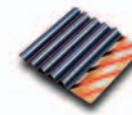
At the non-corrosion layers, mostly hot and upper intermediate layers, a cold rolled mild steel is suitable and less costly. However the cold rolled mild steel material has to be of "drawing" standard or also called "formable steel", which has controlled upper limits of carbon and other hardening elements. The pressing and rolling of a higher efficient element profile generates fast stretching that would crack normal standard carbon mild steel.

For corrosive layers there are several practical useable materials and corrosion protection material available. The most commonly used material is the Low corrosion resistance steel (LCAR). LCAR is essentially a mild steel with a specific additional amount of Copper (Cu) and few other trace elements. However the smelting and processing of LCAR requires additional tooling and care. For that reason there are only few global steel smelters that actually have a licence (approved for continuous LCAR production) to produce and label the finished goods LCAR, a guarantee control.

Howden also designs and manufactures higher alloy element plates of several stainless steel materials.

When operational Rotary Air Preheater corrosion rates and fouling rates are unacceptably high, which reduces the useable operation-life to less than 3 to 4 years due to high fuel sulphur contents above 0.5% and/ or high moisture with high dew points the element plates should be vitreous enamelled. It is a must for most oil fired operations.

The base material is a low carbon steel (or also called decarbonised steel) suitable for vitreous enamelling. The process consists of acid cleaning in eight stages, then ground coating and top coating and then heating up to 1562 to 1742 DegF (subject to specification) for a specific time. The process requires the correct coating materials, called "Frit". Strict control of Acid Resistance (Sulphuric -and Hydrochloric- Acid), Thermal Shock Resistance, Heat Resistance, Adhesion with strict lower and upper coating thickness, extreme low porosity, smooth gloss enamel surface finish and edges are essential requirements.



**Corrugated-Undulated**  
Lower thermal performance  
Easiest to clean



**Double Undulated**  
Medium thermal performance  
Medium to clean



**Flat-Notched-Crossed**  
High thermal performance  
Difficult to clean

## Element Profile (shape)

Over the past 80 years, Howden has developed and tested many hundred element plate profiles and a multitude of layer to profile combinations. Howden has the most advanced and matured practical useable profile range narrowed down to 45 practical profiles, carefully optimised for every type of Rotary Air Preheater (Regenerative Heat Exchanger). The elements range from those with simple 'closed channel' profiles which have a lesser tendency for fouling but reduced heat transfer properties to more complex profiles which are more compact and induce extra

turbulence in the gas flow to improve heat transfer. It should be noticed that a wrong profile certainly reduces performance and/ or efficiency, which we often experience at the site surveys. A wrong profile might not always be an original selection mistake but also includes changed operation conditions (flow, ash and gas contents) and inferior manufacture. The element plate manufacturing requires precise tooling that manages material stretch behaviour of different materials, profile shaping and consistent repetitive production.

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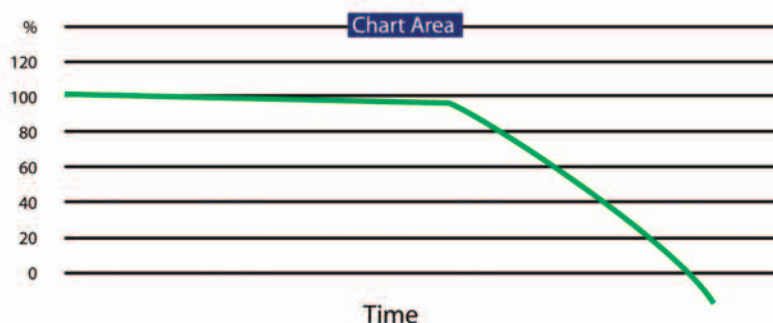
Tel + 1 803 713 2336  
Tel + 61 2 8844 9100

Fax +1 803 713 2351  
Fax + 61 2 8844 9128





### Element Basket Efficiency



### When is it time to replace element baskets?

The attached mechanical evaluation and graph describes the failure process, which becomes evident when visually experienced. Visual evidence indicates that destruction quickly follows the last accelerated phase. However most plants have such limited access that slight visual evidence of material losses should be taken seriously and the opportunity taken at the next outage window to replace the baskets even if there may be some extra operating hours remaining.



### Mechanical Evaluation of Element Baskets:

The element basket consists of a wrapper plate formed to a container, support bars, undulated plates (minor pressed profile) and corrugated plates (major pressed profile). The undulated and corrugated plates are packed and compressed to a specific force into the container to achieve stiffness to resist flow and pressure changes (air to gas pressure differential) in operation.

Hot end and intermediate element baskets, depending on the abrasiveness and volume of ash, can fail mechanically. Cold end element baskets, depending on the aggression of the corrosion attack and material (generally Corten or enamel), can fail earlier. The useable operation life gradually reduces linearly to a point of thinning of material to about 0.3 to 0.4 mm. Thereafter collapse of profile stiffness causes ever increasing accelerated disintegration. Corrosion, blockage and erosion eventually causes total loss of element plates and containers

### The Following damage pattern has usually been experienced:

Firstly the element plates reduce in material thickness. Thereafter the profile loses its structural strength that deforms the plate shape and consequently loosens the original container compression. The loose plates vibrate continuously, due to air and gas passing and sootblowing, which causes fatigue and consequently breakouts of large element plate pieces. The breakout process continuously accelerates which causes more severe vibration to the point of total basket disintegration, which causes baskets blockage of fallen locked-in loose plate pieces and complete looseness of other baskets.

