

Kawasaki Centrifugal Compressor



Kawasaki Value Framework

Delivery Control

Kawasaki has been continuously concentrating on "delivery and total schedule control", all the way from engineering to delivery, as one of our company policy to fulfill customer satisfaction. Monthly, weekly and daily control of each process including sub-vendors enable us to achieve the most desirable and efficient delivery records.

Reliability & Availability

Kawasaki possesses proven track records of firm machinery designs suitable for long term operations under various harsh conditions. Additionally, with our flexibility of timely field support and services, shortened downtime from reduced site activities during maintenance periods may also be expected by working jointly with the customer. With these factors, we are able to mark a fairly high machinery reliability and availability expected from all customers.

Research & Development

Continuous investment in research and development has enabled us to achieve efficiency improvement, sophisticated manufacturing practises as well as introducing other state-of-the-art products. Some of these development activities are jointly being done in collaboration with our partnership company Rolls Royce Energy Systems, Inc.

Gas Compression Module

For offshore gas compression needs, Kawasaki has provided more than 50 packages of single lift type Gas Compression Modules, which is an engineered and compactly packaged plant with centrifugal compressor, driver, process equipment, control system, and auxiliaries. The module is fabricated and tested at the onshore yard before shipment in order to minimize the commissioning work and unexpected troubles at the offshore platform. The fabrication yard can be nominated globally upon capability and experiences as well as customer's preference.

Quality Management System complying with ISO 9001

The quality management system of Kawasaki has been certified by Nippon Kaiji Kyokai (NK), Japan for ISO 9001.

Environmental Management System complying with ISO 14001

The environmental management system of Kawasaki has been certified by Nippon Kaiji Kyokai (NK), Japan for ISO 14001.

Quality of Pressure Vessel complying with ASME "U" STAMP

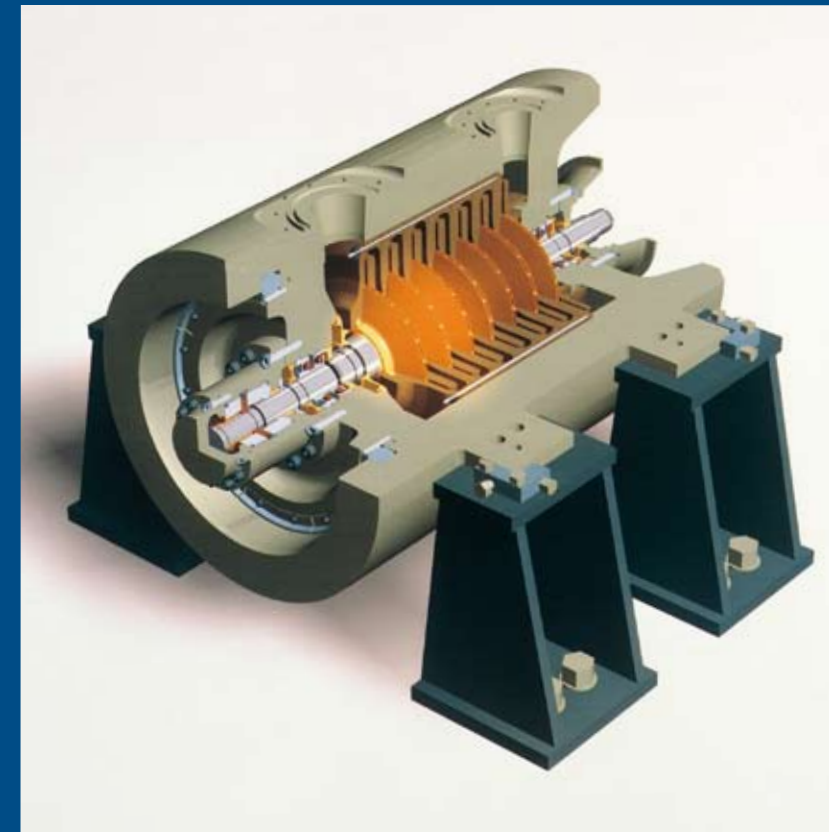
The quality of pressure vessels manufactured in Kawasaki Kobe Works has been certified by the American Society of Mechanical Engineers (ASME) for "U" stamp in accordance with ASME Boiler and Pressure Vessel Code.

Ever since the late 1960s, Kawasaki has been designing, manufacturing, testing and supplying API 617 compliant multi-stage centrifugal compressor all over the world.

Kawasaki has the flexibility to design suitability for various services in both Offshore & Onshore areas including high discharge pressure, high pressure ratio, low suction temperature, highly corrosive gas services such as H₂S, CO₂ and Hg, as well as for severe climate environments.

With the aforesaid experience and technological background, Kawasaki can offer an ideal compression package solution, and will endeavor to support a safe and stable gas production under severe operating conditions.

