

Mitsui TOP PRESSURE RECOVERY TURBINE

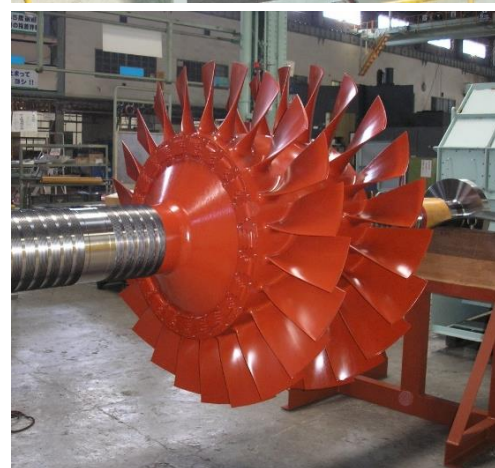
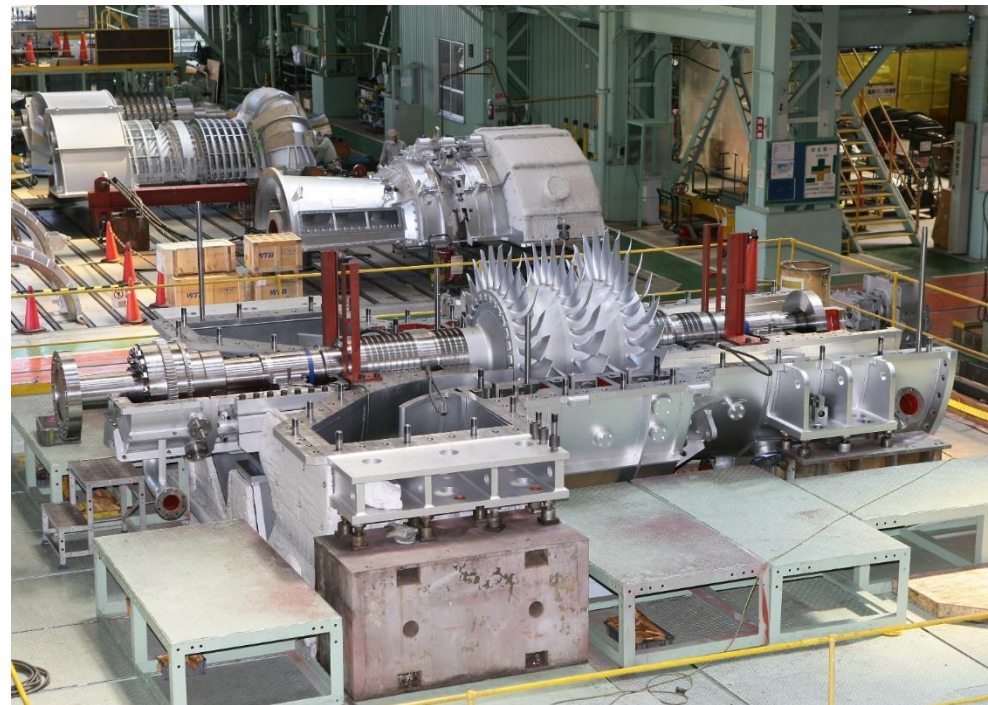
Top pressure Recovery Turbine

An energy saving system, which generates electric power by energy from Blast Furnace Exhaust gas and contributes to conservation of the environment.

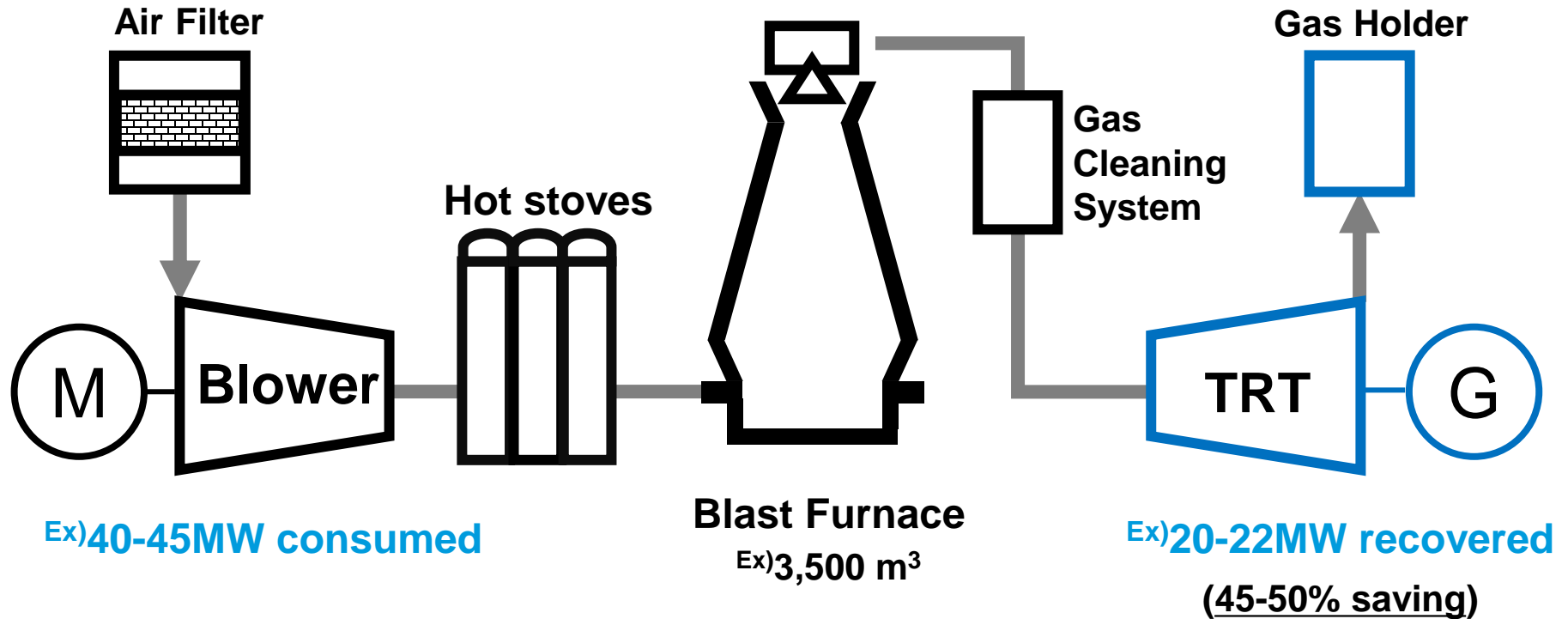
High efficiency, reliability, and durability

