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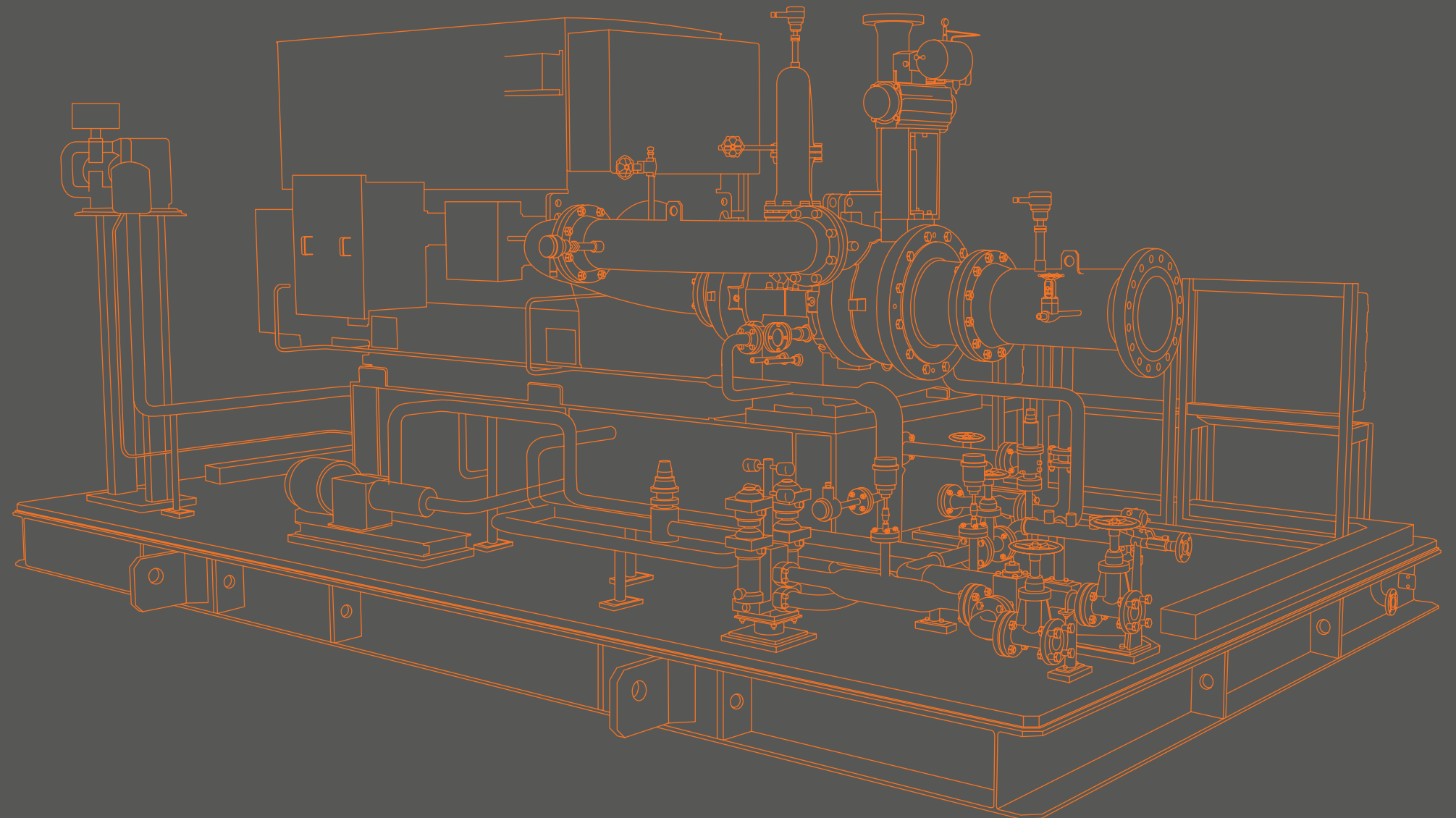
Present State of Hanwha Power Systems
Turbo Compressor Authentication

- ISO14001 Authentication
- Korea New Technology Authentication
- IR52 Jang Young Sil Award
- ISO9001 Authentication
- CE Authentication
- ASME-compliant
- ISO 8573-1 Class zero Authentication

The information in this publication is
subject to change without a notice for
improvement.

CENTRIFUGAL AIR & GAS COMPRESSORS

PROCESS & GAS SOLUTIONS



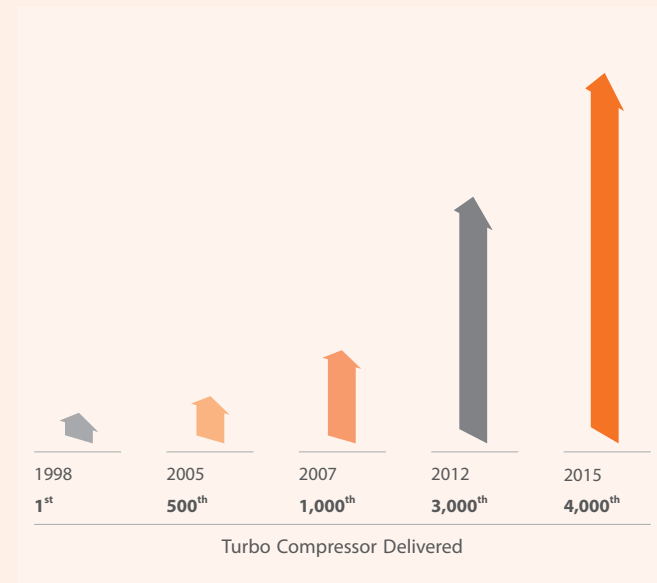
History

Based on over 35 years of accumulated experience in precision machine industry from Gas Turbine to Compressor Business, Hanwha Power Systems has been chosen by more than 1,000 customers worldwide.

- **1977** Company Established (Samsung Techwin) in Samsung Group
- **1979** Overhaul and Repair of Aircraft Gas Turbine Engines
- **1996** Industrial Gas Turbine Developed
- **1997** First model of Turbo Compressor Introduced
- **2011** Penetrated into Gas Compressor Market
- **2013** SA3100, the World's Largest Capacity of Air Cooled Compressor Introduced ISO8573-1 (Class 0) Certified
- **2014** Contract to Supply the World 1st Integrally Geared Centrifugal Compressor for Offshore VRU Application
- **2015** New Beginning in Hanwha group as "Hanwha Techwin"
Penetrated into the Offshore Market with Turbo Air & Gas Compressors
Launched Long-term Aftermarket Service Program
Expanding Portfolio by Cooperation with Screw Compressor Manufacturers
- **2016** Saudi Aramco Approved Vendor registered (API617 Process Compressor & Blower)
Reciprocating compressor packager agreement with GE Oil&Gas
- **2017** MOU signed with KEPCO to jointly develop Oxy-Fuel Gas Turbine technology
New beginning as "Hanwha Power Systems"

Hanwha Power Systems is one of the fastest growing solution providers in its industry since 1997.

