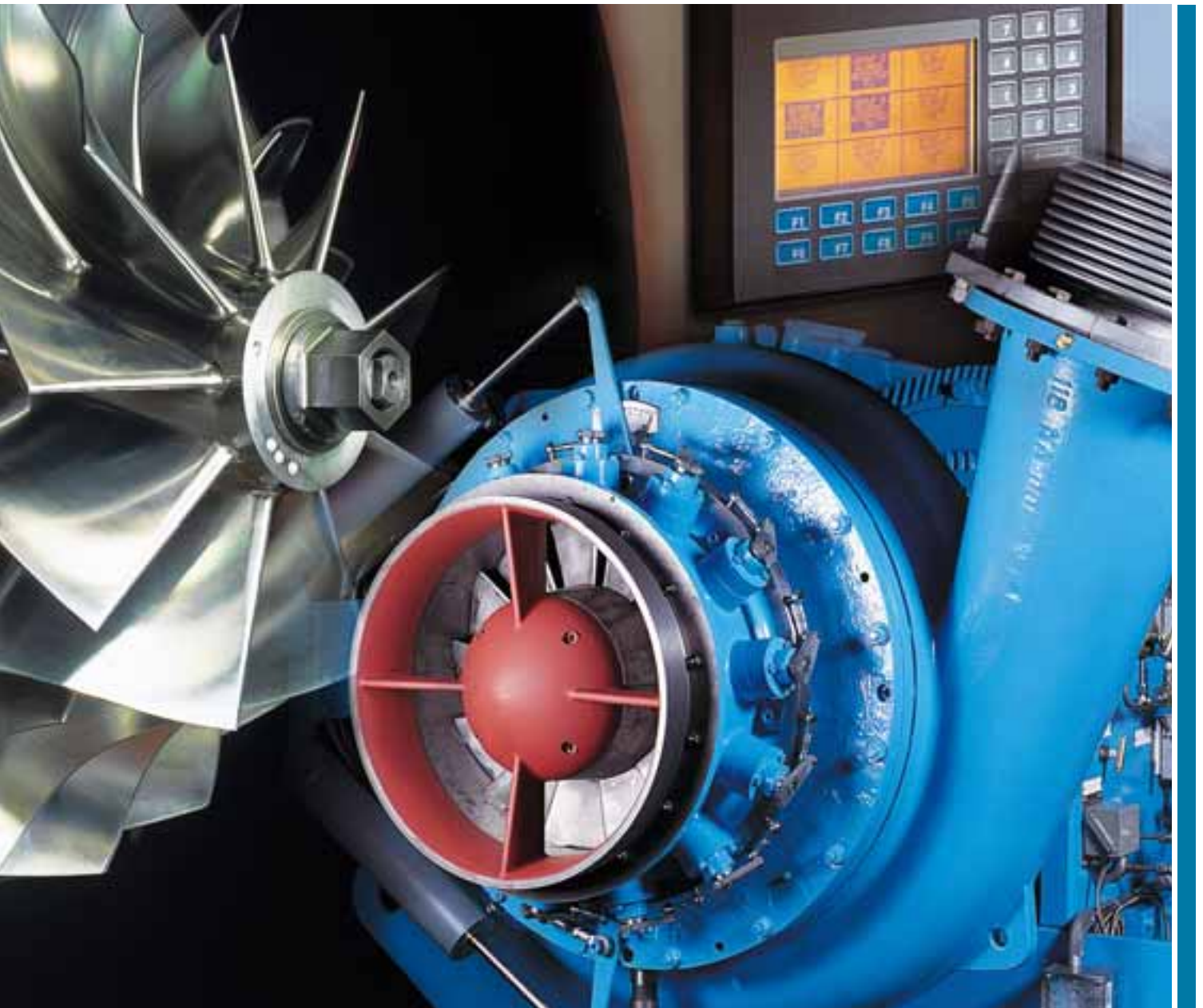


HIGH PERFORMANCE DONKIN CENTRIFUGAL TURBO COMPRESSOR SYSTEMS

HOWDEN PROCESS COMPRESSORS



DESIGN AND MANUFACTURING GLOBAL SOLUTIONS FOR AIR AND GAS HANDLING

Howden, the world's largest and longest established fan and compressor manufacturer provides solutions for the air and gas handling needs of clients. James Howden, a pioneering Scots engineer, founded the company in Glasgow in 1854. Today the Group has subsidiaries in five continents and more than 15 countries worldwide.

Howden Process Compressors is the organisation within Howden that designs and manufactures various types of blowers and screw compressor packages. Bryan Donkin, one of the longest established designers of rotary blowers and compressors with a history extending back to 1856, was integrated into Howden Process Compressors in 1997. A centre of excellence encompassing all these compression technologies was developed at our manufacturing site in Scotland. Design, application engineering, manufacturing, testing and after sales support are available for the full range of compression products offered by the company.

THE HOWDEN PEDIGREE

Howden, Bryan Donkin, Sirocco, Reavell, Davidson, Neu, Sofrair and Berry – all renowned worldwide for their technical expertise in the design and manufacture of fans and blowers – combined to provide an enviable resource of experience for customer confidence.

Combining more than 150 years experience in the utility, process gas, petrochemical and many other industries, we are uniquely placed to offer customers an individually engineered compression solution to suit their particular application and individual requirement.

WORLDWIDE COVERAGE GUARANTEED

Worldwide Cover is achieved via Howden's comprehensive network of regional facilities, and a network of technically qualified regional managers.

A thorough review of process requirements by qualified project and applications personnel ensures that the most cost effective and energy efficient design proposal is submitted to the customer, whether for a centrifugal blower or a full process compression package installation.

The Howden Donkin range of integrally geared, high efficiency turbo compressors has been developed, over 40 years, for use in a broad range of process applications worldwide.

Product integrity, long operational life and maximum efficiency of compression are the main focus of design.



Howden Process Compressors' total commitment to quality covers all aspects of design, manufacturing, testing and servicing.