- Total 79 units delivered
- World's largest Wet type TRT 33MW
- World's largest Dry type TRT 40MW
- Longest life operation of 38 years
- Easy maintenance

Mitsui TRT adapting axial flow type can handle small to large gas volume and provide wide range of generator output 2,500kW to 40,000kW



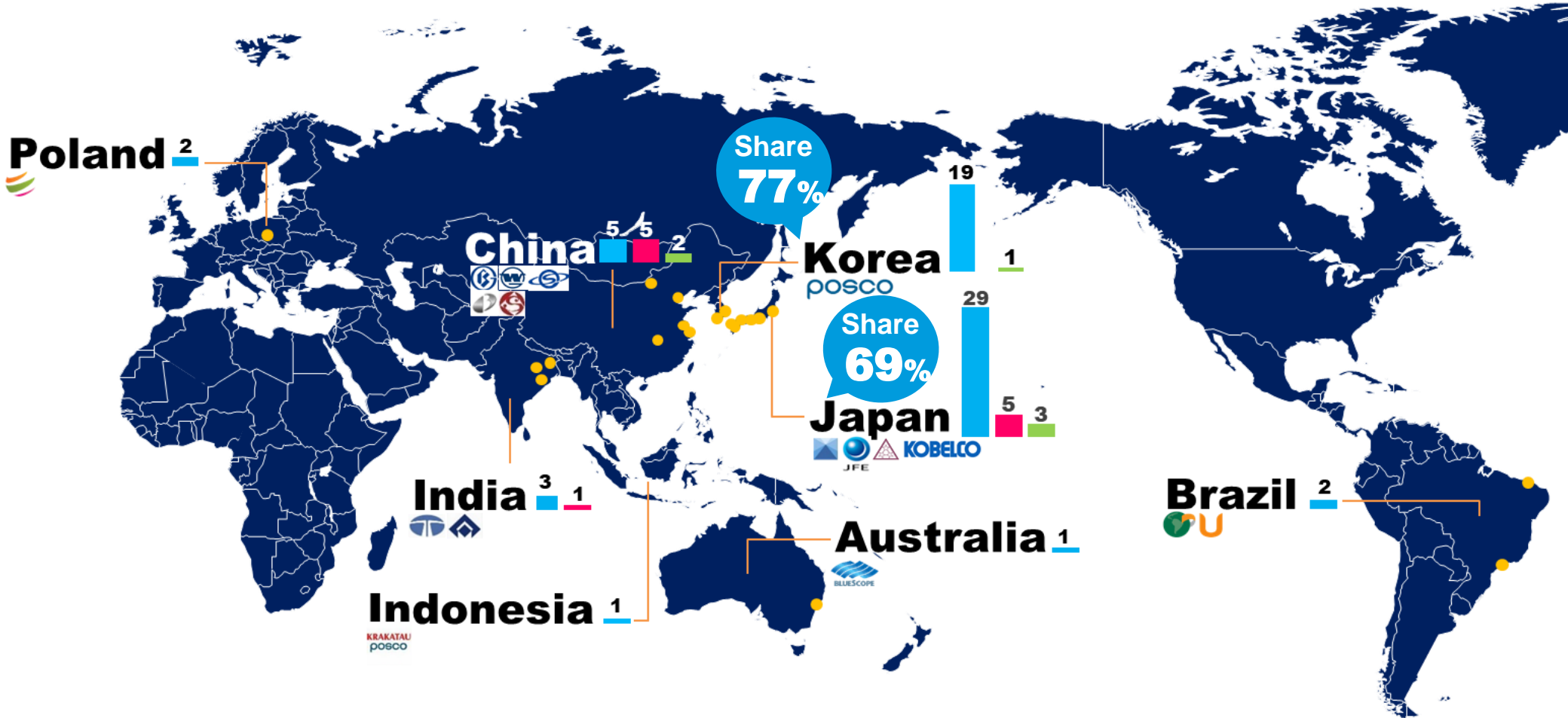
Application of TRT for Blast Furnaces



Supply Record in the Overseas Market

Grand Total: **1,649,281 kW**

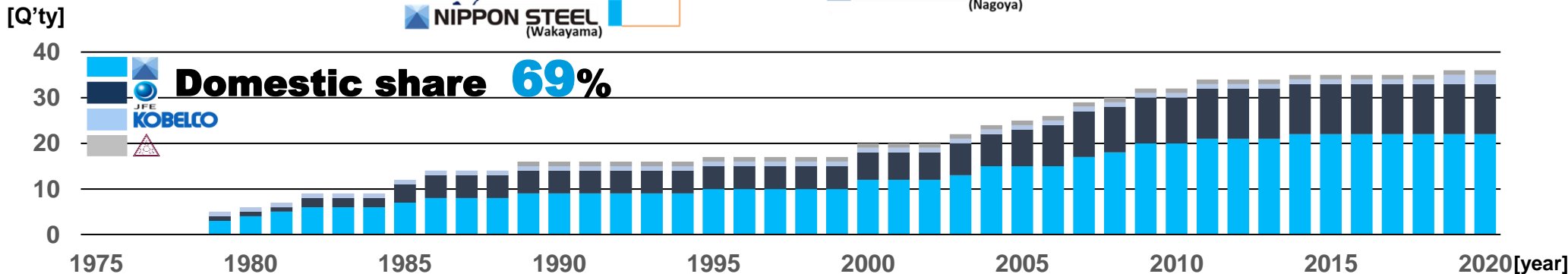
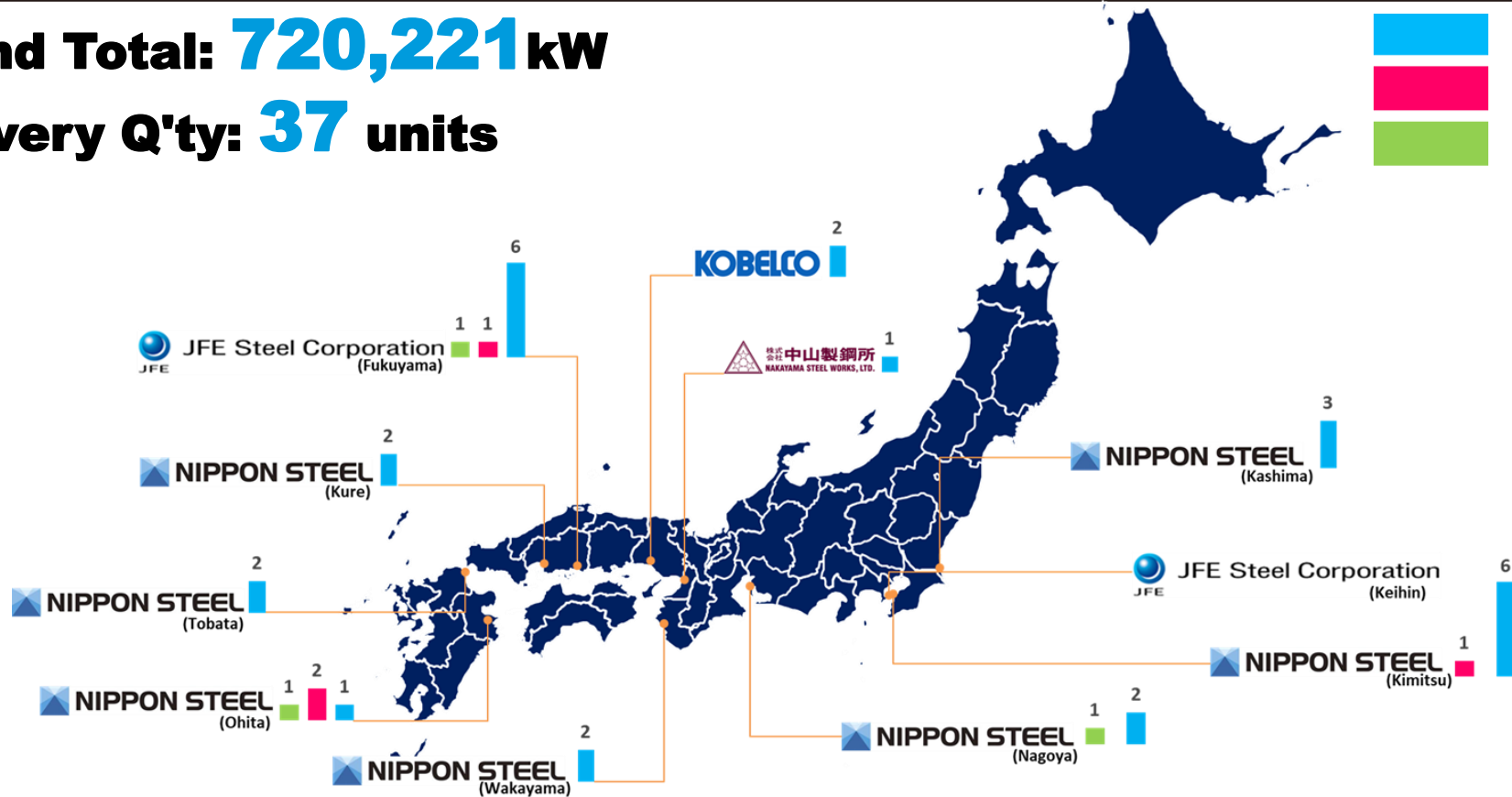
Delivery Q'ty: **79 units**