During the last two decades Hanwha Power Systems delivered over 4,000 units of turbo compressors worldwide.



Industries & Applications

Upstream & Offshore

- Flash Gas, LP, MP
- Vapor Recovery / Instrument Air

Refinery

- Make-up, Recycle, Booster (H₂, Wet)
- Sulfur Recovery / Process Air / Instrument Air

LNG

- Boil off gas (Terminal, LNG Plant)
- High Pressure (Terminal)
- Low / High duty (LNGC, LNG FPSO)

Power Generation

- Fuel Gas Booster / N₂ booster (IGCC)
- Syngas / Instrument Air

Air Separation

- Main Air / Booster Air or N₂
- Cryogenic Expansion

Fertilizer / Gas Processing

- Process Air / Process Gas (NG, NH₃, CO₂)
- N₂ Booster / Instrument Air / NGL

Petro-chemical

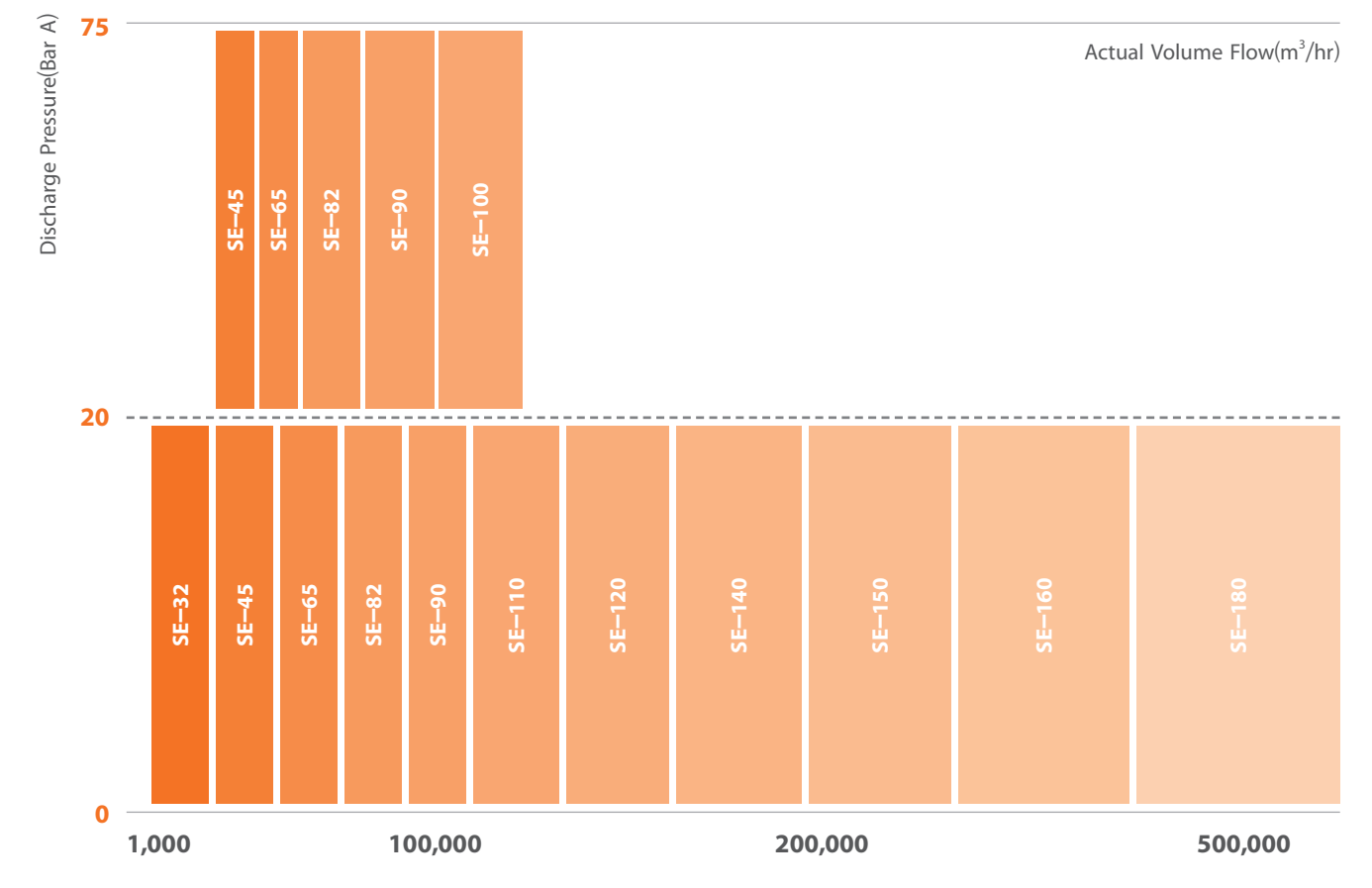
- High Pressure (Terminal)
- Refrigeration (Propane, Propylene)
- PTA / Boil off gas / Process Air / Instrument Air

Environment & Energy Saving

- Aeration for wastewater treatment
- Pneumatic conveying materials
- Mechanical vapor recompression

By combining precision machinery with integrated technologies, Hanwha Power Systems provides a full range of centrifugal compressors that covers instrument air compressors, process air and gas compressors, expanders, companders and power generation systems. In any market that includes oil & gas, power generation, petrochemical, air separation and cryogenic processes, Hanwha Power Systems's remarkable products meet the requirements of each of these segments. Customized solutions improve the productivity and save energy for customer applications in various industries.

Product Range



*suction : Atmospheric Condition, Working Fluid : Air

- Gases: Air, any combination of hydrocarbons and other gases such as N₂ and CO₂
- Stage: Single and multi-stage (1-6 stages) gear type centrifugal compressors
- Range: up to 550,000 m³/h, 75bar
- International Spec: Compliance with API617, API672, API614, and other API / global specifications

Benefits

Reliable operation

- Products designed and manufactured with proven components guarantee stable operation and long life spans.
- Each product complies with global industry standards as ISO9001, API specifications, and other customer requirements.
- More than 4,000 air and gas compressors has been operating in various industries.