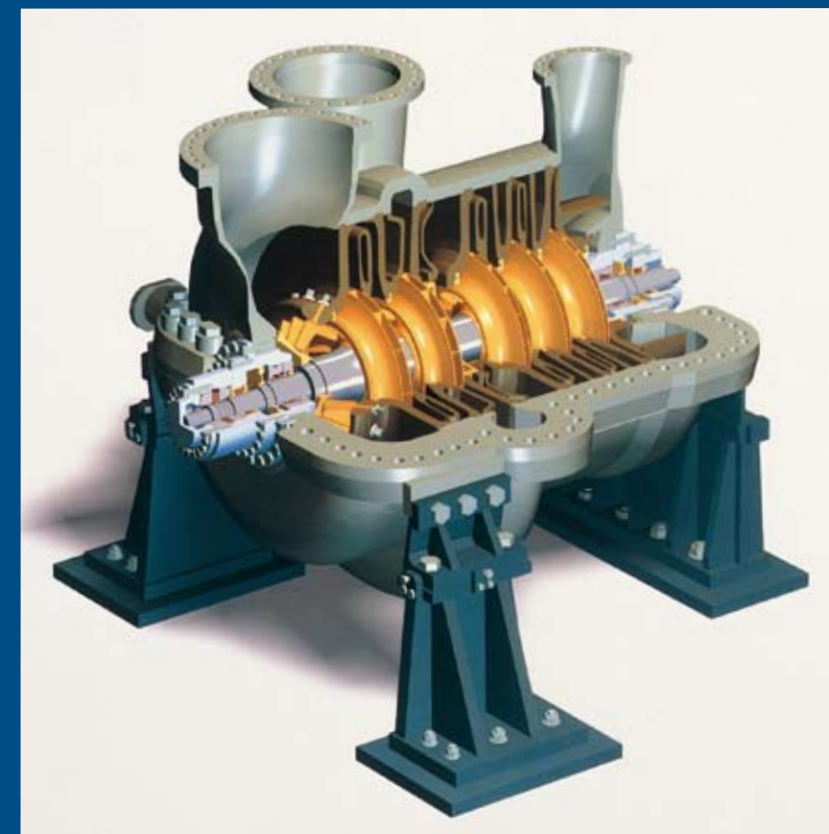
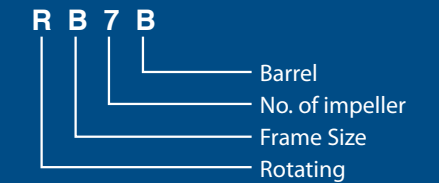
It is Kawasaki's mission to continuously supply upgraded products and also propose a new attractive concept in line with the market needs together with sufficient customer satisfaction.



R-B TYPE (BARREL TYPE)

VERTICAL SPLIT CASING MULTI-STAGE CENTRIFUGAL COMPRESSOR

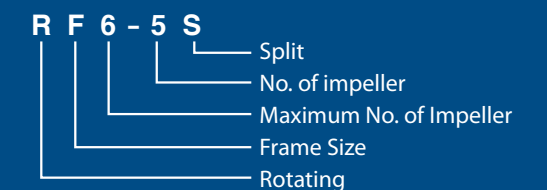
• Example



R-S TYPE (SPLIT TYPE)

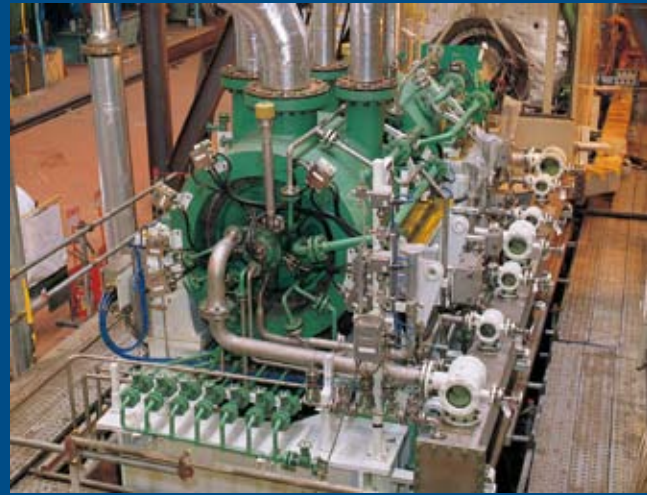
HORIZONTAL SPLIT CASING MULTI-STAGE CENTRIFUGAL COMPRESSOR

• Example





7-Compressor modules installed on SHG platform, ONGC (India)



Gas turbine driven compressor for D35 platform, SSB (Malaysia)



Gas Turbine driven compressor delivered by Antonov, ONGC (India)



Compressor modules installed on CHAMPION-7 platform, BSP (Brunei)



Motor driven compressor for FPSO, PTSC (Vietnam)



Triple tandem arranged gas turbine driven compressors, PSCB (Malaysia)

Offshore Service

- Gas Booster
- Gas Transmission
- Gas Lift
- Gas Injection
- Gas Fuel Facility
- FPSO
- Others

Kawasaki has rich experience with offshore / upstream applications together with our gas compression module. Typically, there are various inlet gas conditions for upstream applications including severe gases such as highly corrosive H₂S, CO₂ and Hg. Kawasaki centrifugal compressors are designed specifically to cater each of these applications to optimize the machine efficiency as well as continuously producing the required flow and discharge pressure specified by the customer.