Supply Record in the Domestic Market

Grand Total: **720,221 kW**

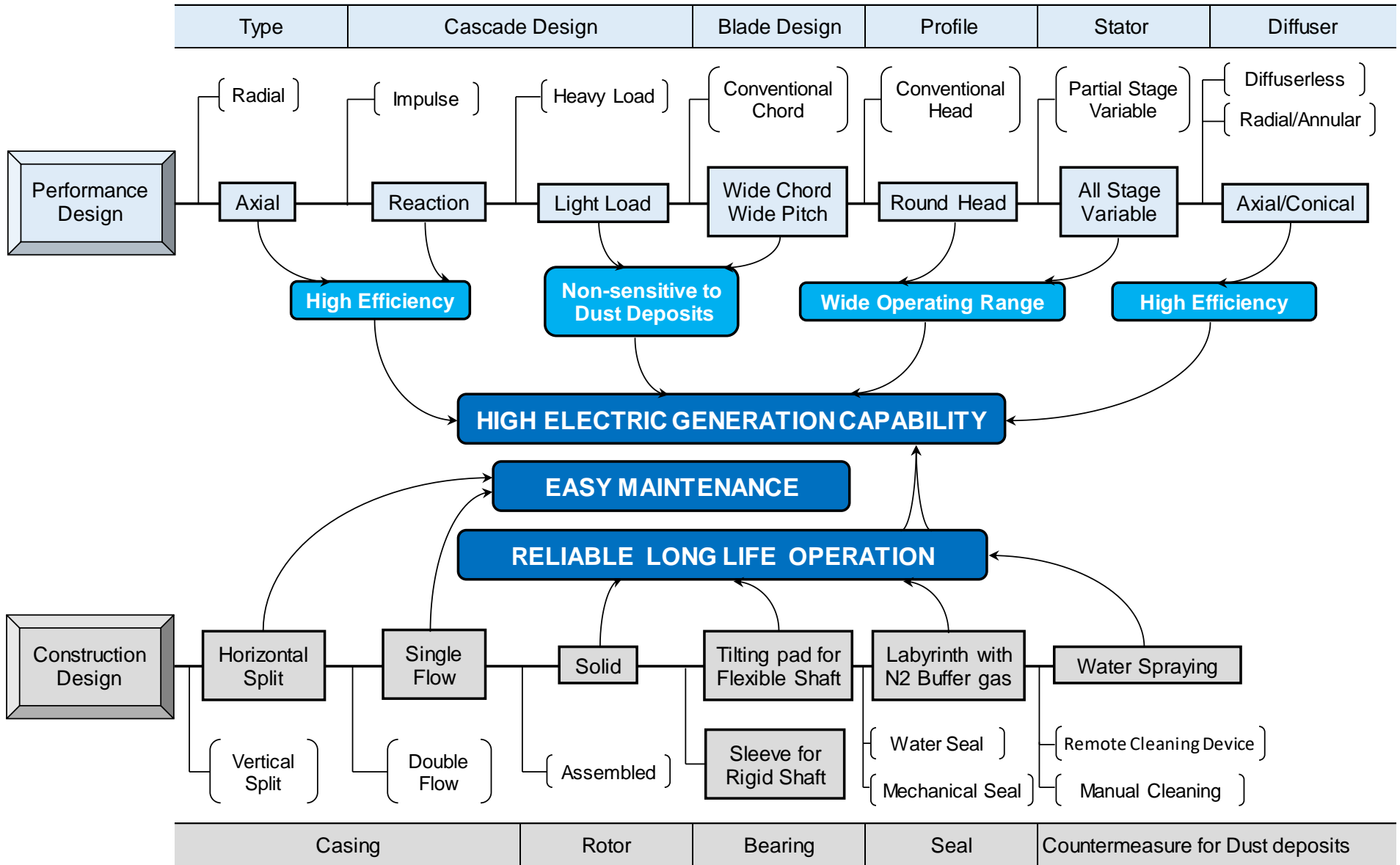
Delivery Q'ty: **37 units**



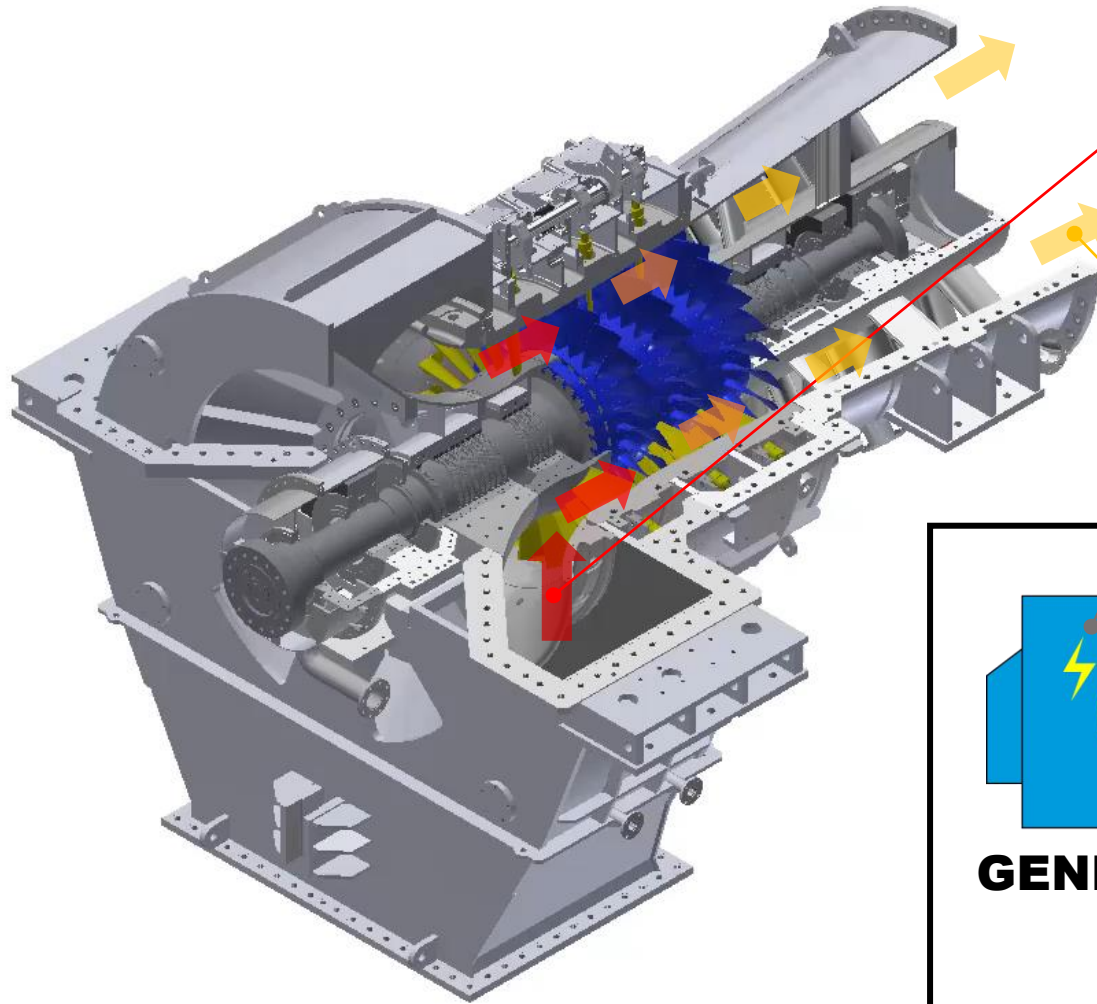
Features of TRT (Summarized)