High performance

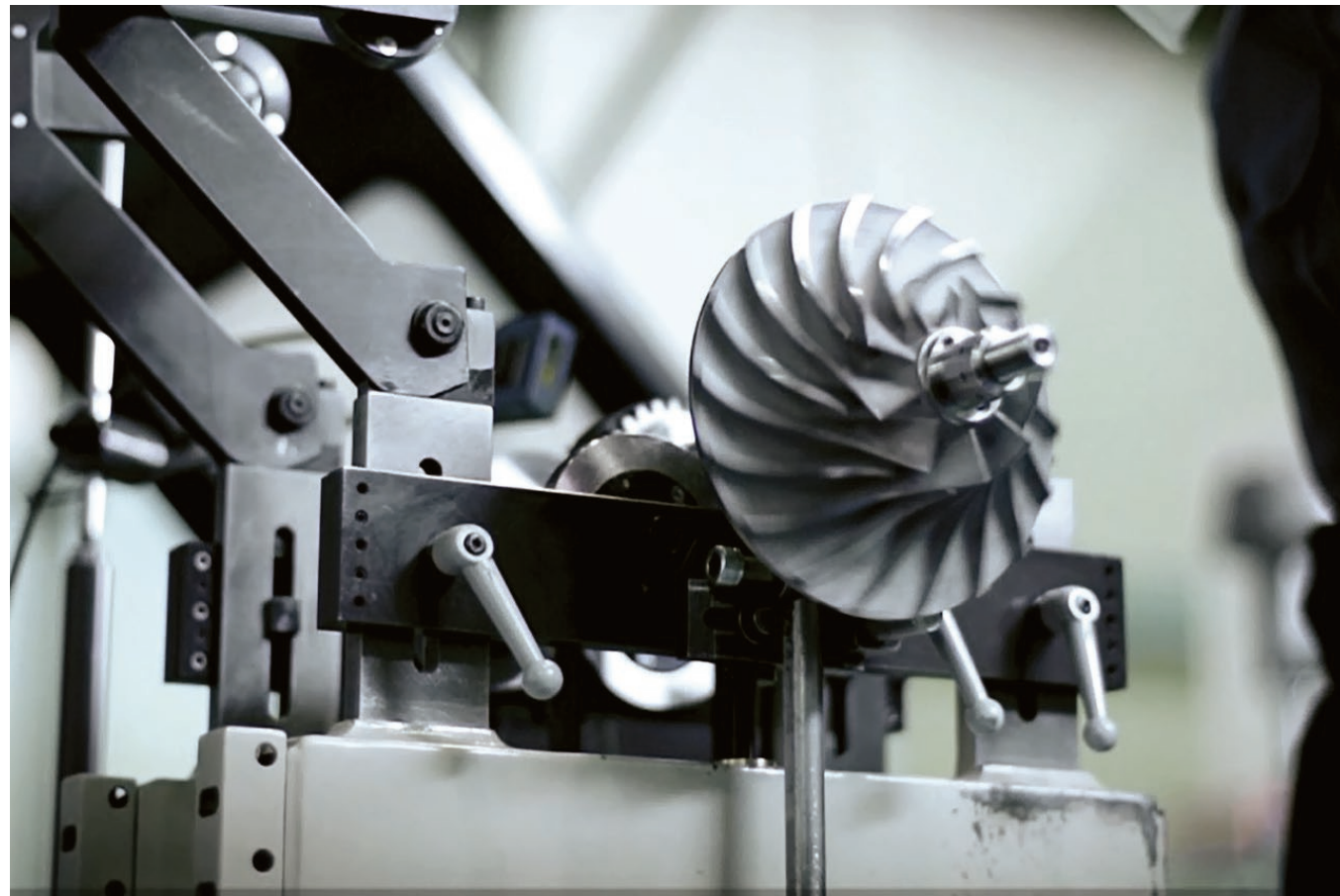
- Optimized aerodynamic design and the structure minimizing losses brings high efficiency.

Easy operation and maintenance

- Simple and customer oriented structure make easy maintenance. Simple Installation and Low Operating Cost to save time and money minimizing maintenance costs.

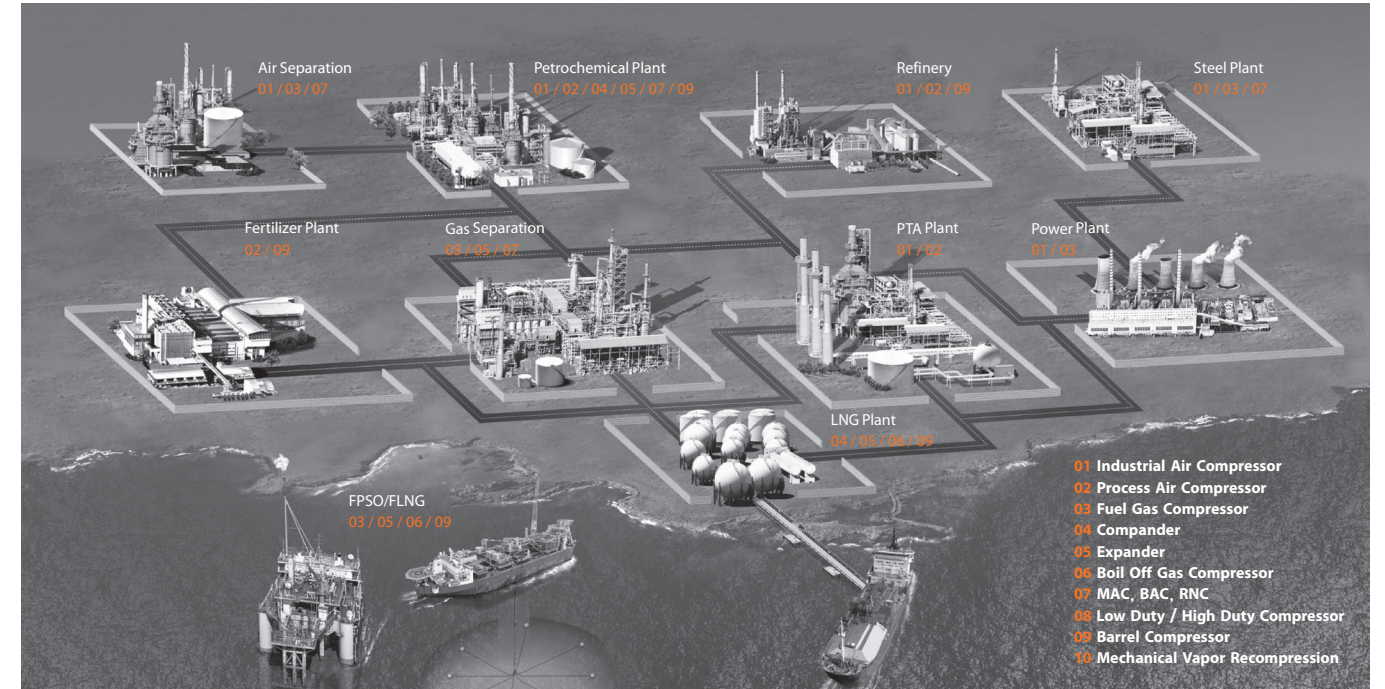
Broad application performance range

- Compressors with up to 6 stages of compression can handle various gas compositions to each stage allowing a single compressor to do what in the past took multiple units.
- Every customer has different needs and Hanwha Power Systems has solutions for every customer. Samsung Compressor provide customized solutions for a vast range of applications.