Onshore Service

- Refinery
- Petrochemical
- Refrigeration
- Synthetic Gas
- Gas Separation
- Gas Gathering
- Gas Booster
- Air Source
- Test Facility
- Others



Motor driven compressor for propane gas service, Woodside Offshore Petro. (Australia)



Motor driven compressor for syn. gas service, RCF (India)



Motor driven compressor for natural gas service, Saudi Aramco (Saudi Arabia)



Gas Turbine driven compressor for natural gas service, CNL (Nigeria)



Tandem arranged steam turbine driven compressors for ammonia gas service, Ube Ammonia (Japan)



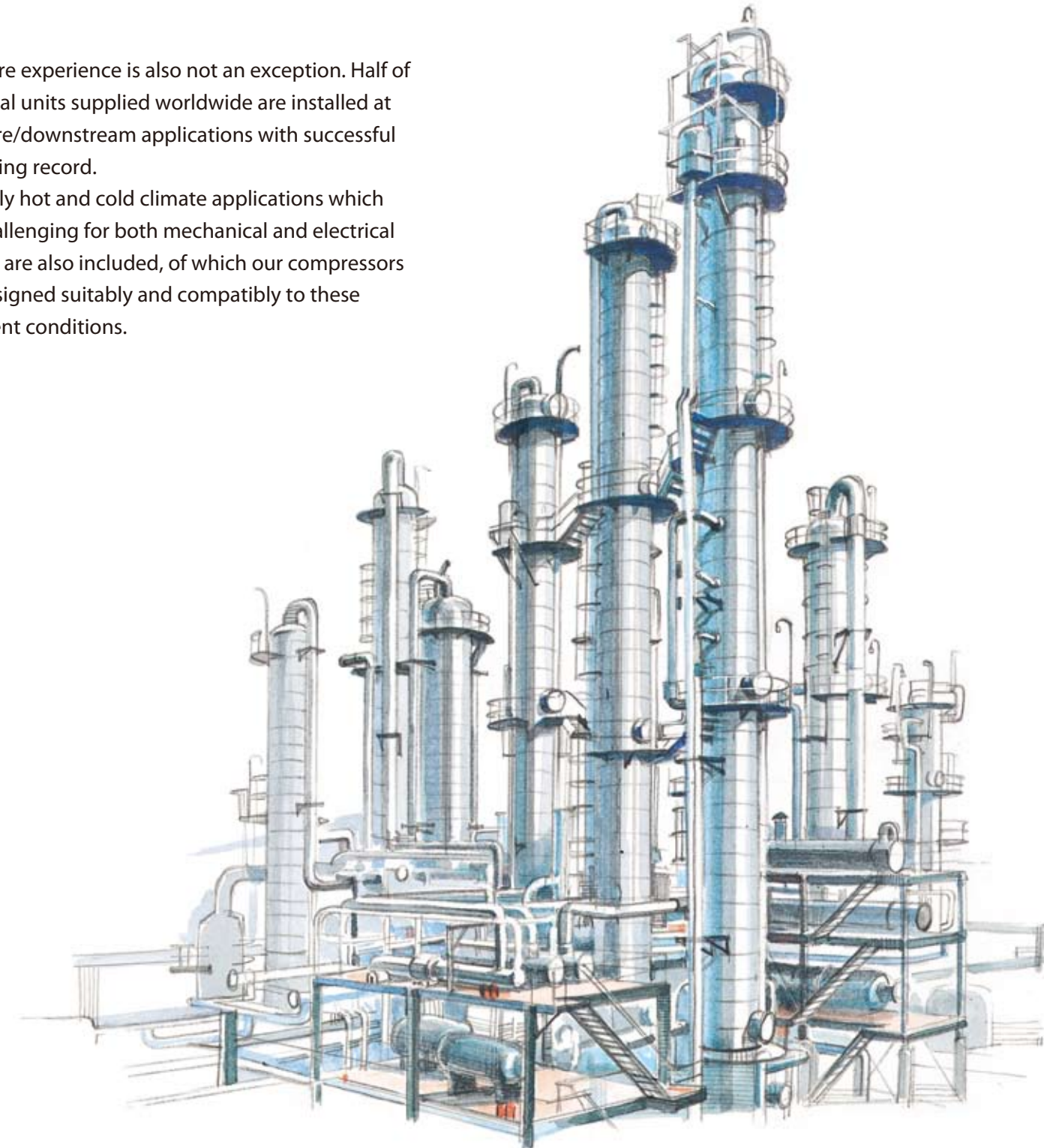
Gas turbine driven compressor for HC mixt. gas service, PERTAMINA (Indonesia)



Motor driven compressor for natural gas service, ZADCO (UAE)

Onshore experience is also not an exception. Half of our total units supplied worldwide are installed at onshore/downstream applications with successful operating record.

Severely hot and cold climate applications which are challenging for both mechanical and electrical design are also included, of which our compressors are designed suitably and compatibly to these stringent conditions.



Advanced Technology

Along with the proven performance and reliability of our compressor established over the past few decades, various state-of-the-art technologies are further applied to achieve the highest performance, quality and features possible in line with industry needs. Through these rigorous challenges, Kawasaki can provide a more optimized compressor to enhance the total benefit for the end user. This is our fundamental mission as one of the leading industrial centrifugal compressor manufacturer.

Efficiency Enhancement

Impeller as well as the stationary aero passage design including the diffuser, return channel and return vane section are optimized to ensure high efficiency and appropriate head characteristic from repeatedly performed geometry design, CFD, FEM followed by in-house single stage verification testing.