- 1. Original Design & Technology**
- 2. High Electric Power Generation Capability**
- 3. Wide Operation Range**
- 4. Higher Efficiency and Longer Lifespan**
- 5. Dry, Wet and Hybrid Type**
- 6. Easy Maintenance and Long Lifetime**
- 7. High Reliability and High Efficiency**

Features of TRT (Detailed)



Overview of Typical TRT



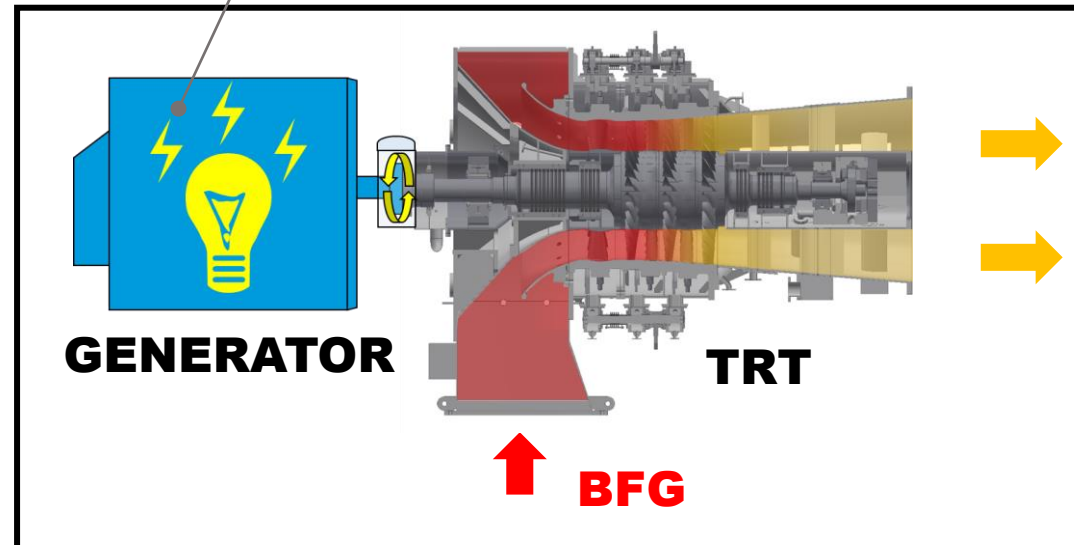
Inlet Condition (Ex: WET / DRY Type)

Inlet temp. : 60/200 [°C]
Inlet pressure : 200/250 [kPa]
Gas flow rate : 700/700 [kNm³/h.dry]