Applications & Solutions

Whether customers operate onshore or offshore, Hanwha Power Systems will apply its specialized technology and expertise to deliver the best solution for customers' needs.



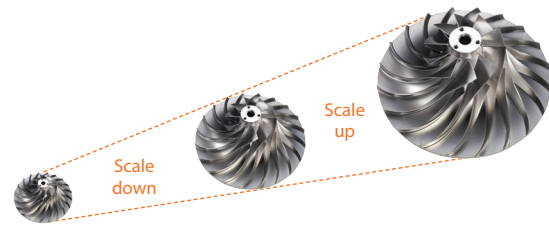
Market	Application	Air compressor (API672)	Gas compressor (API617)	Expander (API617)
Upstream / Offshore	Flash Gas, LP, MP		•	
	Vapor Recovery		•	
	Instrument Air	•		
Oil Refinery	Make-up, Recycle, Booster (H ₂ , Wet)		•	
	Process Air	•	•	
	Instrument Air	•		
LNG	Boil off gas (Terminal, LNG Plant)		•	
	High Pressure (Terminal)		•	
	Low/High duty (LNGC, LNG FPSO)		•	
Petro-chemical	Recycle, Booster (PE, PP)		•	
	Refrigeration (Propane, Propylene)		•	
	PTA	•	•	•
	Boil Off Gas		•	
Power Plant	Instrument Air	•		
	Fuel Gas Booster	•	•	
	N ₂ booster (IGCC)		•	
	Syngas		•	
Air Separation	Instrument Air	•		
	Main Air	•	•	
	Booster Air or N ₂		•	
Fertilizer / Gas Processing	Cryogenic Expansion			•
	Process Air	•	•	
	Process Gas (NG, NH ₃ , CO ₂)		•	
	N ₂ Booster		•	
Others	Instrument Air	•		
	NGL		•	•
	Mechanical Vapor Recompression		•	

Customized integration of 'Master' and 'Standard' parts allows Hanwha Power Systems engineered compressors to meet a wide range of applications. This provides the best design combination and optimized solutions for each customer's process.

The Master impellers

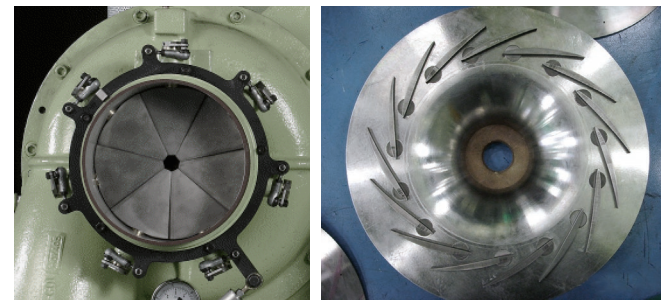
The master impellers are conceptual parent impellers from which various child impellers can be produced using aerodynamic scaling techniques.

- Allows for scaling design over a range of size and applications.
- Realize high efficiency, state-of-the-art performance.
- Established full line up for SE Series using 5 master impellers.



Inlet Guide Vanes

Inlet guide vanes (or Variable Geometry Diffuser) offer a wide operating range and excellent part load performance. This option is recommended for medium to high pressure ratio applications and when there will be substantial changes in demand pressure as a function of capacity. Inlet guide vanes can be installed on the first stage only, or on all stages.



Standard Gearbox Concept

allows high efficiency and modularity in design that minimizes time and costs. This Standard helical gears are designed to AGMA 6011 service factors (design to API 617 is optional).

The pinion gear and bull gear teeth are nitrided carburized, and ground.



High Reliability Bearing

5 Tilting pad journal bearing for high speed pinion, sleeve journal and taper land thrust combined bearing for bull shaft.

Thrust collars on pinion gear are designed to manage thrust loads and provide high reliability in a variety of applications.



Seals

eliminate or minimize the outward leakage of process gas and/on inward leakage of air into the compressor case.

The type of seal (Labyrinth/ Carbon Ring/ Dry gas Seal) applied depends upon the process requirements. Gas seal support systems are designed and tested per API specification.



Lubrication System Per Duty and Application

Lubrication systems are basically designed in accordance with API standards.

- API 614 Part 2, special-purpose oil system for the most of process and gas application
- API 614 Part 3, general-purpose oil system for the application with stand-by unit



The Oil & Gas industry works with the exploration and recovery of energy resources such as crude oil, natural gas, transportation, re-processing, commercialization and delivery to the end customer. These processes can be divided into three major streams, and Hanwha Power Systems supports every process of this industry. Hanwha Power Systems can apply API codes on and design compressors to API672 and API617, including oil systems to API614.

API 617 Process Compressor

- VRU (Vapor Recovery Unit) Gas Compressor
- Feed /Fuel Gas Compressor
- Dryer regeneration compressor
- Tail Gas Compressor
- Instrument Air Compressor
- Hot Gas Expander for power recovery
- Refrigerant (C₃, MR and other refrigerant) Compressor
- Flash Gas, LP, MP Compressor
- Process Gas (NG, NH₃, CO₂) Compressor
- N₂ Booster Gas Compressor
- Process Blower(SRU, Carbon Black, Gasification, etc.)

API 672 Air Compressor

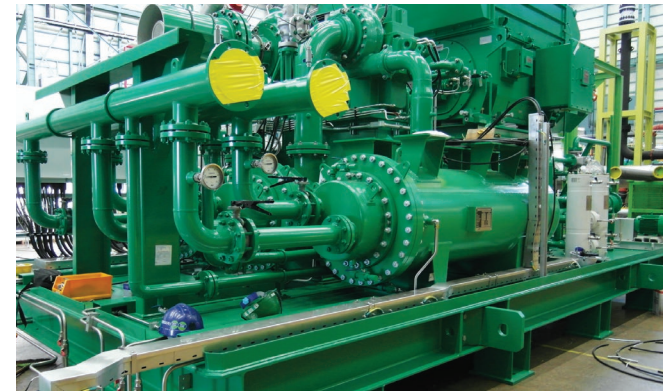
- Instrument Air Compressor
- Combustion Blower



Process Air Blower for Sulfur Recovery Unit



Process Air Blower for Carbon Black



Instrument Air Compressor for Floating Liquid Natural Gas Plant



Compressor for Hydrogen Peroxide(H₂O₂) Process

Vapor Recovery Unit

The world 1st "Integrally Geared Turbo Compressor" for Offshore VRU application

VRU Compressor is the component which re-compresses gas vapor which is the by product from the oil storage tank and passes it back to the main gas compressor.