All machines bear the European Standard's C.E. mark (when supplied within the European Union).

Our quality systems have been assessed/approved by a third party to ISO 9001:2000, ensuring consistent quality throughout all aspects of the design and manufacture.



MARKETS AND APPLICATIONS

SULPHUR RECOVERY

- Air blowers providing reaction air for the catalytic recovery of sulphur within the petrochemical industry.

SULPHURIC ACID PLANT

- Combustion air blowers and process gas mixture cleaning, sometimes combined.

FLUE GAS DESULPHURISATION

- Oxidation air blowers associated with the cleaning of flue gases produced within power and heavy industry.

INDUSTRIAL EFFLUENT TREATMENT

- Aeration blowers associated with the biological treatment of effluent within industrial plants.

FURNACE/SMELTER/REACTOR AIR SUPPLY

- Air blowers providing combustion or reaction air primarily for the petrochemical and metals industries.

PROCESS GAS BLOWERS

- Blowers handling a wide range of process gases for the petrochem and heavy industry.

FUEL GAS BLOWERS

- Blowers handling natural and 'dirty' coke-oven, manufactured, landfill and other bio gases. (landfill extraction)

CARBON BLACK PLANT

- Air blowers providing combustion air for the associated furnaces.

WASTE WATER TREATMENT

- Aeration blowers associated with the biological treatment of effluent in municipal sewage treatment plants.

FERMENTATION

- Air blowers associated with biochemical fermentation within pharmaceutical and yeast production industry.

FEATURES

- Continuous operation/critical service
- Maximum reliability
- Ease of maintenance
- Skid mounted with integral lubrication
- Variable flow by means of variable vane diffusers, pre-rotational inlet guide vanes or a combination of both systems
- Wide flow range, available to below 45% of design flow
- Highest efficiency levels over entire operating range
- Steep pressure/volume curve to give inherent stability and protection against surge
- Horizontally split gearbox for ease of maintenance and inspection
- Well proven long working life. (Machines 30 years old still operational)
- Two stage labyrinth or carbon ring sealing to give guaranteed oil free process gas delivery
- Compact packaged unit, factory assembled on underbed to minimise installation time
- Capacity up to 250,000 m³/hr
- Pressure up to 5 Bar A.

COMPRESSOR SPECIFICATIONS – SINGLE STAGE TURBO COMPRESSORS, PROVEN RELIABILITY



Impeller: Induced backward curved vane impeller

The Howden Donkin range of single stage turbo compressors provide proven reliability developed over 40 years. The integration of overhung high efficiency impeller, precision gears and high stability bearings results in smooth, minimum power loss transmission. Pressurised oil lubrication with high integrity protection systems ensures maximum reliability and hence availability of equipment.

IMPELLER

- Fully machined from solid aluminium forging (ASTM B2471) by multi axis computerised machining centre.
- Also available in nickel-chrome corrosion resisting steel.
- Induced backward curve or radial profile.
- Retained on high speed shaft by a central bolt.
- Subjected to ultrasonic test before final machining.
- Dynamically balanced to ISO 1940 Specification.
- Overspeed tested to a minimum 115% of operating speed.

GEARBOX

- Gearcase in cast iron grade 250 to BS 1452 (ASTM A48-83-35B).
- Horizontally split for ease of maintenance.
- Single helical speed increasing type.
- Shafts and gearwheel are fully machined from carbon steel forgings.
- Gearing is to AGMA Quality 11 to 13 as required.
- All gears have ground tooth profile.
- AGMA service factor of 1.4 minimum.
- API optional.



Split Gearbox: Horizontally split gearbox provides easy access to gears and bearings



Protection Devices:
Optional API lubrication system

PRESSURE LUBRICATION SYSTEM

Integrated lubrication system to provide a safe and reliable oil supply.

- Baseplate acts as oil reservoir.
- Main oil pump is mechanically driven from low speed shaft, sized to provide satisfactory oil supply throughout run down period.
- Electrically driven auxiliary oil priming pump, complete with T.E.F.C. motor, used to prime the system before start-up and act as a standby unit in emergency and during shutdown.
- Oil cooler of the water cooled shell and tube type or air blast type.
- Simplex oil filter, (Duplex optional).
- Differential pressure indicator across filter.
- Immersion heater and thermostat.
- Oil temperature control valve.
- API optional.

CASINGS

- In cast iron grade 250 to BS 1452 (ASTM A48-83-35B).

SHAFT SEALS

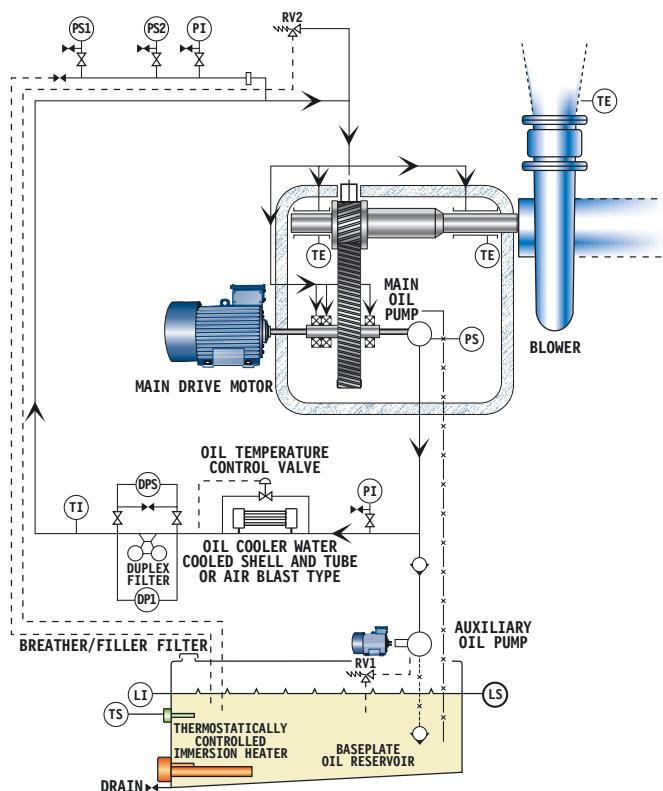
- Double labyrinth type with air vent to atmosphere to guarantee oil free air discharge from the blower.