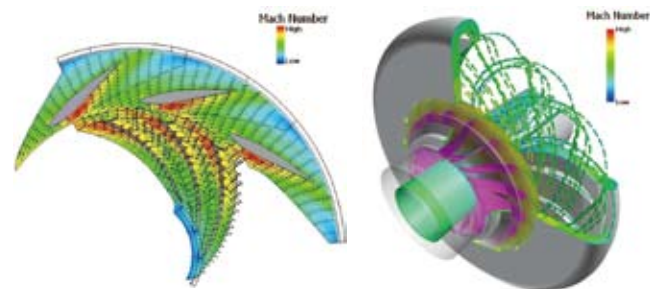
Advanced technology such as 3D-impellers, modified vaned diffusers, sealing component improvement, etc. are applied to achieve the aforementioned purpose, followed by satisfactory test results for deployment to our compressors which are to be installed and operated at the customer's site.



3D Impeller



3D Impeller Machining



CFD study



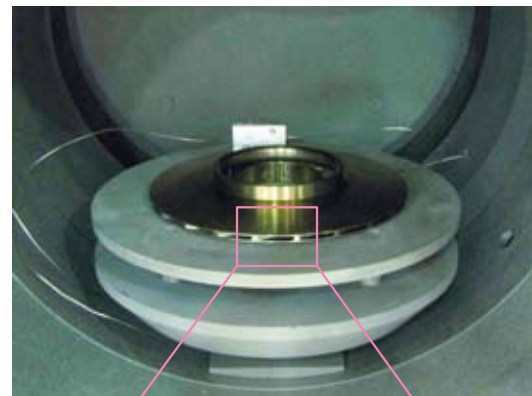
PEEK labyrinth slant seal



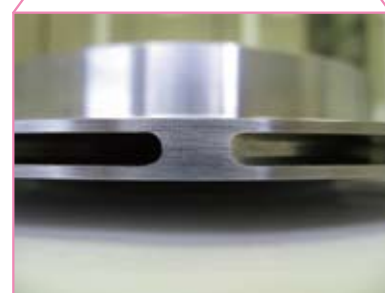
Single Stage Test Rig

Impeller Brazing

For small diameter and narrow flow passage impellers where the conventional shroud-to-hub welding is not practical, Kawasaki has developed manufacturing with vacuum brazing using Gold-Nickel filler metal. Brazing enables the impeller to be manufactured exactly per the geometric design definition as less deformation is expected in comparison with welding. This enables the impeller to yield sufficient performance characteristic even with a very small geometry design where precise manufacturing is crucial.



Impeller brazed in vacuum furnace

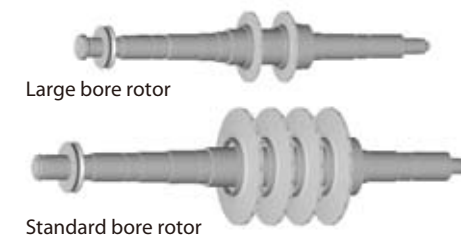


Narrow exit of brazed impeller

High Pressure Technology

Development of high pressure / small flow compressors are targeted especially for applications such as deep water exploration including FPSOs, FLNGs and also EOR (Enhanced Oil Recovery). These compressors are equipped with large bore ratio (impeller outer diameter/shaft diameter) rotors as well as damper seals for the purpose of high rotor stability as a countermeasure to destabilizing aerodynamic forces expected under high pressure/high density gas. Such compressors are expected to have an average discharge pressure of 350 barG (5000 psig).

Various testing are conducted to ensure proper operation at the customer's site with full satisfaction on both mechanical and aerodynamic performance.



Large bore rotor

Standard bore rotor



Hole Pattern Seal



Swirl braker at labyrinth



High Pressure / Small flow compressor Test Rig

Kawasaki Oil-Free Compressor (MAG Comp™)

With Kawasaki's rich experience and advanced technology, an "oil-free" compressor unit can now be offered which is equipped with an active magnetic bearing. In this package, the compressor is directly coupled to a high speed motor which eliminates a speed increasing gearbox.

Consequently, lube oil can be completely eliminated from the entire package which can offer an **E**asy, **E**fficient and **E**co-friendly solution to the customer to optimize the lifetime operating cost (OPEX). Moreover, the package footprint itself is smaller than conventional packages which is beneficial when minimal installation area is preferable.



MAG Comp™



Active Magnetic Bearing



Test Facility

Kawasaki has the capability of in-house compressor testing in full compliance with the latest API 617 and ASME PTC-10 standard codes, as well as the flexibility to comply with any other additional testing requirements as per the customer's specification. Complete compressor package string test capability is also available.

The followings are some of the features of Kawasaki's compressor shop test facility:

- Compressor test rig with fully automated high speed data acquisition/processing and real-time analysis
- Mechanical Running Test (API 617)
- Compressor Performance Test (PTC-10 Type-II)
- No Load String Test
- Additional options for Full Load/ Full Pressure/ Full Speed String test
- Rotor balancing including High Speed Balancing (Operating Speed Balancing)
- Independent test rig for compressor test and string test to enable simultaneous testing
- Completely indoor test facility to avoid unforeseen weather affects



Compressor shop test rig

Rotor Balancing

In addition to the standard low speed rotor balancing, high speed balancing within a vacuum chamber can be performed for the completely assembled compressor rotor in order to avoid unexpected vibration problems under the project specific operating speed. This is one of the approach to ensure high machine reliability / availability at the customer's site. Both balancing machines are available at Kawasaki Kobe works, therefore minimal production schedule impact is expected since the process goes in a sequentially managed manner.