Target

Offshore Platform Zero Continuous Flaring

Installation

Lethal service with H₂S content of 23.787 mol%, SO₂ and more than 50ppm traces of Chlorides at the inlet stream



VRU Compressor for Offshore artificial island

Petrochemical

Reliability is one of the key considerations in equipment selection as it plays an important role in safety and cost savings especially for petrochemical industry. Therefore stringent specifications for the equipment are required. Hanwha Power Systems provides various air and gas solutions for a wide range of applications in the petrochemical industry, and receives favorable evaluations from the customers. Reliable and efficient solutions to meet the customers' requirements as well as API specifications are successfully operated all over the world.

Key design features

- Designed to API code requirements as well as customer specifications
- Completely packaged, self contained water to air cooling circuit
- The use of water cooled heat exchangers and closed circuit water to air cooling system
- Maintain high efficiency for operating economy
- Meet client's recognized high standard of design and engineering
- Low noise level of core design to allow uninterrupted access to the full skid without using sound canopy



Process Gas Compressor for Fertilizer Facility

Mechanical Vapor Recompression

Efforts to minimize energy loss have been made to confront rising energy costs and to improve efficiency in various industry applications. Steam Compressors for MVR (Mechanical Vapor Recompression) supply steam from distillation towers (at petrochemical plants) and convert it to an additional heat source for reboilers to improve the overall system efficiency. Steam compressors introduced by Hanwha Power Systems will minimize energy loss by recompressing the low pressure waste steam and recycling it as a heat source back into the process, in effect recovering the previously lost heat value of the steam that used to be vented to atmosphere.



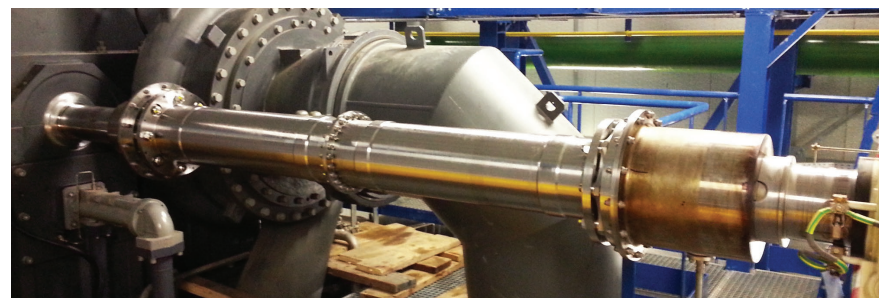
Steam Compressor for Mechanical Vapor Recompression

Air Separation

Air separation, a key process in industrial manufacturing for over 100 years, still remains integral to efficient operations. Moreover, Today it grows even more significant, as its demand increases. Various manufacturing processes require oxygen, nitrogen and argon gases from air separation, and compressors are used in the process to produce the purified products. Hanwha Power Systems has been strengthening its position in the market through successfully providing air and gas compressors to diverse customers.

Hanwha Power Systems can supply main air compressors, nitrogen or air boosters, cryogenic expanders, etc.

- MAC (Main Air Compressor)
- MNC (Main Nitrogen Compressor)
- Nitrogen Booster Compressor
- BAC (Booster Air Compressor)
- RNC (BNC, Recycle Nitrogen Compressor)
- Cryogenic expander



Air Compressor for Air Separation Plant



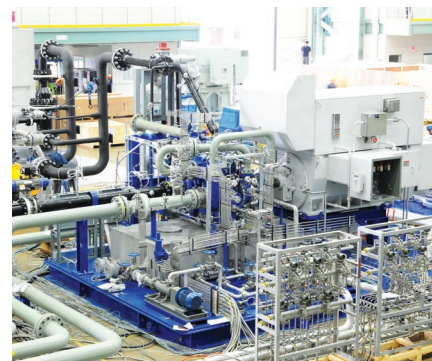
Air Compressor for Air Separation Plant



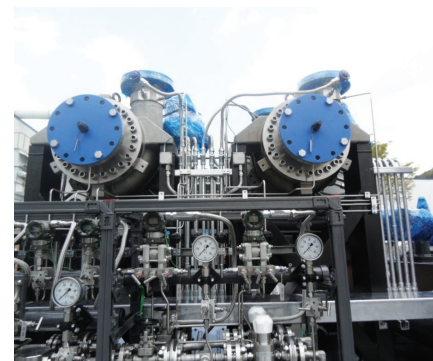
LNG market demands the solutions with high reliability based on the latest technology to ensure stable operations. LNG process requires equipment to operate at cold temperatures (-160 degC), so special design considerations must be met. Although stored as a liquid, LNG sees some evaporation (or boil off gas) which occurs as the liquid adsorbs some heating during storage or transport of the product. Some of this gas is re-liquefied, and some is used as fuel for the propulsion of the LNG carrier's shipboard engines and power generation systems. Hanwha Power Systems is one of the fastest growing players to overcome the many difficulties and gain entry into this LNG market with its Boil Off Gas (BOG) compressors, high pressure process gas compressors, and expanders.



Boil Off Gas Compressor for LNG Terminal



High Pressure Compressor for LNG Terminal



Cryogenic Expander for LNG Liquefaction Plant



LD & HD Compressor for LNG Carriers

Compact Design

- Integrally geared compressor with SE series gearbox, integrated lube-oil system, seal gas system and accessories on a common rigid skid achieving very compact footprint

High Performance

- State-of-the-art 5-axis machined Impellers and overhung volutes
- Thrust bearings used for better clearance control between impellers and casings

Reliable & Flexible Operation

- Designed to meet API 617 and 614 standard based on SE series
- Tilting Pad Journal Bearings for very reliable operation
- Simple and adjustable IGV and VGD for flexible and wide operation

Oil Free Bulkhead Seal

- Gas type floating carbon ring seal on bulkhead for low maintenance cost and safe operation

Ship-class Certification for Marine Applications

- DNV and ABS Type approval
- Other certification options available upon customer request

LD Compressor

The multi-stage Low-Duty (LD) Compressor supplies fuel gas for LNG carriers, maintaining the cargo tank pressure and supplying boil-off gas to dual-fuel engine as fuel on the voyage.

- Wide operation using VGD (Variable Geometry Diffuser) on the first stage and two recycle loops for capacity control

HD Compressor

The single-stage High-Duty (HD) Compressor re-circulates gas on LNG carriers and terminals, and transfers heated gas back to cargo tank to warm up, and return LNG vapor or gas generated during loading or initial cool down to shore.

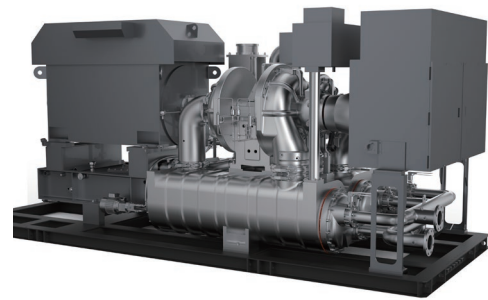
- Flexible operation using simple and reliable IGV (Inlet Guide Vanes)



Power generation industry is growing rapidly all over the world. Based on various experience, Hanwha Power Systems's Gas and Process solutions can meet power industry applications needs that maximize customer's productivity. Every energy plant has different pressure and capacity needs. We focus on customer's needs and the best efficiency.