BEARINGS

- Low speed bearings are of the anti-friction type, or Taperland Journal type if specified or required due to loading.
- High speed bearings are of the tilting pad journal type, to give almost vibration free operation at high speed.
- Axial loading is absorbed by thrust rings at periphery of lower speed gear wheel transferred from high speed shaft via thrust collars to minimise power loss.
- All bearings are oil lubricated from the integral pressure oil lubrication system.
- All bearings are easily accessible by removal of the top half gearbox casing.

INSTRUMENTATION & PROTECTION DEVICES

- Oil pressure indicator at bearing supply manifold.
- Lube oil temperature after cooler monitoring.
- High speed shaft journal bearing temperature monitoring.
- Process air temperature monitoring.
- Lube oil pressure low (acts as both alarm and also re-starts auxiliary oil pump in the event of falling oil pressure).
- Lube oil pressure low trip.
- Oil reservoir temperature low switch (inhibits blower operation with oil temperature below 20°C).
- Additional instrumentation can be provided as required.
- All alarm/trip/indication functions are displayed at the local control panel (pages 8 & 9).
- API optional.



Pressure Lubrication Schematic

NOTE: To suit the individual applications, various materials of construction are available to ensure maximum resistance to corrosion, abrasion and high temperature.

CONTROL SYSTEMS – MAXIMISING OPERATING EFFICIENCY



TYPES OF CONTROL SYSTEM AVAILABLE:

Variable Outlet Vane Diffuser (VVD)

Pre-rotational Inlet Guide Vane Control (IGV)

Combined Inlet & Outlet Control (CVC)

Howden Donkin control systems maximise operating efficiency and provide infinitely variable capacities over a wide duty range. Fully automatic capacity control is achieved from a single input signal, processed and relayed to the electric, pneumatic or hydraulic guide vane actuators. Constant speed drive motors are retained to ensure maximum reliability.

COMBINED CONTROL (CVC)

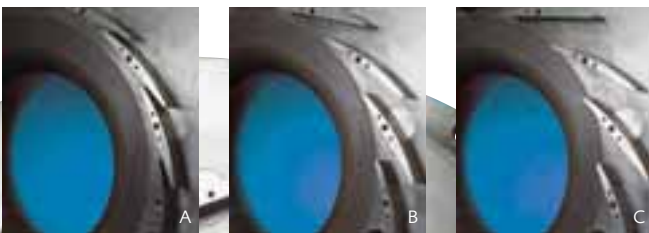
The Howden Donkin combined vane control (CVC) features:-

- Enhances the advantages of both the variable vane diffuser and inlet guide vanes.
- Maintains high design efficiency over a wider range air flow and ambient temperature range than either of the individual control systems.

INLET GUIDE VANE CONTROL (IGV)

- Inlet guide vane control assembly is fitted to the blower to enhance efficient capacity control whilst retaining the simple constant speed motor.
- Guide vanes are manufactured from AISI 316 stainless steel and equally spaced radially about the bore of the inlet branch, to pre-rotate the air before entering the impeller.
- Guide vanes are supported in self lubricated bearing sleeves, provided with an "O" ring seal at the vane shoulder to isolate linkage from the flow medium.
- Actuation is by a single spindle, via non-lubricated linkage system.
- Electric servo motor actuator fitted for modulating control. (Pneumatic actuators can be provided).

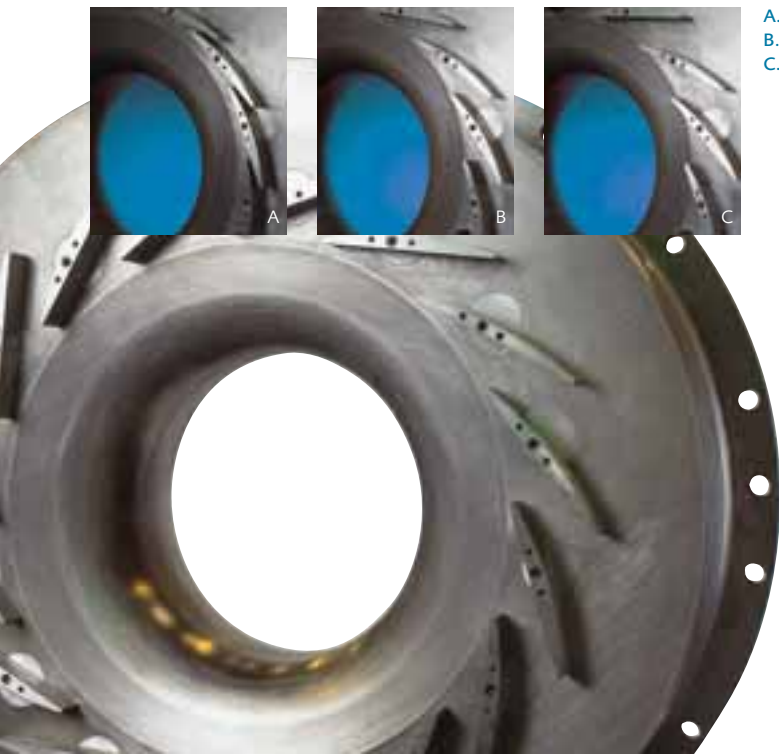
VARIABLE VANE DIFFUSER ASSEMBLY




- A. VVD closed
- B. VVD partially open
- C. VVD fully open

VARIABLE DIFFUSERS FOR FLOW CONTROL (VVD)

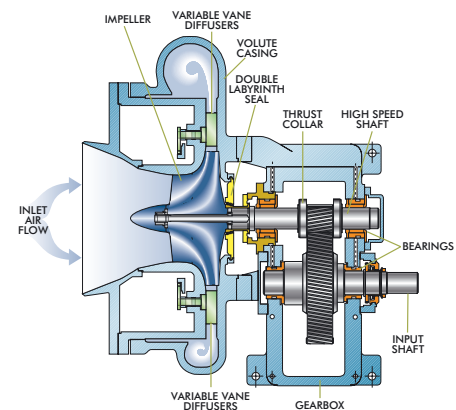
- Diffuser vane control assemblies are incorporated within the blower to achieve efficient capacity control whilst retaining the simple constant speed motor.
- Aerofoil vanes are manufactured from AISI 316 stainless steel.
- Actuation is by a single spindle, via a non-lubricated linkage system.
- Electric servo motor actuator fitted for modulating control. (Pneumatic actuators can be provided).