Low Speed Balancing Machine



High Speed Balancing Machine

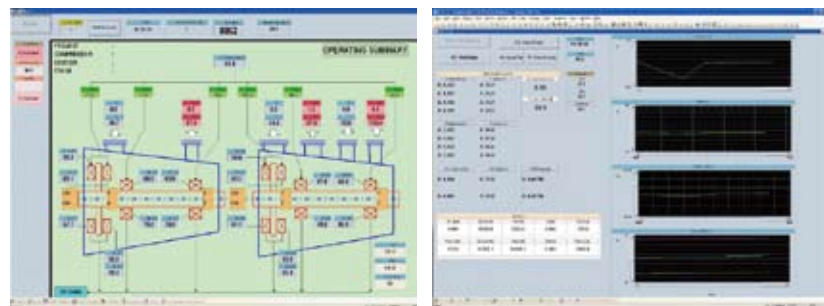
Automated Data Acquisition and Analysis System

Compressor mechanical / performance testing system is based on fully automated high-speed data acquisition/processing and real-time analysis of the compressor's mechanical and aerodynamic performance. General feature of the testing system are as follows:

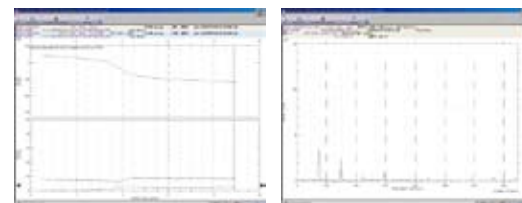
- High performance industrial-grade data acquisition system featuring 120 channels of measurement capability
- Measured/Calibrated Test gas condition (Pressure, Temperature, Flow)
- Real-time calculated aerodynamic performance data and mapping
- Vibration measurement as well as analysis/diagnostic feature including analyzed graphical outputs (Bode, Spectrum, Polar, Cascade, Waterfall plots)
- Alarm and emergency shutdown functionality for machinery protection



Shop test controls room



Real-time monitoring data



Vibration analysis graphical outputs

Complete Unit String Test

No load string test can be carried out to demonstrate the mechanical and controls system integrity for the complete compressor train. In addition to the No load string test, optional Full load/ Full pressure/ Full speed string test is also available to verify the mechanical behavior of the compressor train under the actual site specific conditions.

■ Test gas flexibility

For string tests, single or a mixture of suitable test gases are chosen in line with the project specific gas to ensure the Full load/ Full pressure/ Full speed conditions are met. Such gas includes air, nitrogen, carbon dioxide, Argon, helium and HFC 134a refrigerant.

■ Supplementary Fuel Gas Compressor for Gas Turbines

For gas turbine driven packages, a shop fuel gas compressor will support the Gas Turbine fuel demand to enable the full load testing. This has prevented the need to convert the turbine fuel system to liquid fuel. The fuel gas compressor is compatible with fuel demands of various industrial gas turbine mechanical drive packages.

■ Power supply for Electric Motor

Sufficient facility power supply capability is available for Full Load/ Full Pressure/ Full speed String tests for the electric motor driven compressor packages.



String test of gas turbine driven compressor train



Shop Fuel gas compressor for GT drives



String test of electric motor driven compressor train

Gas Compression Module

More than just a compressor supplier, being a consolidated and an integral solution supplier for offshore gas compression needs is also one of our outstanding benefit.

Kawasaki is one of the major API-617 Centrifugal Compressor suppliers in the world and also well known as a Gas Compression Module supplier. Our service covers not only supply of Kawasaki Centrifugal Compressor, but also all areas of Gas Compression Module, i.e. Engineering, Procurement of material & equipment, Construction, Inspection and Test, Load-out, and Offshore Commissioning. Our Gas Compression Module will be designed in accordance with specific customers' requirements, applicable codes and standards to ensure safe and stable gas production under severe offshore environment.

Module Concept

Gas Compression Module is a mini plant compactly packaged with centrifugal compressor(s), main driver(gas/steam turbine or electric motor), gas & lube oil coolers, pressure vessels, process piping, electrical items, instrumentation, fire & gas system, lighting system, maintenance facilities in a single point lifting structure. Typically, Gas Compression Module is applied to Gas Gathering, Gas Transportation/Boosting, Gas Lift, and Gas Re-injection services at offshore platforms.

Gas Compression Module can be string-tested at the module fabrication yard to ensure good quality and performance before shipment. This onshore work also contributes to simplifying the installation / hook up work at the offshore site.

This concept can drastically minimize the offshore construction, installation & commissioning work and eliminate unforeseen problems and risks, since offshore environment is harsh for construction and commissioning due to unpredictable climate/weather/tide conditions, limited construction facilities/manpower, and limited construction space.

Various type of module can be designed and fabricated in accordance with the customer's preference. Multiple-deck type module gives space flexibility especially for offshore platforms, where very limited space is available for topside equipment, without compromising the emergency escape route, maintenance space, and accessibility. The flexibility to design the Module accommodating multiple compressor trains is available. The controls room for the Gas Compression Module can also be fitted within the module boundary if desired.