Instrument Air Compressor

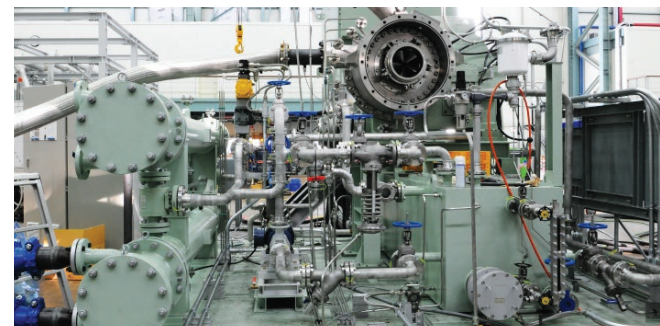
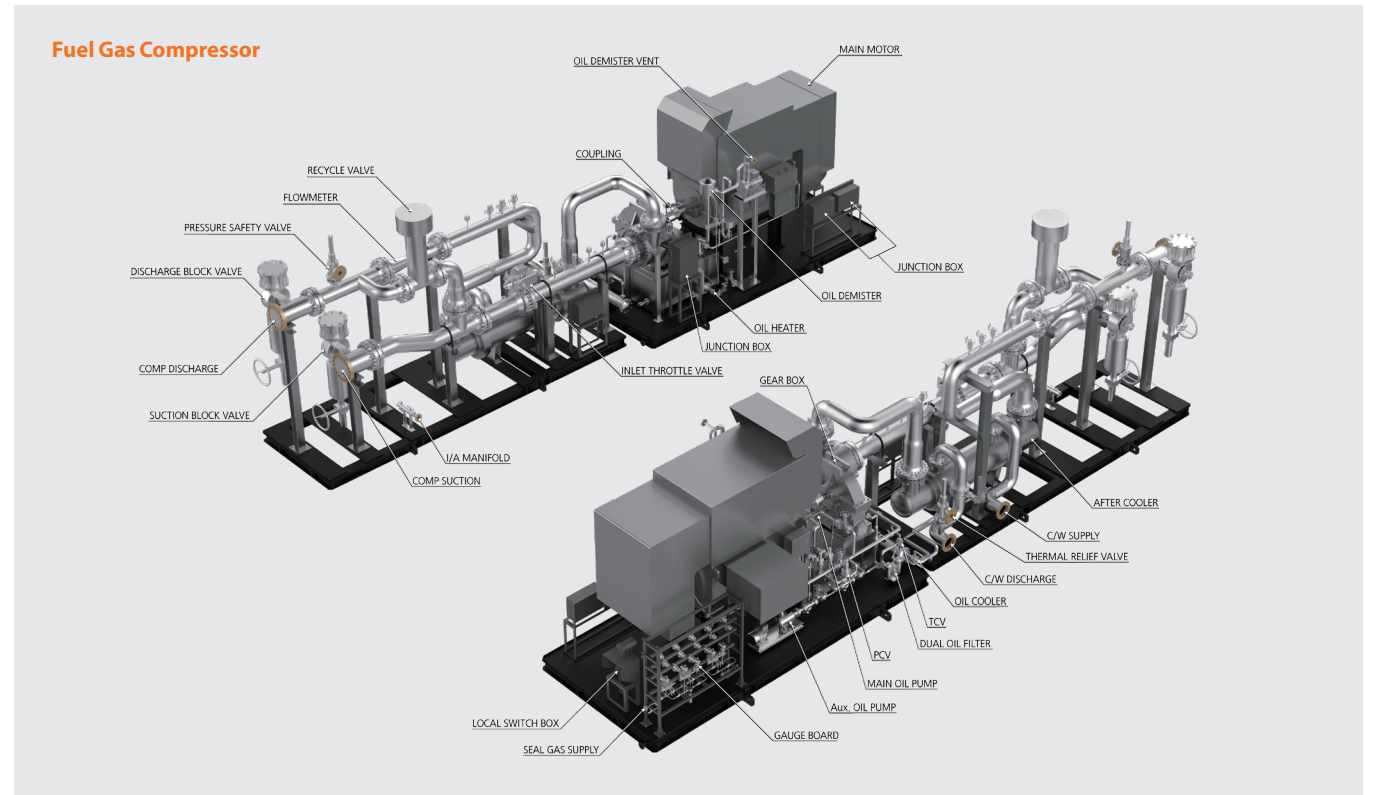
- Suitable for larger coal-fired power plants with a capacity over 1,000MW



Fuel Gas Compressor

- Industry proven parts and products
- Various experiences in operation with gas turbines
- Designed in accordance with customer's requirements
- Packaged by Hanwha Power Systems
- Valve skid & compressor skid package for easier site installation work

Fuel Gas Compressor



Fuel Gas Compressor for Combined Cycle Power Plant



Fuel Gas Compressor for Combined Heat & Power Plant

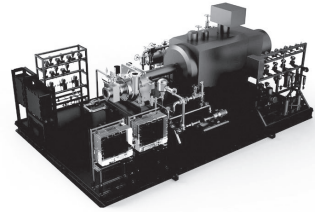


Fuel Gas Compressor for Cogeneration Plant



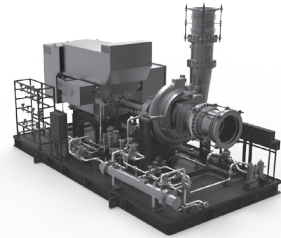
Instrument Air Compressor for Combined Cycle Power Plant

Offshore Platform(Sour Gas Service)



- VRU(Vapor Recovery Unit) Compressor**
- Model : SE-45G (Single-stage)
 - Capacity : 18 ton/h
 - Discharge pressure : 10 barA

Refinery



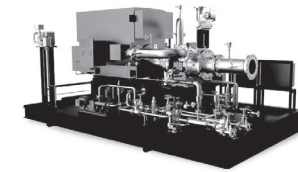
- Process Air Blower**
- Model : SE-45A
 - Capacity : 59,544 kg/hr
 - Discharge pressure : 1,753 kg/cm²A

LNG Storage



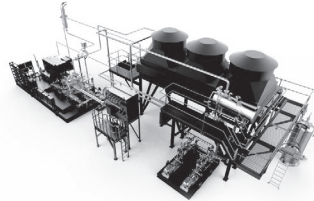
- High Pressure gas Compressor**
- Model : SE-45G (Six-stage)
 - Capacity : 20 ton/h
 - Inlet pressure : 9 barA
 - Discharge pressure : Max. 75 barA
 - Inlet temperature : -30 ~ 80°C