PERFORMANCE CURVES

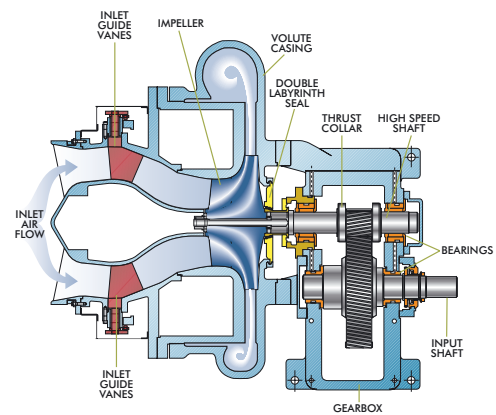
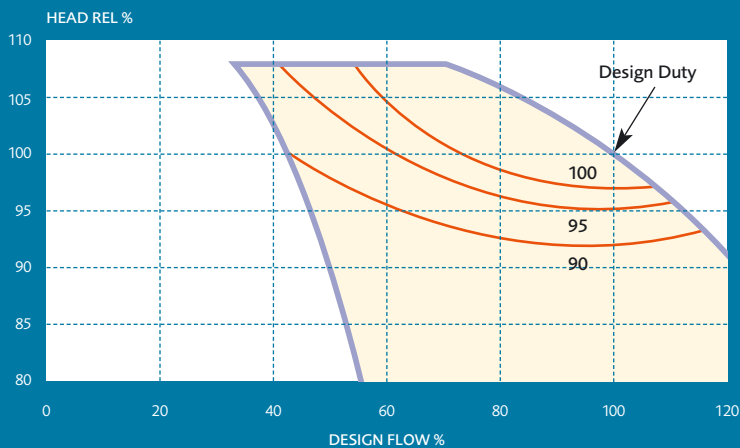
The performance curves below show lines of constant blower actual efficiency relative to design efficiency () throughout flow range and isentropic head range.

PERFORMANCE CURVES



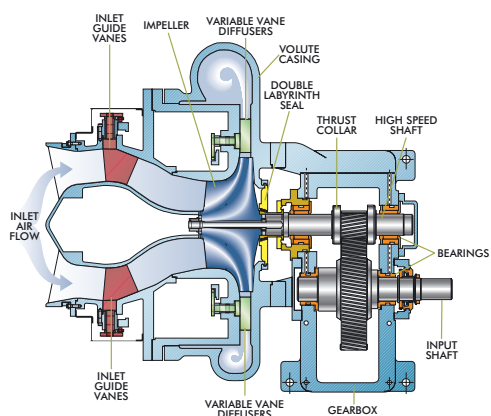
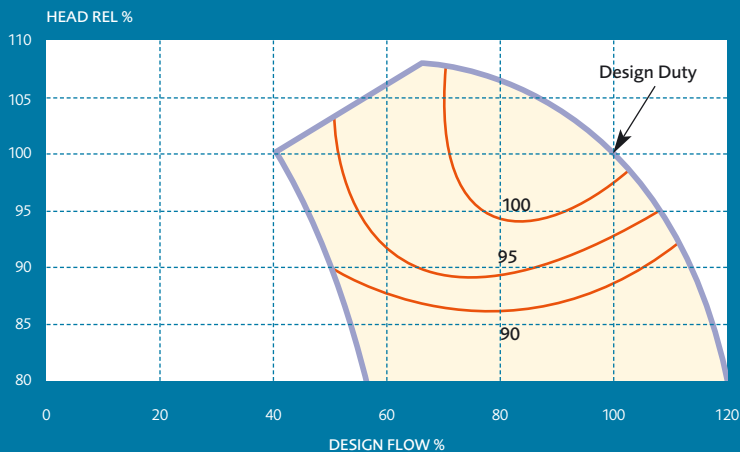
VVD Control

VVD: VARIABLE VANE DIFFUSER CONTROL



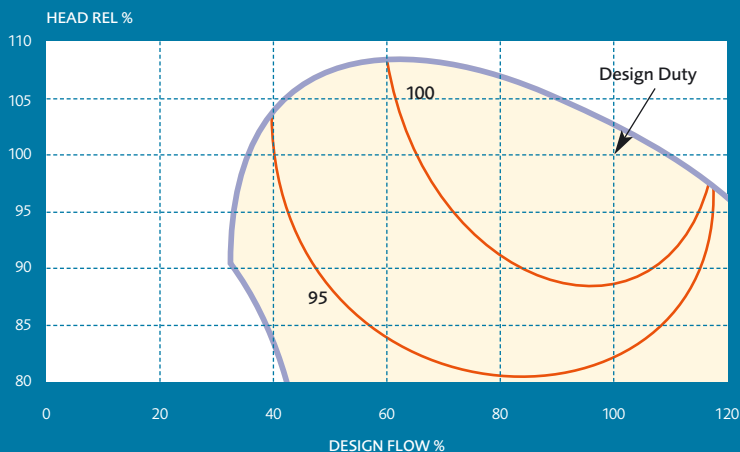
IGV Control

IGV: INLET GUIDE VANE CONTROL



CVC Control

CVC: COMBINED VANE CONTROL





LOCAL CONTROL PANEL WITH FULLY AUTOMATIC SEQUENCING

Howden Donkin local control panels are designed by our experienced team of electrical engineers specifically to provide fully automatic sequencing of start up/shut down cycles, together with the monitoring of all blower safety systems.