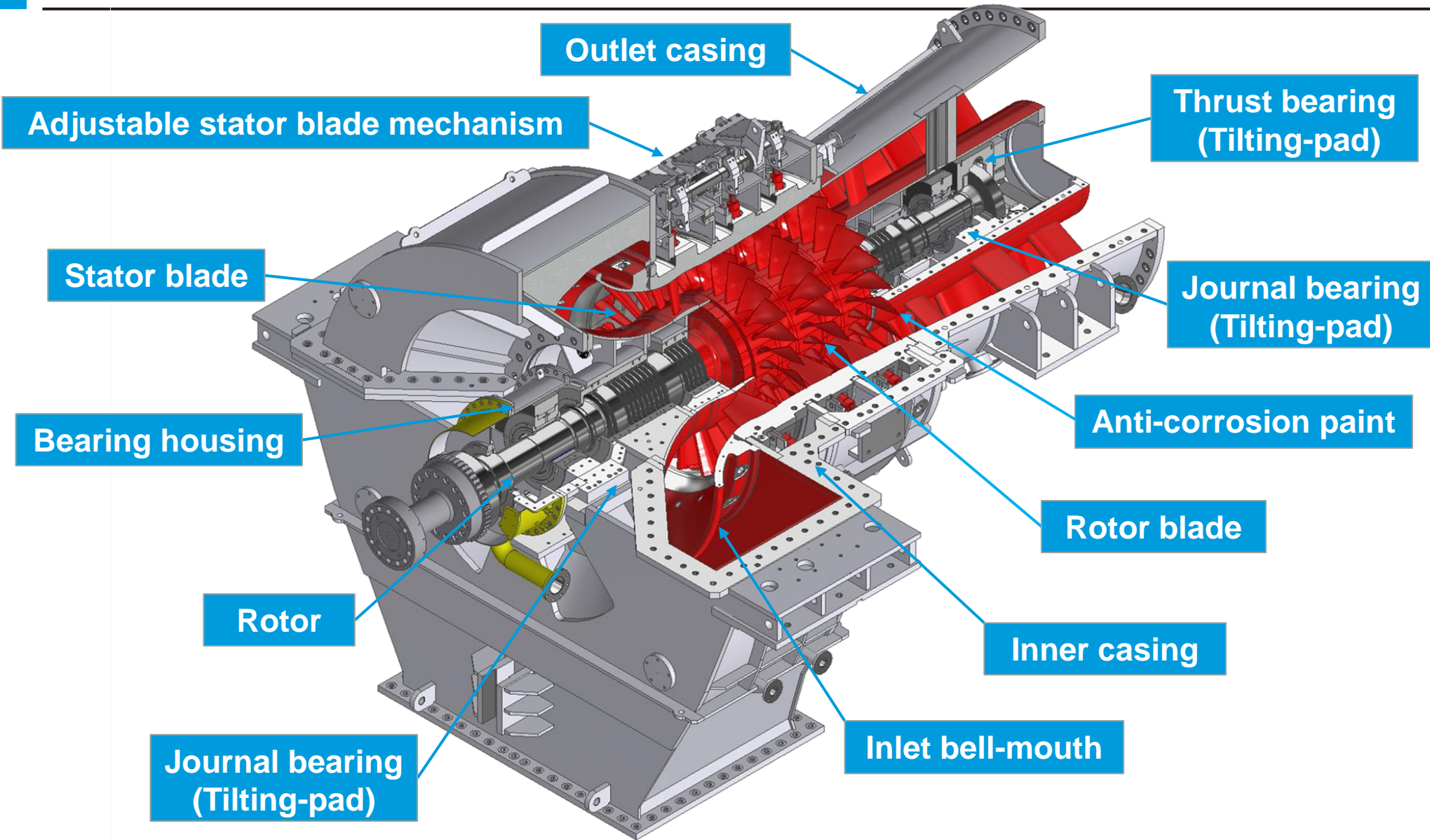
Outlet Condition (Ex: WET / DRY Type)

Outlet temp. : 29/95 [°C]
Outlet pressure : 10/10 [kPa]

Generator output : 22,500/30,000 kW



3D Model



Types of Notation for TRT Models

MAT – SERIES;

MAT

□

□

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□

Example) MAT 160 D - 3
MAT 140 W - 2

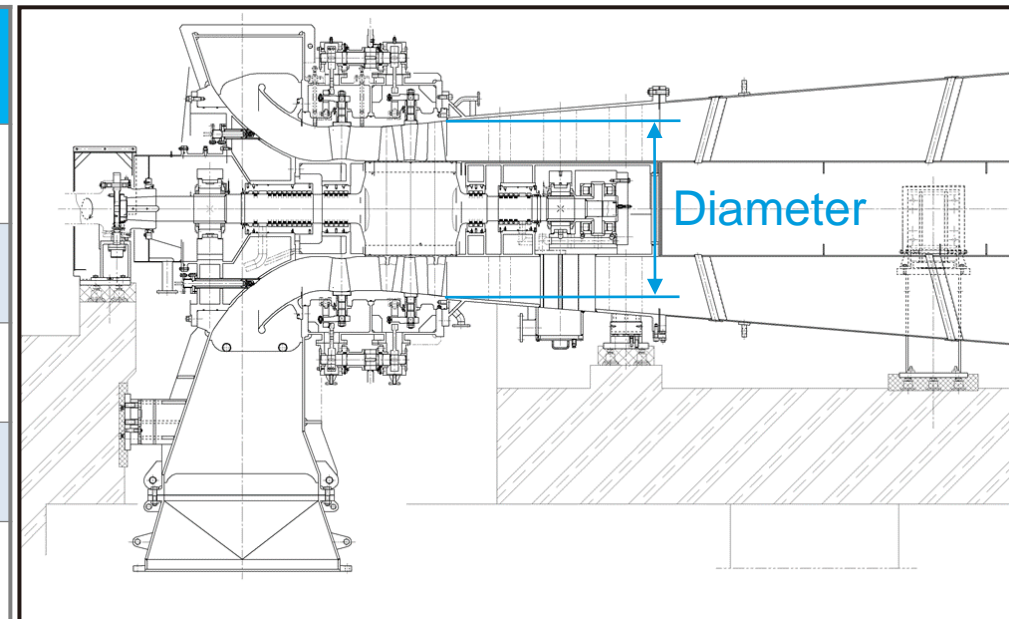
CASING SIZE
(Diameter [cm])

