

# **mitsubishi** **Integrally Geared** **Compressors**



<http://www.mhicompressor.com/>

# Design Features of Mitsubishi Integrally Geared Compressor

Mitsubishi Integrally Geared compressor has found widespread application principally as air and gas booster compressors, nitrogen-gas compressor, CO<sub>2</sub> compressors, natural gas compressors and vacuum pumps, and have gained a superior reputation among every user. The latest Mitsubishi Integrally Geared Compressor has been designed to offer "even higher levels of performance" and "greater user-friendliness", thus giving users greater satisfaction in operation and maintenance.

## Standardized component design

The Mitsubishi integrally geared compressor is built by combining proven standardized components for the required specification. And complete packing design including coolers, lubrication system and driver can facilitate shipment, site installation and start-up.

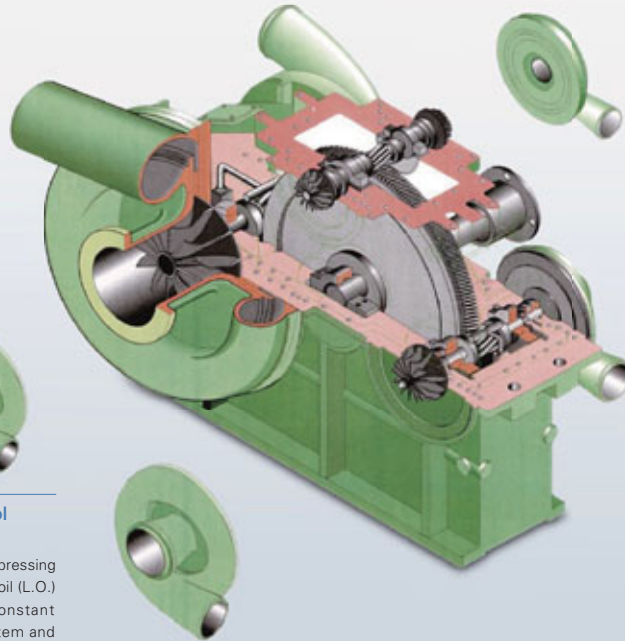


## Highly reliable continuous operation with minimum maintenance

Both simple and rigid, Mitsubishi integrally geared Compressor is manufactured under strict quality control promising highly reliable and continuous long-term operation. Its simple structure also facilitates easy maintenance.

## Simplicity of operation and optimum control

On Mitsubishi standard control system for compressor, depressing merely a single push-button results in both the lubricating oil (L.O.) pump and compressor to automatically commence constant blow-pressure operation. The highly reliable control system and protection devices employed for the fully automated operation continuously monitor the entire compressor plant during operation. Also, customer's requirement control system is available to be included in Mitsubishi standard control system.



Typical 6-stage integrally geared compressor

## High efficiency and low running cost

The three-dimensional impeller design employed smoother internal fluid flow than the conventional impellers and an intercooler is provided at each stage of the multi-staged compression to deliver a very high level of efficiency.

## Reliable gear casing system

Total gear casing system (casing, gear, shaft, bearing) is designed by Mitsubishi own technology.

With the impellers, gears, and pinion shafts thoroughly dynamically balanced during manufacture, compressor vibration is reduced to an extremely low level.

## Complete freedom of air from L.O. contamination

The space between the gear casing where each shaft enters and the speed-increasing-gear compartment is open to the atmosphere to completely prevent L.O. contamination into the discharged air. Additionally, pulsation-free air can be supplied as it is forced by the rotary motion of the impellers.

## Quick and excellent after-sales service

Our highly skilled engineers and technicians are ready to perform installation, test runs, and after-sales servicing to meet user demands for quick and efficient attention.

Also, we can positively respond to users requests for modification, etc. as Mitsubishi integrally geared Compressor is of our own development and manufacture.