Single lifted Gas Compression Module for KNOG



Typical Module Overview



Single-deck type



Double-deck type

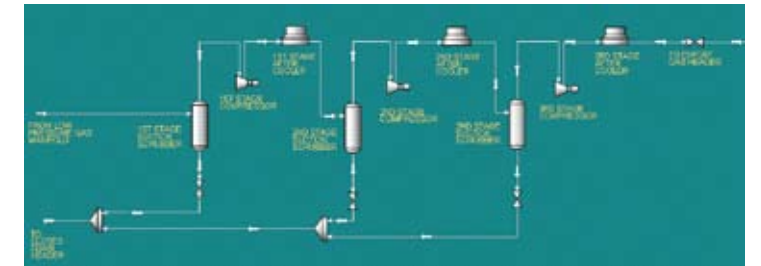


Triple-deck type

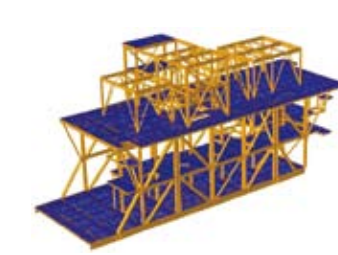
Module Engineering

Kawasaki undertakes module engineering in all areas including process, mechanical, piping, structural, electrical, instrumentation, and architectural engineering with the latest technologies established from the rich experiences of Gas Compression Modules for over 40 years. All safety features such as fire fighting, fire suppression, alarm and communication system etc. are taken into consideration as the basis of module engineering. Commercial codes such as HYSYS, SACS and CAESAR II, PDMS etc, which are common for engineering firms for Oil & Gas sector, are utilized to module engineering.

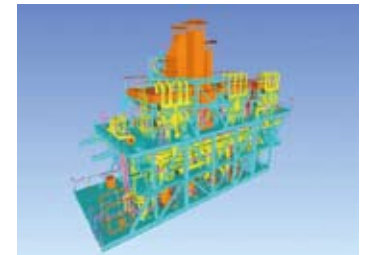
Our design satisfies not only the customer's specifications and international codes & standards, but also all requirements for easy operation and maintenance. This is achieved by applying our highly reliable Kawasaki Centrifugal Compressors with consideration to maintenance and operation. Concurrent engineering between Kawasaki compressor engineering section and module engineering section shortens the overall engineering period, which eventually maximizes the engineering quality. This is our basis of providing the best benefit to all of our favorable customers.



Process Design - HYSYS



Structural Analysis - SACS



3D Modeling - PDMS



Kawasaki Centrifugal Compressor

Module Fabrication & Test

Kawasaki is able to fabricate the module either at its own facility or at the subcontractor's yard outside of Japan under the supervision of Kawasaki personnel, depending on the size & weight of module, final destination etc. In both cases, Kawasaki ensures the total quality of the module by comprehensive quality controls, all the way from raw material procurement up to the fabrication and installation stage. Fabrication will be carried out only by qualified welders or workers and subject to applicable inspection at each stage. Finally, to ensure reliable package integrity, shipments are made after confirming the quality through intensive testing, including optional no load string test and/or full load/ full pressure/ full speed string tests.