STANDARD FEATURES

- Base plate mounted with all on base plate items fully wired/piped up;
or
Mounted off base plate - with all items wired to the terminal box at the blower base plate. Wiring from the terminal box to the panel would be done by a third party on-site.
- Control carried out by PLC, interfaced with the operator interface on the front of the panel.
- The operator interface is a combined data entry and display station, comprising a LCD screen and a membrane keypad.
- Local control panel houses contactors, fuses, overloads and interface terminals necessary for the effective safe control of the compressor and auxiliary drives only.

Each local control panel is individually factory tested prior to delivery.

Systems may be designed to accommodate individual customer needs if required.

All control panels comply with European Union (EU) machinery directive.

Control panel illustrations and descriptions are typical only.

TYPICAL DISPLAYS ON THE GRAPHIC SCREEN



AUTOMATIC START SEQUENCE

Before the compressor can start up, the local control panel (LCP) ensures that:-

- IGV/VVD are fully CLOSED to ensure and minimise load start-up condition;
- blow-off valve (BOV) is OPEN;
- outlet check valve is CLOSED;
- cooling water is FLOWING or air blast oil cooler fan is RUNNING;
- acoustic enclosure ventilation fan is RUNNING (if enclosure is to be supplied);
- inlet isolating valve is OPEN (if fitted);
- outlet isolating valve is CLOSED (if fitted);
- bearing temperature is ok;
- outlet air temperature is ok;
- oil temperature in reservoir is 20°C minimum.

When all these interlocks are satisfied, the compressor start signal starts the electrically driven auxiliary oil pump. This pump pressurises the lubrication system and, when this pressure has been maintained for a pre-determined length of time, the LCP signals the main compressor drive motor to start. At this point, the mechanically driven oil pump begins to deliver oil and, after a pre-determined time just in excess of the main motor run-up time, the electrically driven pump is shut down and reverts to standby duty. The compressor then comes under the influence of the process control signal, and is delivering air to process.

VIBRATION MONITORING

All Howden Donkin compressors are dynamically balanced within ISO 1940 levels. Vibration monitoring takes several forms:-

- a) A simple switch to detect total machine vibration which STOPS the blower.
- b) One or two non-contacting probes at each high speed bearing with the option of axial displacement monitoring also.

The graphic display in the LCP gives ALARM, TRIP and INDICATION functions. This system detects a trend of increasing vibration levels and can also be used as a preventative maintenance system.

OTHER SAFETY SYSTEMS

Surge

Howden Donkin compressors are designed with a steep pressure/volume characteristic between DESIGN point and SURGE point. This gives an in-built protection against a surge condition, whilst still keeping the compressor running and supplying air to process.

A serious SURGE condition can be dealt with in several ways:-

- a) on detecting a SURGE condition - STOP the blower;
- b) on detecting a SURGE condition - OPEN FULLY the blow-off valve;
- c) PREVENT A SURGE condition use a flow/pressure sensing system to a modulating blow-off valve.

AUTOMATIC STOP SEQUENCE

The compressor stop sequence can be initiated either:-

- a) under normal conditions where the air demand is falling;
- b) falling oil pressure;
- c) under other emergency conditions, where a serious fault arises.

Under normal conditions, the auxiliary oil pump re-starts if oil pressure falls to a pre-set value. On compressor reaching STOP, the LCP powers all positional devices listed left to the correct position in readiness for the next start-up.

On falling oil pressure, the auxiliary oil pump re-starts and initiates ALARM in the graphic display in the LCP. If oil pressure continues to fall, the machine SHUTS DOWN.

Under other EMERGENCY conditions causing shut down, the above oil pump sequencing is repeated. Whichever fault initiated the STOP condition, the graphic display in the LCP gives the 'first up' indication of the fault to identify exactly and clearly the cause of the STOP condition.

Fully automatic sequencing control panel



MASTER CONTROL SYSTEMS

FIG 1: OUTLET PRESSURE CONTROL

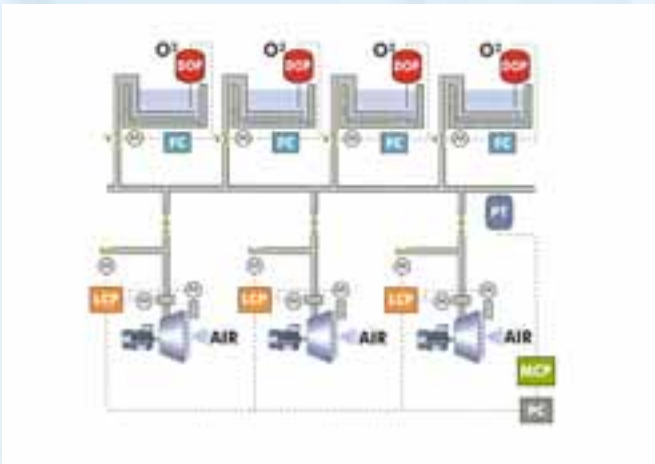
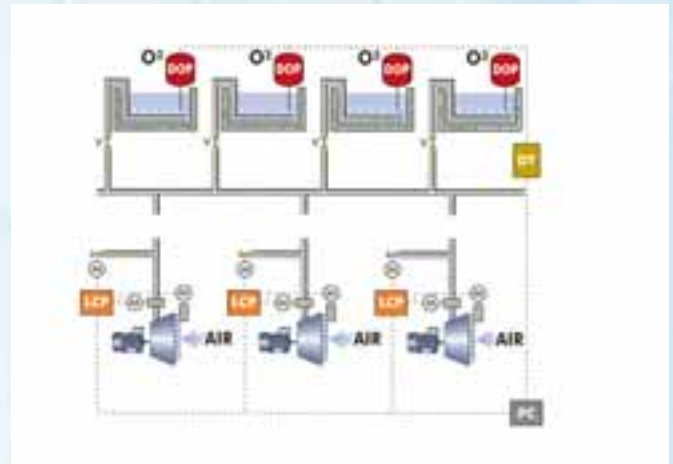


FIG 2: FLOW CONTROL



The Howden Donkin master control systems provide fully automatic control of a multi-blower installation from a single process variable. Overall plant efficiency is maximised with the Howden Donkin 'load sharing system' control philosophy.