## Application Line up

### Air and N<sub>2</sub> compressor

Air compressor and Nitrogen compressor are used in several applications, such as Air Separation, PTA, Ammonia and other chemical plants. Application range is as follows;

- Flow volume 20,000 to 75,000Am<sup>3</sup>/h with pressure up to 100barA
- Flow volume 75,000 to 450,000Am<sup>3</sup>/h with pressure up to 50barA
- Flow volume up to 1,000,000Am<sup>3</sup>/h with pressure up to 8barA

### Fuel gas compressor

Integrally geared fuel gas compressor is fully standardized to be suitable for low/middle pressure fuel gas condition. Compressor core unit, motor driver, lube oil system, dry gas seal control unit and process gas piping are completely packaged on common base skid to minimize site installation work. Flow volume is up to 200,000Am<sup>3</sup>/h with discharge pressure up to 60barA.

### Carbon dioxide (CO<sub>2</sub>) compressor

Fields of application are CCS, EOR and CO<sub>2</sub> separation in IGCC, oxy-fuel, pre combustion and post combustion processes. Flow volume is up to 200,000Am<sup>3</sup>/h with discharge pressure up to 200barA.

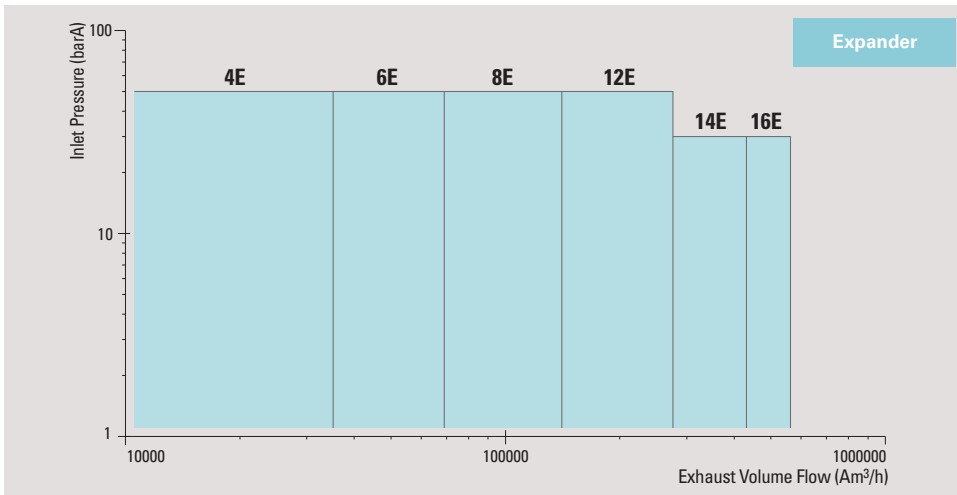
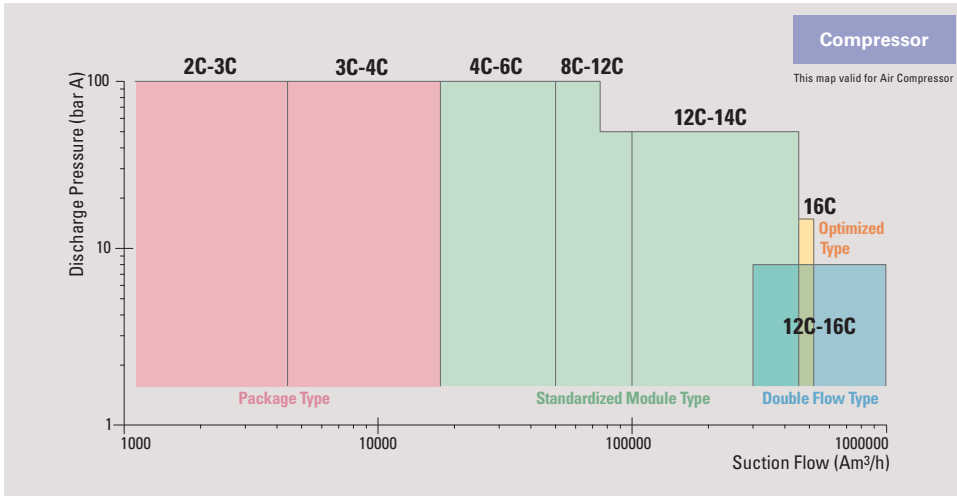
### Expander

Expander, Integrally geared radial type, is designed based on proven integrally geared compressor concept as power recovery system. Fields of application are PTA, Nitric Acid and others. Gas inlet temperature is up to 550°C, discharge volume flow is up to 550,000Am<sup>3</sup>/h.