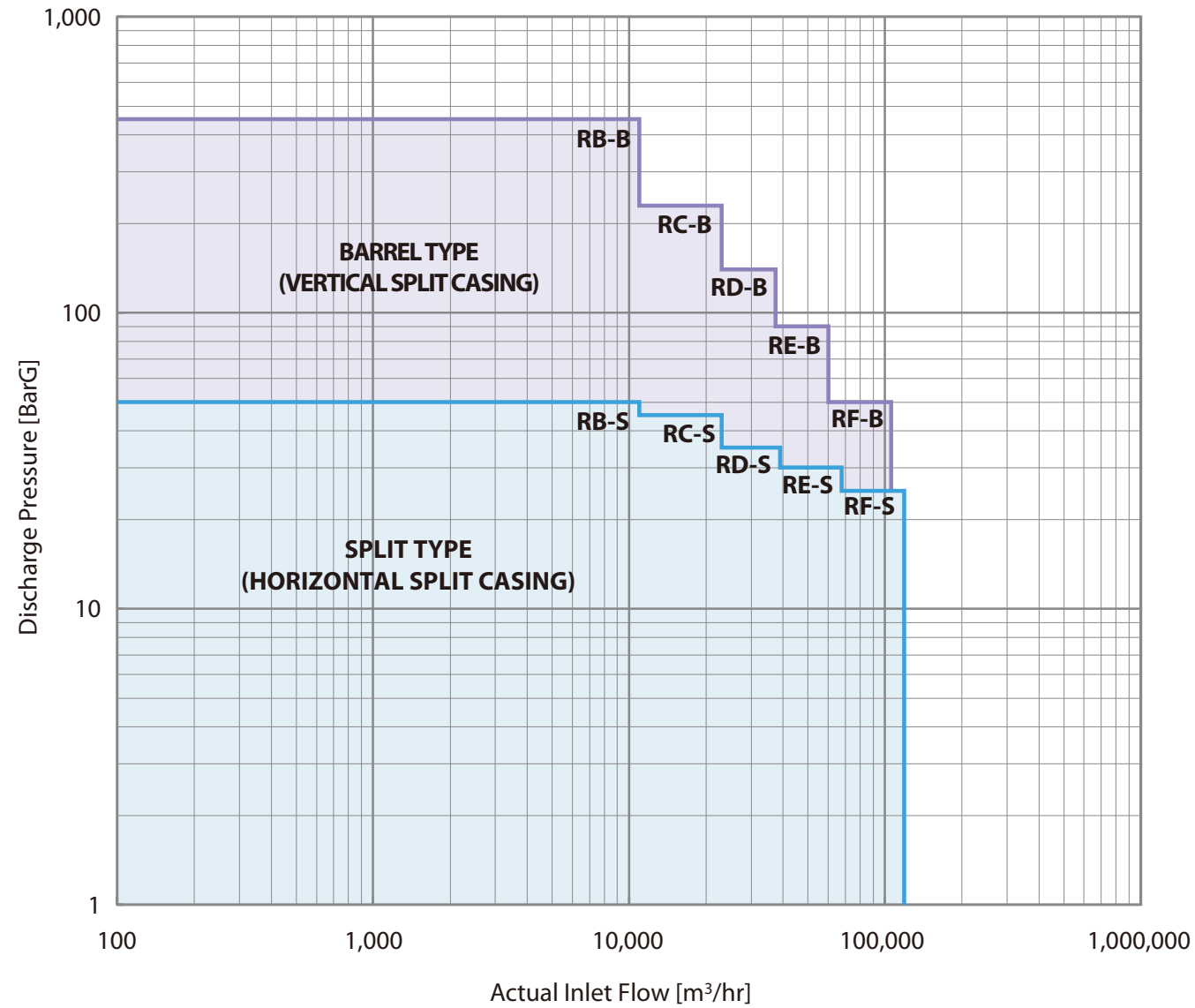


Gas Compression Module for KNOG (Korea)



Gas Compression Module for PCSB (Malaysia)

Capacity and Pressure Range

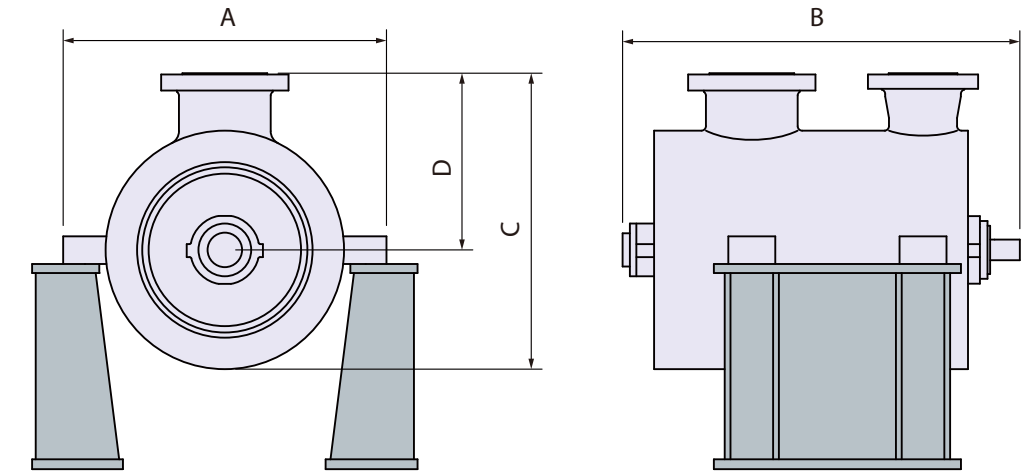


Driver Options

- Gas turbine (Aeroderivative and Industrial type)
- Steam turbine (Condensing, Back pressure and Extracting type)
- Electric motor (Low speed, high speed and variable speed type)