GAS type
W: Wet GAS
D: Dry GAS

Number of Stage

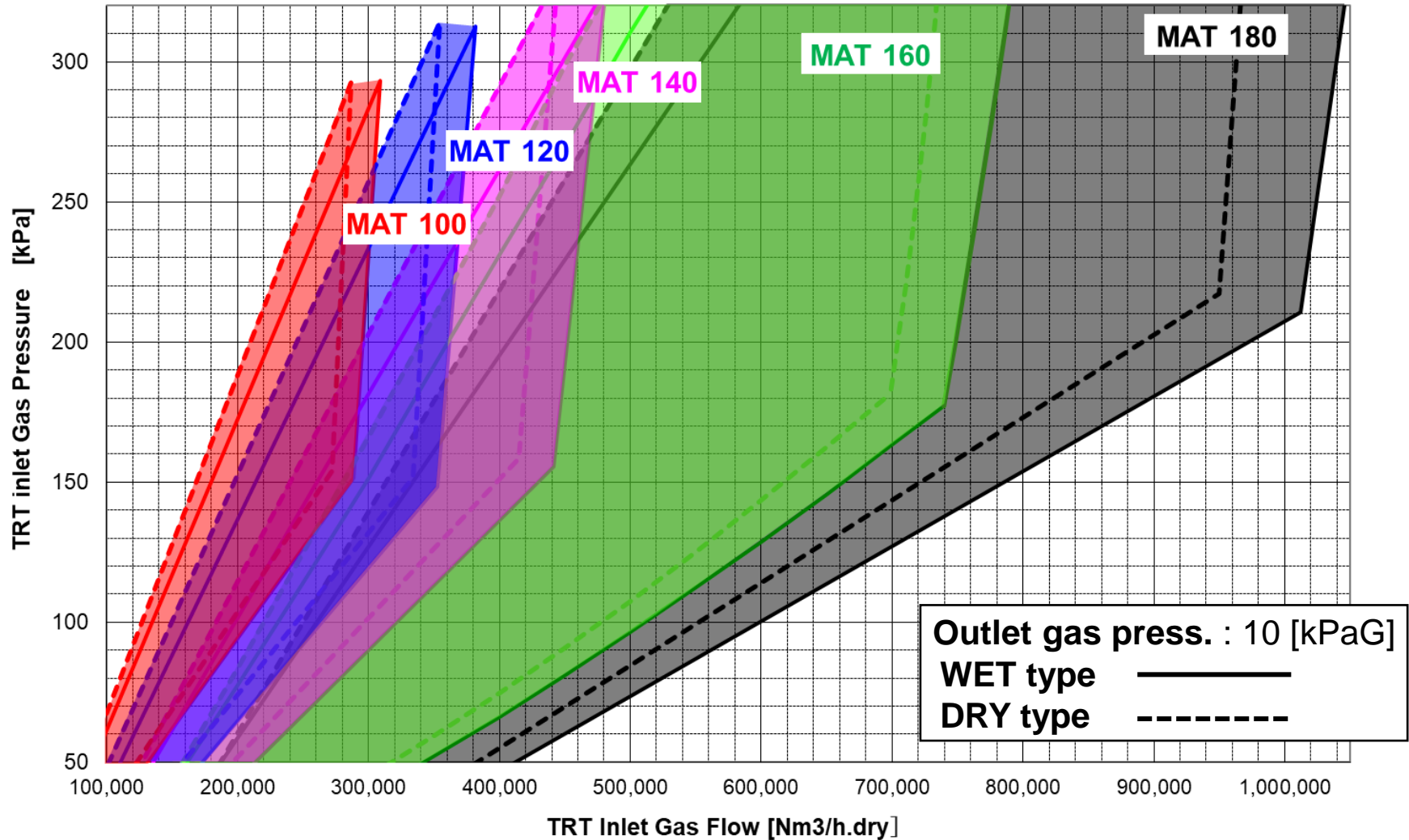
MAT : Mitsui Axial Turbine

MAT-(SERIES)	Type	Estimated Gas Flow Range (Nm ³ /h.dry)	Expected Power (MW)
100	Dry	80,000 ~ 290,000	11.0
	Wet	80,000 ~ 310,000	10.0
120	Dry	100,000 ~ 350,000	14.0
	Wet	105,000 ~ 355,000	13.0
140	Dry	112,500 ~ 440,000	18.0
	Wet	117,500 ~ 460,000	16.5
160	Dry	175,000 ~ 780,000	30.5
	Wet	185,000 ~ 780,000	28.0
180	Dry	260,000 ~ 970,000	40.0
	Wet	270,000 ~ 1,040,000	37.5