# Types of Mitsubishi Integrally Geared Compressor

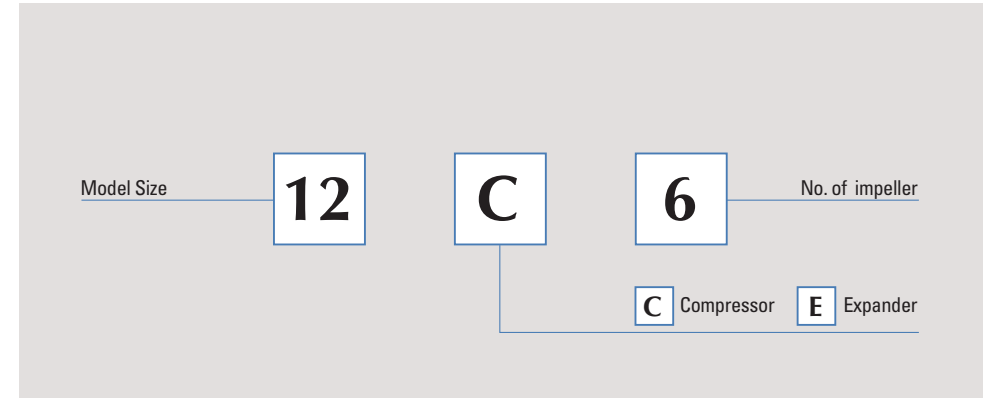
## Application Range

Application models of Mitsubishi Integrally Geared Compressor are shown in the following chart.

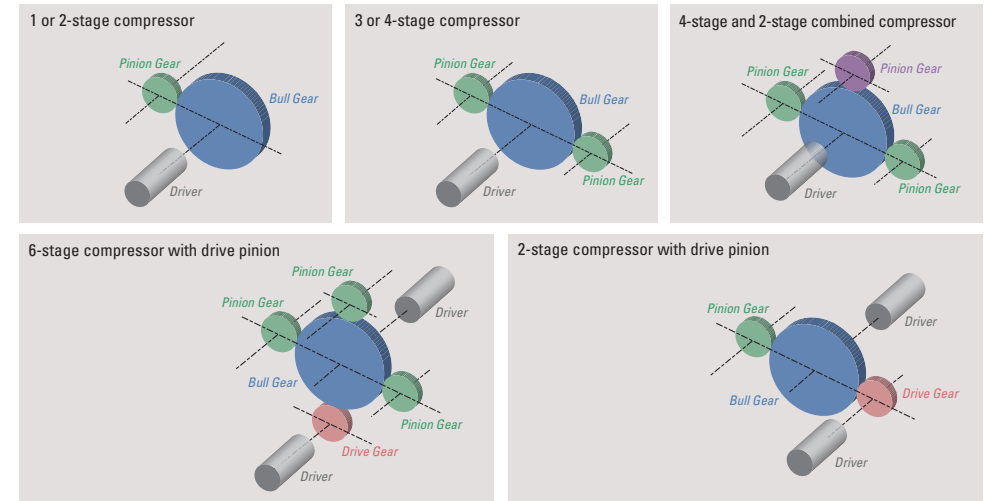


## How to Indicate Models

Mitsubishi Integrally Geared Compressor Models are generally indicated by a three-digit code.



## Gear Arrangement





# Design Features of Components

## Gear casing

A two-part casing with its upper and lower halves joined together by means of their horizontal flanges permits the gears and bearings to be readily checked without removing the scroll casing.

## Impeller

Impellers are equipped with three-dimensional-backward-curved blading which was developed through computer analysis of air flow for an ideal flow pattern, guaranteeing maximum compressor efficiency. Impellers are also high in strength and resistant to corrosion and abrasive wear.

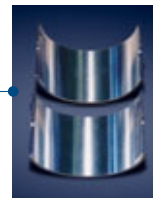


## Pinion Shaft

Each pinion shaft rotates at high speed enable the impellers fitted on each end to efficiently compress the gas. The shafting with the two impellers is nearly symmetrical for well-balanced aerodynamic thrust. Pinion shaft assembly (with Impeller) is removable design, for easy maintenance.



## Bull gear shaft journal bearing



A plain bearing is used as the Bull gear shaft journal bearing.