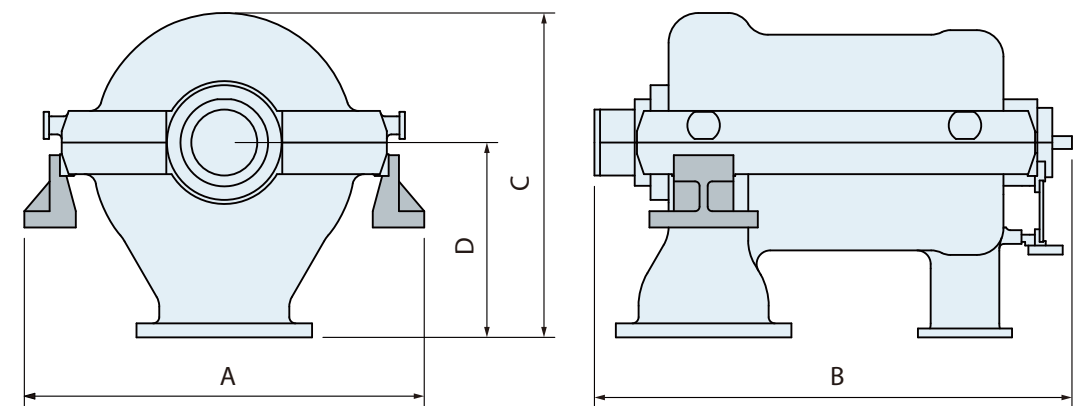
Compressor Frame Summary

■ BARREL TYPE



TYPE	A [mm]	B [mm]	C [mm]	D [mm]	WEIGHT [kg]	MAX. DISCHARGE PRESSURE [BarG]	MAX. INLET FLOW [m³/hr]	MAX. ROTATING SPEED [rpm]
RB-B	1,400	1,650	1,250	750	9,000	450	10,200	19,000
RC-B	1,750	2,000	1,600	950	16,000	230	23,000	12,000
RD-B	2,000	2,450	1,800	1,050	20,000	140	37,400	9,000
RE-B	2,500	2,850	2,200	1,300	35,000	90	60,300	7,000
RF-B	3,000	4,200	3,000	1,800	55,000	50	106,000	5,500

■ SPLIT TYPE



TYPE	A [mm]	B [mm]	C [mm]	D [mm]	WEIGHT [kg]	MAX. DISCHARGE PRESSURE [BarG]	MAX. INLET FLOW [m³/hr]	MAX. ROTATING SPEED [rpm]
RB-S	1,300	1,650	1,100	650	3,500	50	10,200	19,000
RC-S	1,600	2,050	1,550	950	6,000	45	23,000	12,000
RD-S	2,200	2,500	1,800	1,100	13,000	35	39,000	9,000
RE-S	2,500	3,100	2,300	1,300	24,000	30	68,000	7,000
RF-S	3,000	3,700	3,000	1,700	40,000	25	119,000	5,500

Specifications contained herein are typical and subject to change without notice.

Kawasaki Heavy Industries, Ltd.

Energy System & Plant Engineering Company

<http://www.khi.co.jp>

Tokyo Head Office

Compressor Sales Section

1-14-5, Kaigan, Minato-ku, Tokyo 105-8315, Japan

Phone: +81-3-3435-2370 Fax: +81-3-3435-2022

Email: turbo_machinery_sales@khi.co.jp

Kobe Works

Compressor Engineering Section

1-1, Higashikawasaki-cho 3-chome, Chuo-ku, Kobe, 650-8670, Japan

Phone: +81-78-682-5350 Fax: +81-78-682-5552

OVERSEAS OFFICES

Bangkok Office

28th FL, Sathorn Square Office Tower, 98 North Sathorn Road Silom, Bangrak Bangkok 10500

Phone: +66-2-163-2839 Fax: +66-2-163-2841

Taipei Office

15th Floor, Fu-Key Bldg., 99 Jen-Ai Road Section 2, Taipei, Taiwan

Phone: +886-2-2322-1752 Fax: +886-2-2322-5009

OVERSEAS SUBSIDIARIES

Kawasaki Heavy Industries (U.S.A.), Inc.

60 East 42nd Street, Suite 2501, New York, NY 10165, U.S.A.

Phone: +1-917-475-1195 Fax: +1-917-475-1392

Houston Branch

333 Clay Street, Suite 4310, Houston, TX 77002-4109, U.S.A.

Phone: +1-713-654-8981 Fax: +1-713-654-8187

Kawasaki do Brasil Industria e Comércio Ltda.

Avenida Paulista 542-6 Andar, Bela Vista 01310-000, São Paulo, SP, Brazil

Phone: +55-11-3289-2388 Fax: +55-11-3289-2788

Kawasaki Heavy Industries (UK) Ltd.

4th Floor, 3 St. Helen's Place, London, EC3A 6AB, U.K.

Phone: +44-20-7588-5222 Fax: +44-20-7588-5333

Kawasaki Heavy Industries (Europe), B.V.

6th Floor, Eurocenter II Barbara Strozziilaan 336-388, 1083 HN Amsterdam, The Netherlands

Phone: +31-20-6446869 Fax: +31-20-6425725

Kawasaki Heavy Industries Middle East FZE

Dubai Airport Free Zone, Bldg. 6W, Block-A, Office No.709 P.O.Box 54878, Dubai, UAE

Phone: +971-4-214-6730 Fax: +971-4-214-6729

Kawasaki Heavy Industries Management (Shanghai), Ltd.

10th Floor, Chong Hing Finance Center 288 Nanjing Road West, Huangpu District,

Shanghai 200003, People's Republic of China

Phone: +86-21-3366-3100 Fax: +86-21-3366-3108

Kawasaki Heavy Industries (Singapore) Pte.Ltd.

6 Battery Road, #23-01, Singapore 049909

Phone: +65-6225-5133 Fax: +65-6224-9029

Kawasaki Heavy Industries (H.K.), Ltd.

Room 3710-14, Sun Hong Kai Centre, 30 Harbour Road, Wanchai, Hong Kong

People's Republic of China

Phone: +852-2522-3560 Fax: +852-2845-2905

Kawasaki Heavy Industries (India) Pvt. Ltd.

Room No: 1777, ITC Maurya, Sardar Patel Marg, Diplomatic Enclave, New Delhi – 110021

Phone: +91-11-4358-3531

Kawasaki Heavy Industries Russia LLC

Office 1803 (18th Floor), Entrance 3, Krasnopresnenskaya nab.12, 123610, Moscow, Russian Federation

Phone: +7-495-258-2115 Fax: +7-495-258-2116