In addition cold end baskets often suffer severe corrosion which causes, besides material thinning, cold spot blockage, fouling and uneven material loss areas. The subsequent uneven flow and heat exchange causes reduced thermal efficiency and high flow volume passing at low-pressure resistant areas and low flow volume passing at high-pressure resistant areas.

Consequently upper element layers and the surrounding rotor housing and seals experience premature accelerated high spot erosion and vibration damage and other upper layer areas suffer from accelerated cold spot corrosion which creeps upwards.

Total loss of cold end element plate material changes the metal temperature with larger hot and cold cycles that changes corrosion conditions of the rotor housing and element plates but also causes unwanted increased cyclic rotor expansion and contraction with accelerated rotor structural fatigue cracking.

In general, boiler operation can adapt gradually to Air Preheater thermal efficiency changes within some limits with the consequence of efficiency reduction. However accelerated hot end damage critically exceeds the limits.

It is obviously economically better to maintain all baskets layers within the mechanical limits, inconsistency changes boiler operation and premature failure of element baskets, seals, rotor housing and drive units.

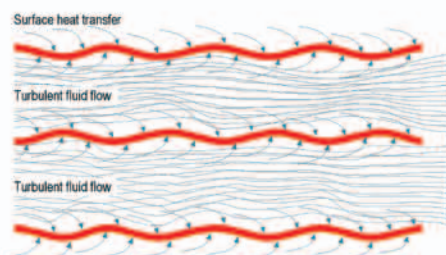


## Element Plates (Heat Exchange Plates)

### Basket (Container)

Packing baskets has two functions. Firstly the vast amount of loose element plates which are needed to achieve efficient heat exchange and fill-up a Rotor/ Stator requires an effective organised method of handling the plates and plate shapes by using tailor-made baskets. Secondly the element plates have to be fixed to prevent movement caused by flow and pressure changes (gas to air pressure differential and duct restrictions flow changes), which would otherwise cause fatigue cracking of singular plates and soon after completely destroy entire basket sections.

This requires consistent manufacture discipline to achieve maximum basket compression without deforming the element plate profile and without damaging the material and coating. Furthermore baskets have to fit in the rotor/ stator cells (compartments) to specific side and wall clearances. Rotor / stator cells are in the first instance manufactured to an upper and lower tolerance, but also years of operation change and deform the cell size. When clearance is too small this causes major time consuming installation problems and installation damage. Some basket designs require a minimum clearance to create plate end turbulence that marginally improves efficiency. Basket (Container) designs are as multiple as the creativity of Rotary Air Preheater designers. However baskets (containers) should not restrict flow, flow direction and unnecessarily reduce net heating surface area. However the basket has to be stable enough to hold the element plates under compressed fix tension for all the operating life.



### Element Plates Manufacturing

Strict manufacturing tooling and control of our Howden designed, tested and proven element plates (heat exchange plates) are essential to maintain optimum operations performance and reliability.

To restate—the Rotary Air Preheater works by allowing hot gas to pass through a matrix, composed of multiple metal plates or vitreous enamel protected metal plates known as element plates (heat exchange plates). The hot gas, which is normally at around 662 DegF, passes the surface of the metallic element plates, at high velocity, raising the metal temperature very rapidly. As the rotor turns slowly, normally at around 1 revolution per minute, the heated element plates are transferred into the airside. Here cold air flows at high velocity between the spaces formed by the element plates, extracting significant amounts of heat and raising the air temperature to around 572 DegF.

The vast quantity of heat transfer element plates are of a specific manufactured form, which promotes the passage of heat in and out of the plates and allows the Rotary Air Preheater to operate to its optimum. Obviously, correct manufactured element plates is essential in addition to choosing the appropriate designed profile (shape).