The Howden Donkin master control systems are designed to control automatically, multiple blower installations from a SINGLE process control signal and to:-

- a) Allow the minimum number of operating blowers to satisfy demand for air.
- b) Share the total load equally between the number of operational blowers to:-
 - achieve maximum overall efficiency;
 - ensure all blowers have equal operating times and loads.

Alternatively the local control panel can be configured to provide a masterless control system.

MASTER CONTROLS

Two basic master control systems are in use:-

Outlet pressure control (Fig.1)

The pressure is kept constant in the discharge manifold. Air is supplied through CONTROL VALVES (V), which are controlled by the process control system.

Pressure transmitter (PT) measures the supply pressure to valves (V) and sends a 4-20 m.a. signal to the PROCESS CONTROLLER (PC) within the MASTER CONTROL SYSTEM. This CONTROLLER output signal then adjusts the compressor control systems and also decides when individual compressors should be started or stopped.

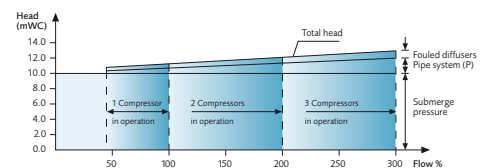
Process/flow control (Fig.2)

A direct FLOW CONTROL system is used in sewage treatment aeration systems. As the quantity and quality of effluent into the secondary aeration zones varies, there is a need to vary the air flow to achieve the desired final water discharge quality. The signals from dissolved oxygen probes are taken to transmitter (DT) which gives a 4-20 m.a signal

proportional to the dissolved oxygen content in the water – this signal is fed to a process control algorithm incorporated into the master control PLC.

This signal is compared with the set point of the PC (manual or remotely adjustable) and any resultant deviation signal is fed to the master control system algorithm. In turn this signal adjusts the position of the control system of individual blowers and ultimately stops/starts blowers as dictated by the DT output signal.

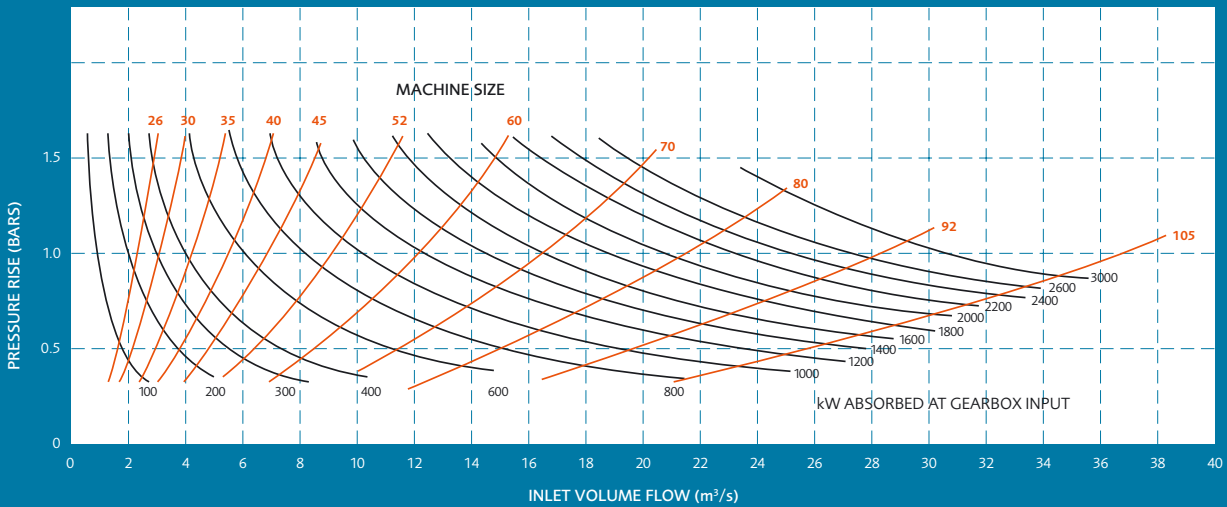
TYPICAL MULTI BLOWER FLOW: Pressure system (Fig.3)



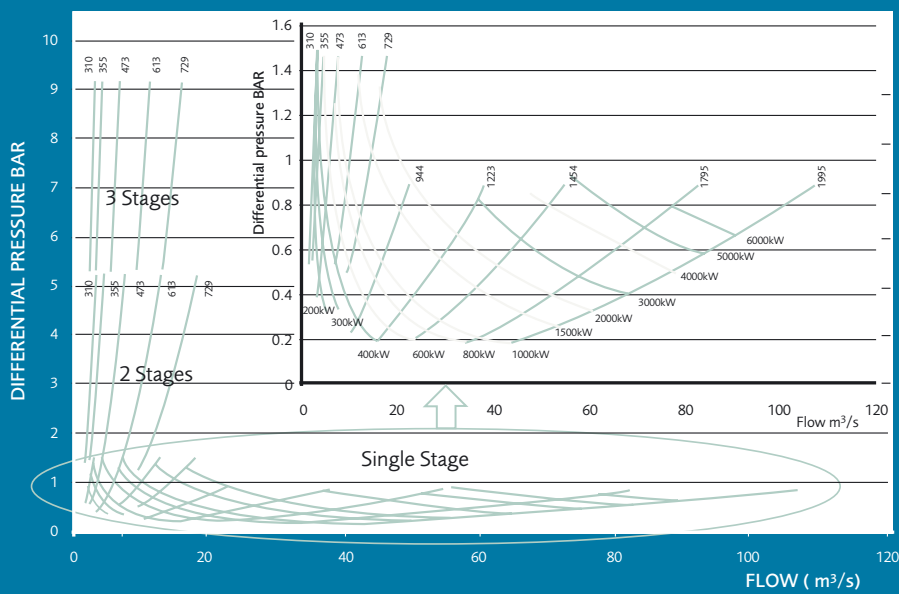
NOTE: The pressure loss (P in Fig. 3) through the pipework between blowers and varies with air flow rate. The HOWDEN DONKIN MCP adjusts, AUTOMATICALLY, the outlet pressure set point to MINIMISE OUTLET PRESSURE and, therefore, MINIMISE POWER ABSORBED.