## Pinion shaft journal bearing

A tilting pad type bearing is adopted as the pinion shaft journal bearing. With the tilting-pad type journal bearing, increase or decrease in shaft load is automatic through pad tilting. Consequently, the proper lubricating oil film can be maintained even if a sharp change in load occurs.



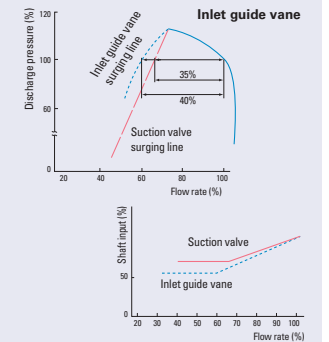
## Inlet Guide Vane (IGV)

Movable inlet guide vanes enable a wide operating range and excellent part load performance. The inlet guide vanes are installed ahead of first stage or all stages as option, and close to the impeller to achieve maximum efficiency.



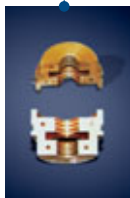
## Adjustment of flow rate

The standard flow rate adjustment resorts to throttling the suction valve, for constant pressure operation. If high-efficiency operation over a wide range of flow rates without blow-off is required the movable inlet guide vane control method is available. The installation of suction guide vane ahead of first stage realizes stable operation with flow rate between 60-100% of design capacity.



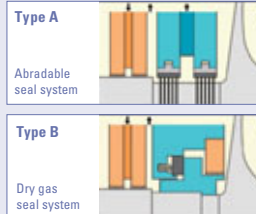
## Shaft seal

An air seal is integral constructed with the oil baffle as one labyrinth seal. It is free from abrasive wear and corrosion as well as easily and securely adjustable for optimum clearance when reinstalling the seal following overhaul. The space open to the atmosphere between the air seal and oil baffle prevents the lubricating oil from entering the compressed air as well as foreign matter from entering the L.O.



## Optional seal systems

In standard unit, labyrinth seal is assembled in gear casing. Depend on the actual design and operating condition (Gas pressure level, Gas handled, etc.), optional seal systems are selected.

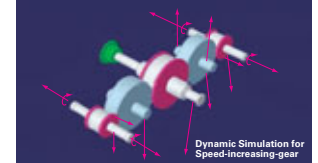


## Thrust bearing

A combined wheel-pinion-thrust-collar-bearing system is employed for the thrust bearing of each pinion shaft. In this system, the thrust force of the compressor is transmitted to the thrust bearing of the low-speed wheel by the pinion shaft thrust collar, resulting in very low mechanical loss.

## Speed-increasing-gear

A single helical gear is employed to raise the drive unit output shaft rotary speed to the specified impeller speed using a single-stage gear train. The gear is made of special heat-treated steel, which is then polished into a high precision, high strength gear capable of stable operation low in vibration and noise. Speed-increasing gear is designed by Mitsubishi own criteria based on research and development, minimum gear quality corresponds to AGMA standard.