LNG Storage



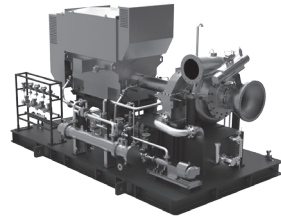
- Boil off gas Compressor**
- Model : SE-45G (Three-stage)
 - Capacity : 12,000 Nm³/h
 - Inlet pressure : 1 barA
 - Discharge pressure : 11 barG
 - Inlet temperature : -115°C

Oil & Gas



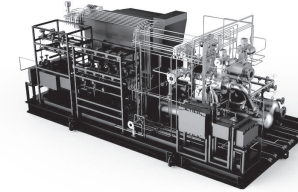
- Instrument Air Compressor**
- Model : SE-45A (Four-stage)
 - Capacity : 6,800 m³/h
 - Inlet pressure : 1 barA
 - Discharge pressure : 10 barG
 - Inlet temperature : 55°C

Petrochemical



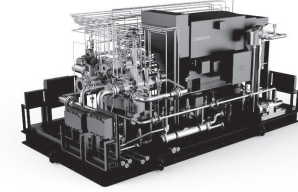
- Process Air Blower(Oxidation)**
- Model : SE-45A
 - Capacity : 45,926 kg/hr
 - Discharge pressure : 2,692 kg/cm²A

LNG Liquefaction



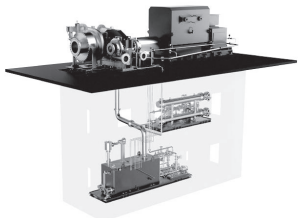
- C3 (Propane) Compressor**
- Model : SE-45G (Four-stage)
 - Capacity : 1,700 Nm³/h
 - Inlet pressure : 1.1 barA
 - Discharge pressure : 19 barG
 - Inlet temperature : -36°C

LNG Liquefaction



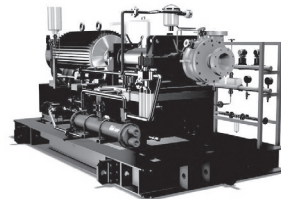
- MR (Mixed Refrigerant) Compressor**
- Model : SE-45G (Six-stage)
 - Capacity : 9,800 Nm³/h
 - Inlet pressure : 4 barA
 - Discharge pressure : 64 barA
 - Inlet temperature : -36°C

Petrochemical



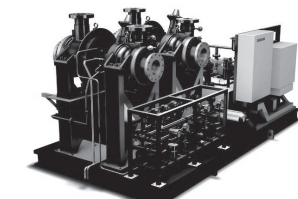
- Steam Compressor for Mechanical Vapor Recompression**
- Model : SE-82V (Four-stage)
 - Capacity : 55 ton/h
 - Inlet pressure : 2.7 barA
 - Discharge pressure : 19 barA

Petrochemical



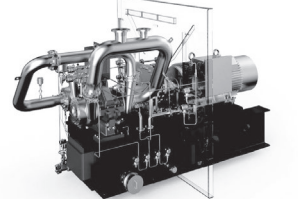
- Process Gas Compressor (API 617)**
- Model : SE-32N
 - Capacity : 31,345kg/hr
 - Discharge pressure : 6.8kg/cm²A

LNG Liquefaction



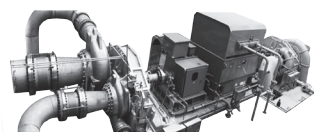
- Expander for Cryogenic or Refrigerant Cycle**
- Model : SE-45N (Four-stage)
 - Capacity : 65 ton/h
 - Discharge temperature : -163°C
 - HP & LP expander + Comp.
 - Cryogenic Turbo Expander for natural gas liquefaction

LNG Transportaion



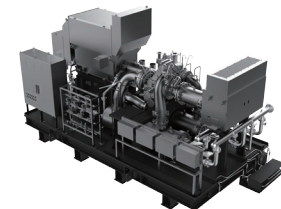
- Low Duty Compressor**
- Model : SE-32G (Three-stage)
 - Capacity : 4,750 m³/h
 - Inlet pressure : 1 barA
 - Discharge pressure : 5.0- 6.5 barA
 - Inlet temperature : -140- 40°C

Petrochemical(PTA)



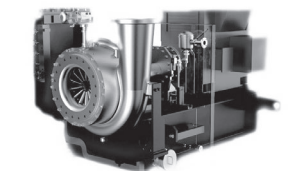
- Compressor Expander Package**
- Model : SE-110A (Four-stage)
 - Capacity : 102,000 Nm³/h
 - Discharge pressure : 16 barA

FLNG



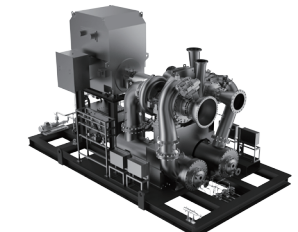
- Instrument Air Compressor**
- Model : SE-45A (Three-stage)
 - Capacity : 10,000 Nm³/h
 - Inlet pressure : 1 barA
 - Discharge pressure : 10.5 barG
 - Inlet temperature : 50°C

LNG Transportaion



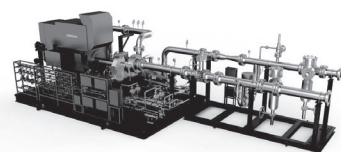
- High Duty Compressor**
- Model : SE-32G (Single-stage)
 - Capacity : 34,000 m³/h
 - Inlet pressure : 1 barA
 - Discharge pressure : 2 barA
 - Inlet temperature : -140°C

Chemical



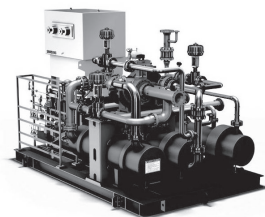
- Comander**
- Model : SE-65A/N
 - Compressor
 - Capacity : 26,000Nm³/hr
 - Pressure : 1 → 7.76barA
 - Expander
 - Capacity : 21,000Nm³/hr
 - Pressure : 6.2 → 1.15barA

Power Generation



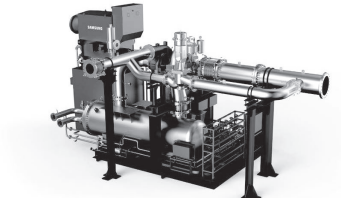
- Fuel gas booster**
- Model : SE-45G (Single-Stage)
 - Capacity : 70 ton/h
 - Inlet pressure : 28 barA
 - Discharge pressure : 40 barG

Power Generation



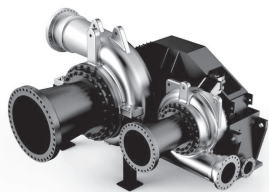
- Fuel gas Compressor**
- Model : SE-45G (Three-Stage)
 - Capacity : 15 ton/h
 - Inlet pressure : 6 barA
 - Discharge pressure : 58 barA
 - Inlet temperature : 42°C