COMPRESSOR RANGES

HOWDEN DONKIN 'SG' RANGE OF CENTRIFUGAL AIR BLOWERS



COMPLETE HOWDEN DONKIN TURBO COMPRESSOR RANGE

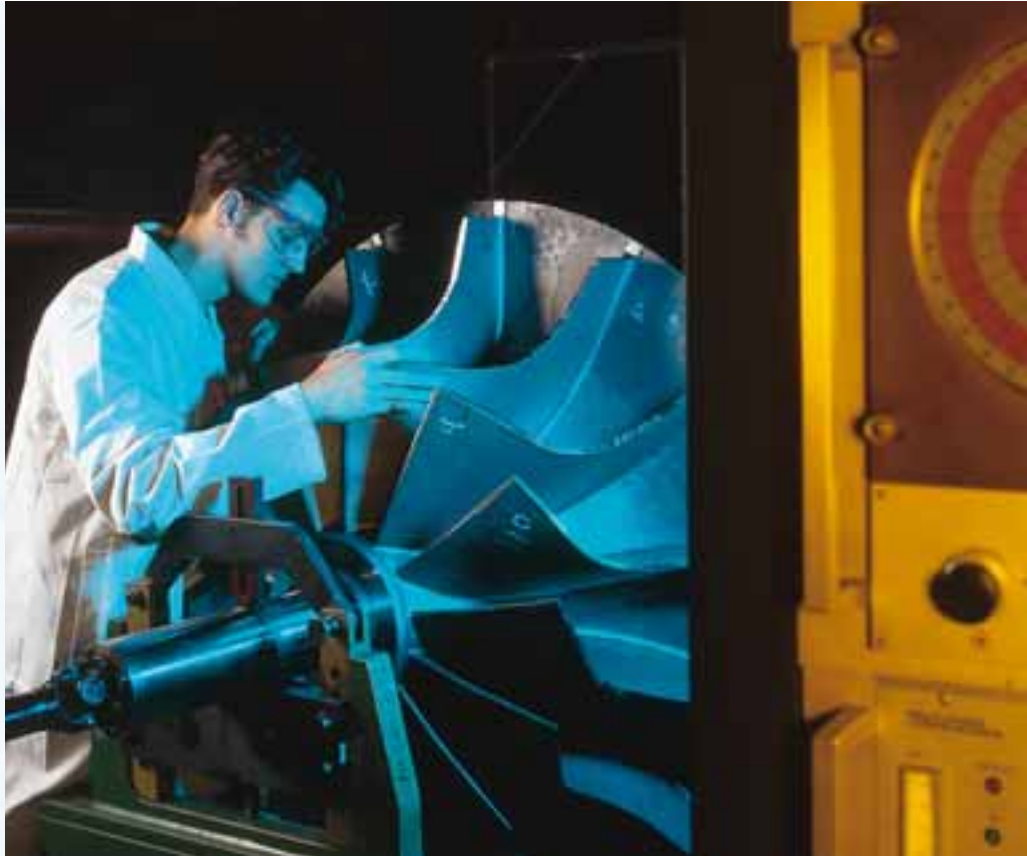


NOTE: Charts for use with inlet air density of 1.2 Kg/m³ (dry air at 15°C and 1 atmosphere pressure).
For duties not covered by this chart please contact Howden Process Compressors.

TOTAL QUALITY COMMITMENT— DESIGN, MANUFACTURING, TESTING AND SERVICING

Howden Process Compressors' total commitment to quality covers all aspects of design, manufacturing, testing and servicing. We regularly work to the requirements of all the major worldwide specifying authorities. All machines bear the European Standard CE mark (when supplied within the European Union). Howden Process Compressors quality systems are audited by Lloyds Register to ISO 9001, ensuring consistent high quality of design and manufacture.

Dynamic balancing of impeller



RESEARCH AND DEVELOPMENT

Howden Process Compressors' commitment to engineering excellence begins with research and development. Many factors influence our customers' requirements. We respond to their changing needs through a continuing programme of product development, using new techniques, materials and manufacturing processes that lead to continuous improvements for resistance to corrosion, abrasion and high temperature, combined with the high speeds encountered on turbo compressors.

SYSTEM DESIGN

Using the latest CAD technology, customised packaged sets are designed to comply with the requirements of international standards such as API, ASME (VIII DIV1), BS, DIN, GOST, AD. Drawings and manuals can be provided in electronic format to facilitate incorporation with total project documentation.



Coupling alignment: Laser alignment of gearbox and motor shafts

CONTRACT MANAGEMENT

Professional contract management has earned us the reputation for on-time delivery. A senior contract engineer is assigned to each project and is responsible for co-ordinating and submitting all required documentation, liaising with the client and closely monitoring progress through to site installation and commissioning. This ensures maximum attention to detail with the greatest flexibility to meet with changing specifications and satisfy individual customer needs.

MANUFACTURING COMPLIANCE

All equipment is manufactured with a view to minimising noise level and surface temperatures, in line with the EU requirements. Due to the nature and individuality of the equipment to meet process requirements, it is not possible to specify noise levels and surface temperatures in a broadly based brochure such as this. In certain circumstances EU guidelines may be exceeded and additional protection required.

TEST FACILITY

Howden Process Compressors' test facility ensures that each compressor is tested rigorously before despatch.

Testing procedures available include:-

Mechanical no-load test

Standard as part of the Howden Process Compressors programme.

String test

Optional. To prove all instrumentation and system.

Performance test

Optional. To BS 2009 or ASME PTC 10 code.