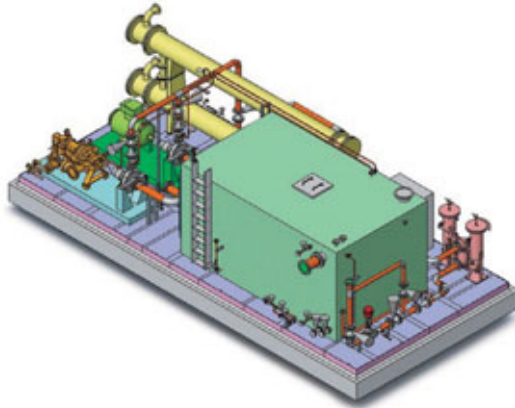


# Design Features of Components

## Lube Oil System Design

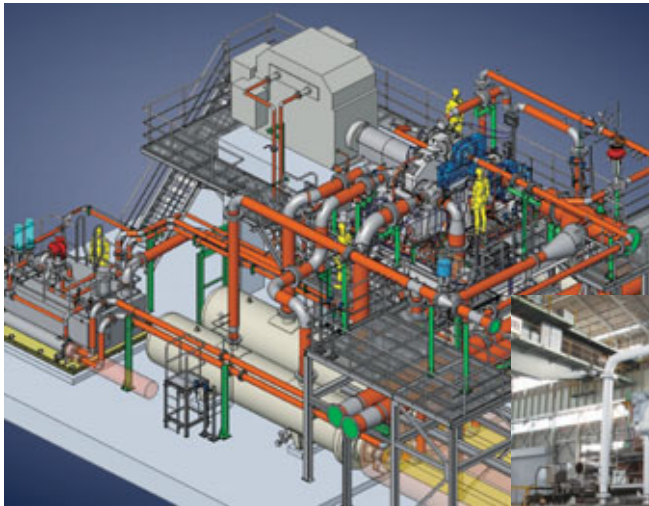
As lubrication system is essential for reliable operation of compressor train, MCO makes special efforts to design on our long accumulated experience with or without API 614 design specification, considering customer's required operating condition.

Each oil systems component is subjected to strict inspections and they are assembled on base plate as one console. Console tests are then performed at verify the performance of the complete system before shipping.



## Ergonomics Design

Ergonomics design by using three dimensional simulations can realize the optimum arrangement design of overall compressor train system, for each stage as assembling, installation, operating and maintenance.



Booster Air Compressor Module for Air separation plant



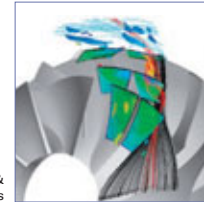
# Research and Development

Always in pursuit of maximum performance and reliability

## Aero dynamic Design (Impeller & Gas Cooler)

### Impeller flow analysis

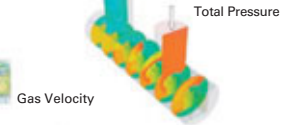
The optimum blade root profile is determined based on the result of three dimensional flow analysis.



Visualization of Flow pattern & Total pressure loss

### Gas cooler analysis

The inside operating condition of gas cooler (heat transfer performance, velocity, pressure loss) is confirmed by three dimensional flow analysis to ensure maximum heat exchange with lowest possible reduction in air pressure.



Gas Velocity

Total Pressure

## Construction Design

The constructed components are designed as optimized and reliable for realizing the long time safety operation by FE and dynamic analysis.



Thermal analysis for Hot gas expander

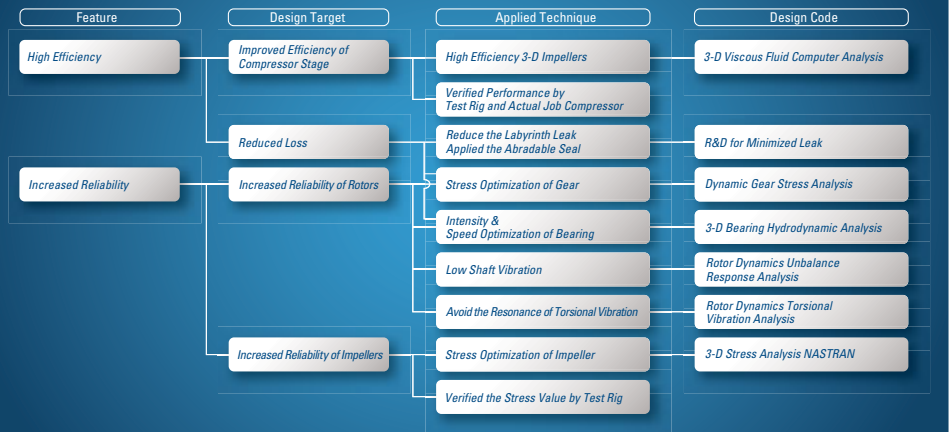


Stress and Vibration analysis for Steel structure



Stress and Deformation analysis for Large casing

## Mitsubishi Own Design Analysis Flow Chart for Geared Compressor



# Typical Applications (Experiences of Integrally Geared Compressor)



Air compressor (6-stage) and gas expander for P.T.A. plant



Nitrogen gas compressor (Combined type) for Air separation plant

Air compressor and gas expander for P.T.A. plant



Gas and Air compressor (Combined type) for Styrene plant

Fuel gas compressor for Power plant



Gas blower for Acrylic Acid plant



Booster air compressor for Power Station IGCC



Air compressor and gas expander (Combined type) for P.T.A. plant