# Howden

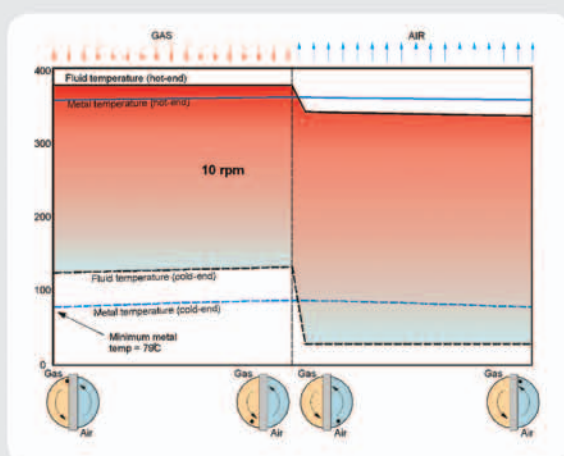
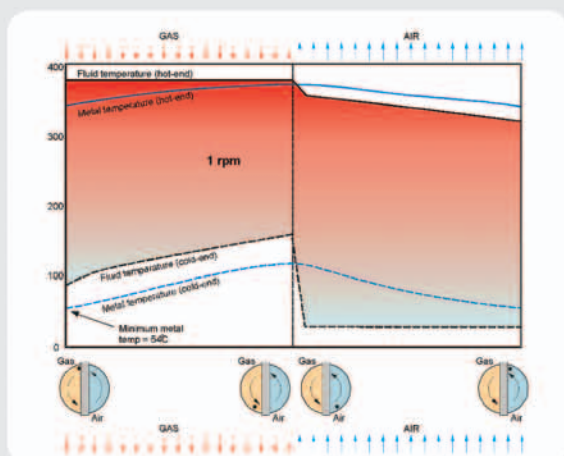
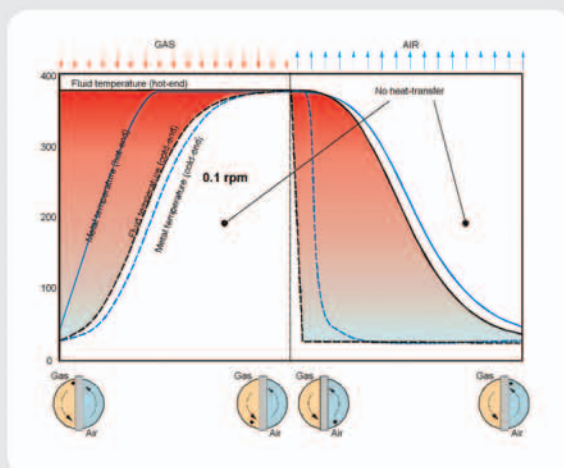
Howden Australia

Howden Power North America  
US Toll Free Tel + 1 866 213 6237

Tel + 1 803 713 2336  
Tel + 61 2 8844 9100

Fax +1 803 713 2351  
Fax + 61 2 8844 9128





### Rotary Air Preheater Speed Change

With a well designed Rotary Air Preheater, speeding up the rotor makes little or no difference to the total heat-transfer from the gas to the air. It is better to have as slow a speed as possible to reduce the entrained leakage to an absolute minimum. Entrained air to gas leakage is that quantity of air which is trapped within the rotor as it passes from the gas to the air side. Increasing the speed increases this leakage and can significantly affect the overall heater air to gas leakage level.

To get a better understanding how rotor speed influences the heat-transfer performance of a size 27 bi-sector Rotary Air Preheater, let's look at some simple graphs of temperature.

The diagrams show plots of temperature for points on the edge of the element plates. One area is at the hot end, and the other at the cold end. In this way we can look at the two extreme cases and see what happens.

The first diagram shows what happens if the Rotary Air Preheater rotor is turning too slowly at 0.1 rpm. (this is around a tenth of the "normal" rotor speed). Here we can see not only dramatic changes in the gas out and air out temperatures, but for a significant part of the rotation, no heat-transfer is actually taking place. In this case, as the elements leave the gas side, the maximum heat in the elements is extracted in the air-side well before they have had a chance to return to the gas-side.

In the second diagram the rotor is now turning at 1 rpm. Here we can see the dramatic improvement in the heater's performance with significant heat-transfer occurring in our "spots" at all positions of the rotor. You can also see the variation that occurs in the "spot" region element metal temperature during a complete revolution. At the cold end of the minimum metal temperature is 54°C (129 Deg F), which is well below the acid dew point and approaching the water dew point. The temperature quickly increases, however, as the rotor moves reaching a maximum at 118°C (244 Deg F). This is well above the water dew-point but still below the acid dew-point.

If we now speed the heater rotor up to 10 rpm., a speed well in excess of the "norm", we can see the effect on the various temperatures. The first thing to note is that the thermal performance of the Rotary Air Preheater is hardly changed. So what has changed? Well, the main change, which can be seen from the third diagram, "10 rpm" is that the variation in fluid and metal temperature, as the "point" moves round, is much more uniform. In addition the minimum metal temperature of the elements at the cold end has now increased from 54°C (129 Deg F) to 124°C (255 Deg F). One major disadvantage is that the entrained leakage, that is that part of the air, or gas, trapped within the rotor as it passes from one side of the heater to the other, has dramatically increased by 8 times, pushing the overall air to gas leakage, from 5% to 15%.

Rotational speed, for optimum heater performance, is normally between 1 to 2 rpm., with no real benefit occurring if speed is increased any further.



#### Howden Australia

Unit 23, 38 - 46 South Street  
Rydalmere-Sydney NSW 2116  
Australia  
Tel. +61 2 8844 9100  
Fax +61 2 8844 9101  
US Toll Free +1 866 213 6237  
email: [solutions@howden.com.au](mailto:solutions@howden.com.au)

[www.howden.com.au](http://www.howden.com.au)

#### Howden Power North America

2029 W. DeKalb Street  
Camden, SC 29020  
USA  
Tel. +1 803 713 2336  
Fax +1 803 713 2351  
email: [solutions@howden.com](mailto:solutions@howden.com)

[www.howdenpower.com](http://www.howdenpower.com)