Power Generation



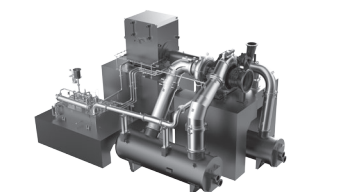
- Flue Gas Compressor**
- Model : SE-82G (Two-stage)
 - Capacity : 24,000 Nm³/h
 - Inlet pressure : 0.05 barA
 - Discharge pressure : 1.5 barA
 - Inlet temperature : 80°C

Power Generation



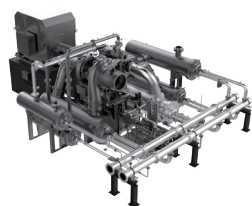
- Hot Gas Expander for Power Recovery**
- Model : SE-110G (Two-stage)
 - Capacity : 113,000 Nm³/h
 - Inlet pressure : 9.3 barA
 - Discharge pressure : 1 barA
 - Inlet temperature : 140°C

Air Separation



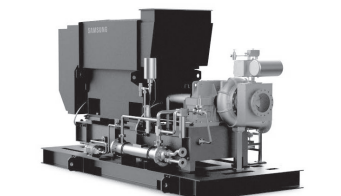
- Main Air Compressor (MAC)**
- Model : SE-110A (Three-stage)
 - Capacity : 126,000 Nm³/h
 - Discharge pressure : 6.2 barA

Air Separation



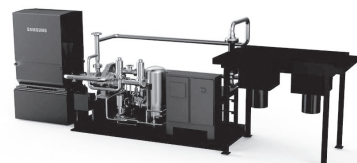
- MAC/BAC combo**
- Model : SE-82A (Six-stage, 4+2)
 - Capacity : 39,000 Nm³/h & 16,000 Nm³/h
 - Discharge pressure : 13.5 barA & 39 barA

Air Separation



- Nitrogen Booster Compressor**
- Model : SE-45N (Single-stage)
 - Capacity : 62,500 Nm³/h
 - Inlet pressure : 5 barA
 - Discharge pressure : 9.1 barG

Wind Tunnel Test



- High Pressure Air Booster**
- Model : SE-45A (Two-stage)
 - Capacity : 63,000 Nm³/h
 - Inlet pressure : 35 barA
 - Discharge pressure : 75 barA

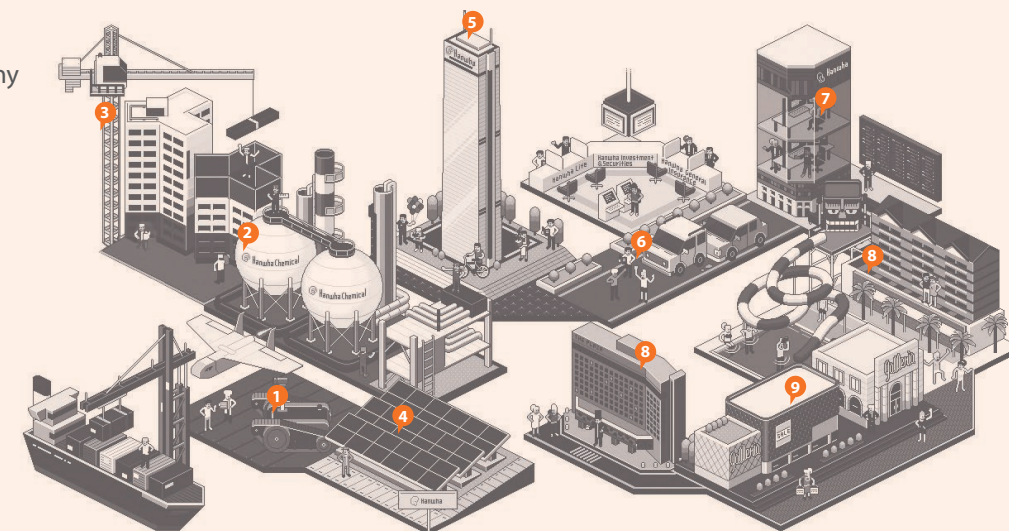
Introduction to Hanwha Group

Hanwha Businesses

a FORTUNE Global 500 Company

64 years of business experience with 190 global networks

2015 Total assets of \$146billion and total sales of \$53billion



Manufacturing & Construction

- Hanwha Corporation ❶
- Hanwha Techwin ❶
- Hanwha Power Systems ❶
- Hanwha Land Systems ❶
- Hanwha Precision Machinery ❶
- Hanwha Thales ❶
- Hanwha Chemical ❷
- Hanwha General Chemical ❷
- Hanwha Total Petrochemical ❷

Finance

- Hanwha Fine Chemical ❷
- Hanwha Engineering & Construction ❸
- Hanwha Q CELLS ❹
- Hanwha Q CELLS Korea ❹
- Hanwha Advanced Materials
- Hanwha Energy
- YEOCHUN NCC
- Hanwha City Development

Services & Leisure

- Hanwha Life ❺
- Hanwha General Insurance ❻
- Hanwha Investment & Securities ❼
- Hanwha Asset Management ❻
- Hanwha Investment
- Hanwha Savings Bank
- Hanwha Hotels & Resorts ❶
- Hanwha Galleria ❸
- Hanwha Galleria Tmeworld
- Hanwha 63 City ❸
- Hanwha S&C
- Hanwha Station Development

Global Network

190 Global Networks (As of June 2015)

58 Affiliates all over the world

- | | | | |
|-----------------|-------------------|--------------|--------------|
| Ponitac | London | Bismayah | Seoul |
| Chicago | Weybridge | Kuwait city | Tokyo |
| Bremen | Aix-en-Provence | Tehran | Nagasaki |
| Franklin | Stuttgart | Dubai | Fukuoka |
| London(Ontario) | Warsaw | Baghdad | Shenzhen |
| Forest | Eschborn | Almaty | Chongqing |
| New York | Ismaning | Mumbai | Guangzhou |
| Cranbury | Bitterfeld-Wolfen | New Delhi | Beijing |
| Bakersfield | Berlin | Yangon | Lingyungang |
| Irvine | Dietfurt | Bangkok | Hangzhou |
| Shelby | Diosd | Samut Prakan | Ningbo |
| Hawaii | Budapest | Ho Chi Minh | Zhangjiagang |
| Monterrey | Moscow | Phnom Penh | Shanghai |
| Hartford | Frydek-Mistek | Selangor | Qidong |
| Teaneck | Bolzano | Kuala Lumpur | Suzhou |
| Ridgefield park | Athens | Singapore | Dongguan |
| Opelika | Istanbul | Jakarta | Tianjin |
| Monroe | | Manila | Hong kong |
| Sao Paulo | | Saipan | Taipei |
| Santiago | | | Sydney |
| | | | Johannesburg |