CUSTOMER SUPPORT

A team of highly experienced engineers is available to install, assist in installation, commission electrical, mechanical and control aspects and also to provide on-site training in maintenance techniques to our customers' own engineers.



SPARES

Our company policy in the area of after sales activities, is one of continuous support through the supply of spare parts for all machinery and its associated ancillary equipment. Full and comprehensive plant records are kept on an almost indefinite basis and, as an example, spare parts are regularly supplied for machinery in excess of 45 years old.

Typical spares:

- Bearings
- Labyrinth seals
- Bearing oil seals



Testing: Performance testing of blowers to international codes at our Renfrew works

Variable vane diffusers:

A blower fitted with variable vane diffusers for capacity control



ENVIRONMENTAL AND INDUSTRIAL APPLICATIONS

Howden's broad experience covers the supply, not only of turbo compressors but also of centrifugal fans, rotary screw and 'Roots' positive displacement machines for almost all industrial zones. Equipment is operational in over 40 countries on 6 continents for environmental, chemical, petrochemical, steel metal refining and general industrial applications.



WATER TREATMENT INDUSTRY

High efficiency single-stage turbo compressors for sewage and effluent aeration

METAL REFINING

High pressure single stage turbo compressor for reactor/combustion air



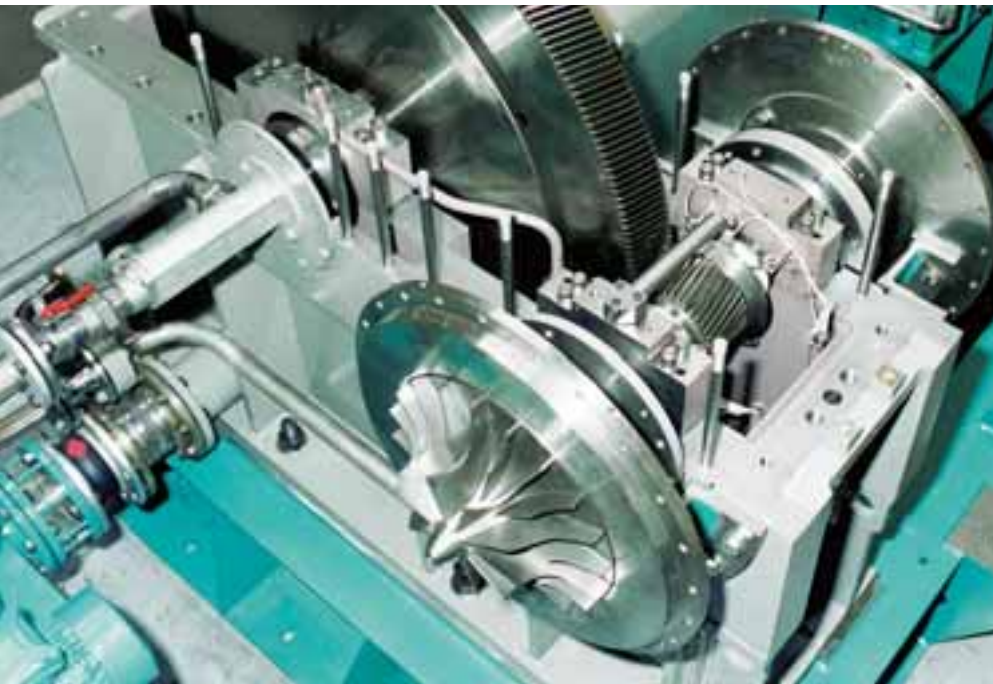
PETROCHEMICAL INDUSTRY

Turbo compressor package
High specification API for process gas handling



SULPHUR RECOVERY

Air blowers providing reaction air for the catalytic recovery of sulphur within the petrochemical industry.



Gearbox: High specification gearbox in multistage turbo compressor



Howden, founded in 1854, is the world's leading supplier of fans, blowers, compressors and rotary regenerative heat exchangers for a large range of industrial applications. No matter whether our fans are pre-engineered or custom built for each application, they are known throughout the world for their high levels of performance, reliability and innovation.

Combining our knowledge with our extensive applications experience, gained by our engineers on sites throughout the world, allows us to support our customers from initial project inception to end of plant life.



Howden Process Compressors

Park Road
Holmewood Industrial Park
Chesterfield S42 5UY
United Kingdom

Telephone: +44 1246 859053
Facsimile: +44 1246 859054
Email: hdb.sales@howden.com
Email: hdb.aftersales@howden.com

Howden Process Compressors

Old Govan Road
Renfrew PA 4 8XJ
United Kingdom
Telephone: +44 141 304 3500
Email: hpc.sales@howden.com
Email: hpc.aftersales@howden.com

Howden BC Compressors

Rue Roland Vachette,
BP 8000160181 Nogent-sur-Oise
Cedex, France
Telephone: +33 3 44 74 41 00
Email: bcsales@burtoncorblin.com

Howden Hua

Suite 14A01 Jinyu Mansion
129A Xuanwumen Xidajie
Xicheng District, Beijing 100031 China
Telephone: +86 10 66419988
Email: dai.fan@howden.com.cn

Howden France

19, rue de la Ladrie,
BP 125 59653
Villeneuve d'Ascq, France
Telephone: +33 3 28 33 32 30
Email: sales@howdensirocco.fr

Howden Ventiladores Ltda.

Rua Dr. Sodré, 122 2 andar
Vila Olimpia 04535 - 110
Sao Paulo, Brazil
Telephone: +55 11 3089 0040
Email: turbo.blowers@howden.com.br

Howden Australia

Unit 23, 38-40 South Street
Rydalmere, NSW 2116 Australia
Tel: + 61 2 8844 9100
E-mail: powersales.au@howden.com

Howden Turbowerke

Naundorfer Strasse 4
D - 01640 Coswig
Germany
Telephone: +49 35 23 940
Email: turbowerke@howden.coswig.de

Sales Offices

Hong Kong
Telephone: +852 2243 2677
Taipei
Telephone: +886 2 8522 7255