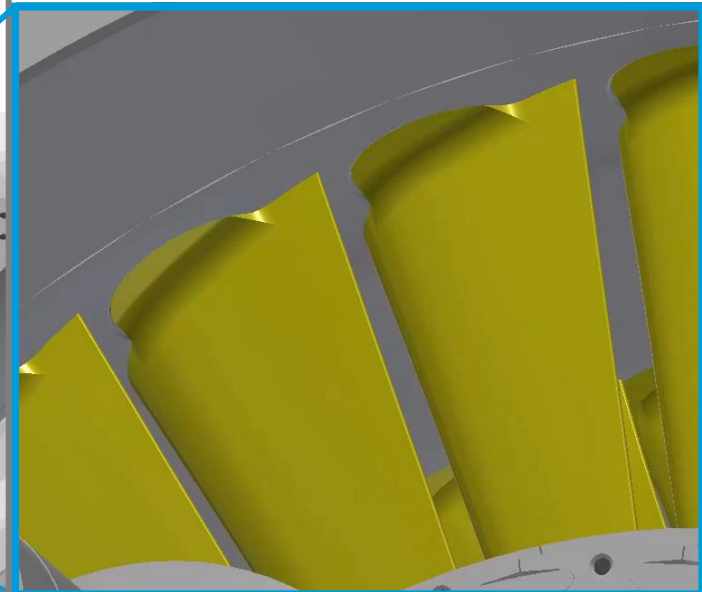
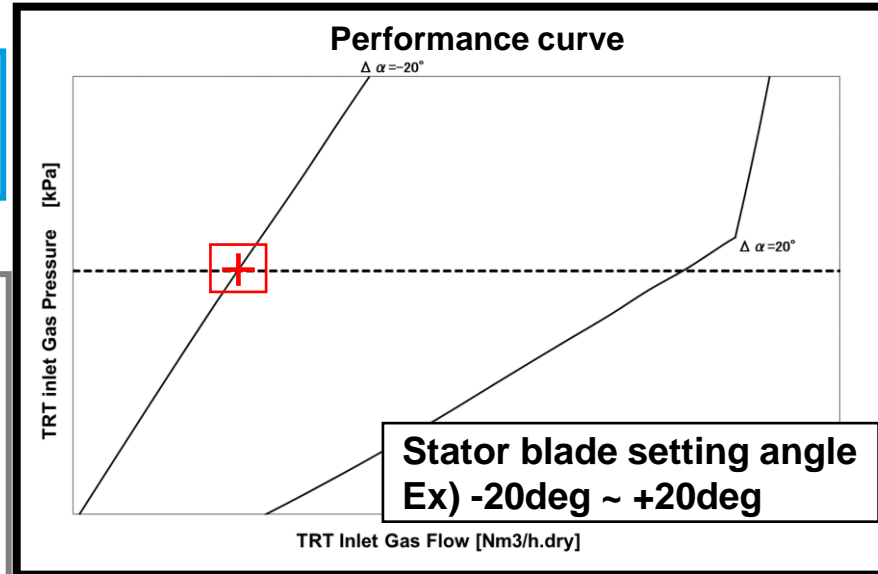
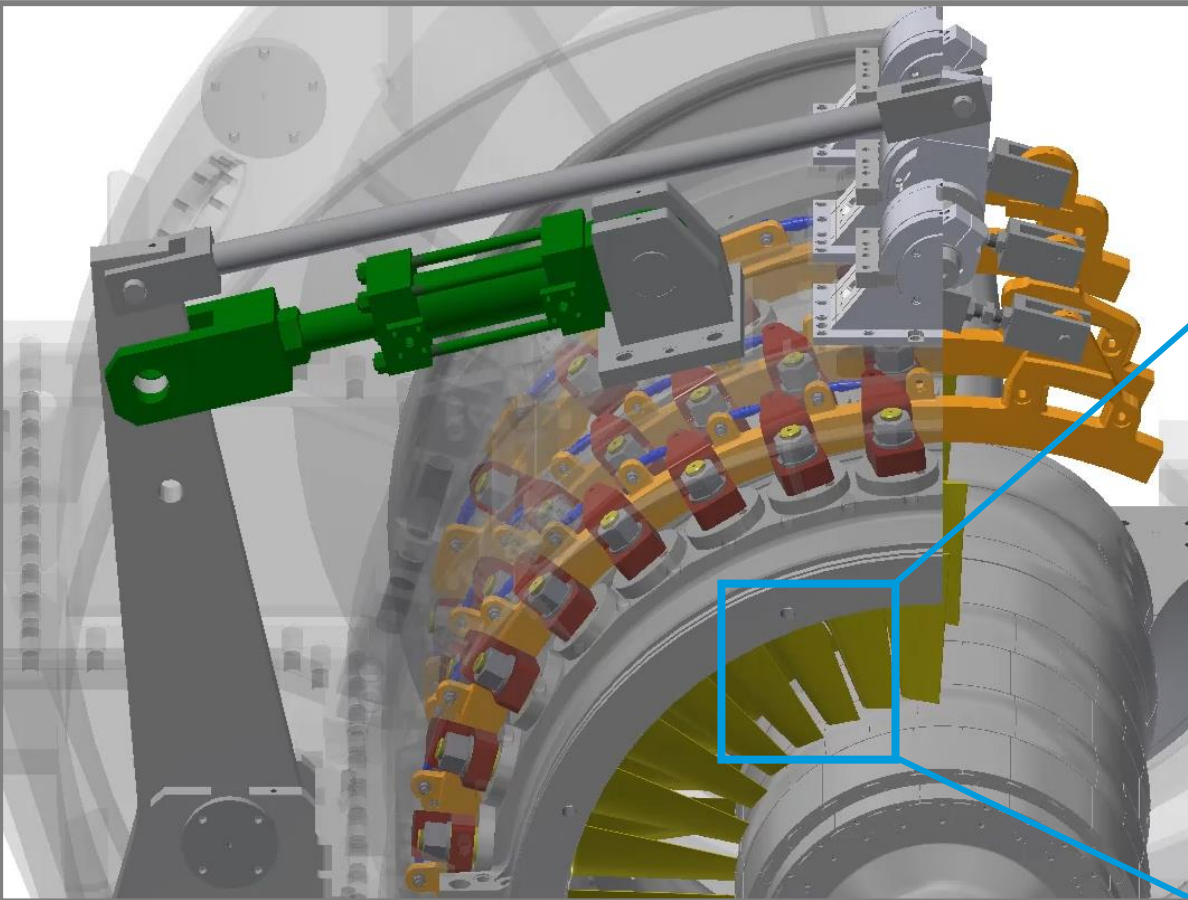
Operation Range of Wet & Dry Types

Wide range operation can be achieved for both WET and DRY types



All-Stage Adjustable Stator Blade Mechanism

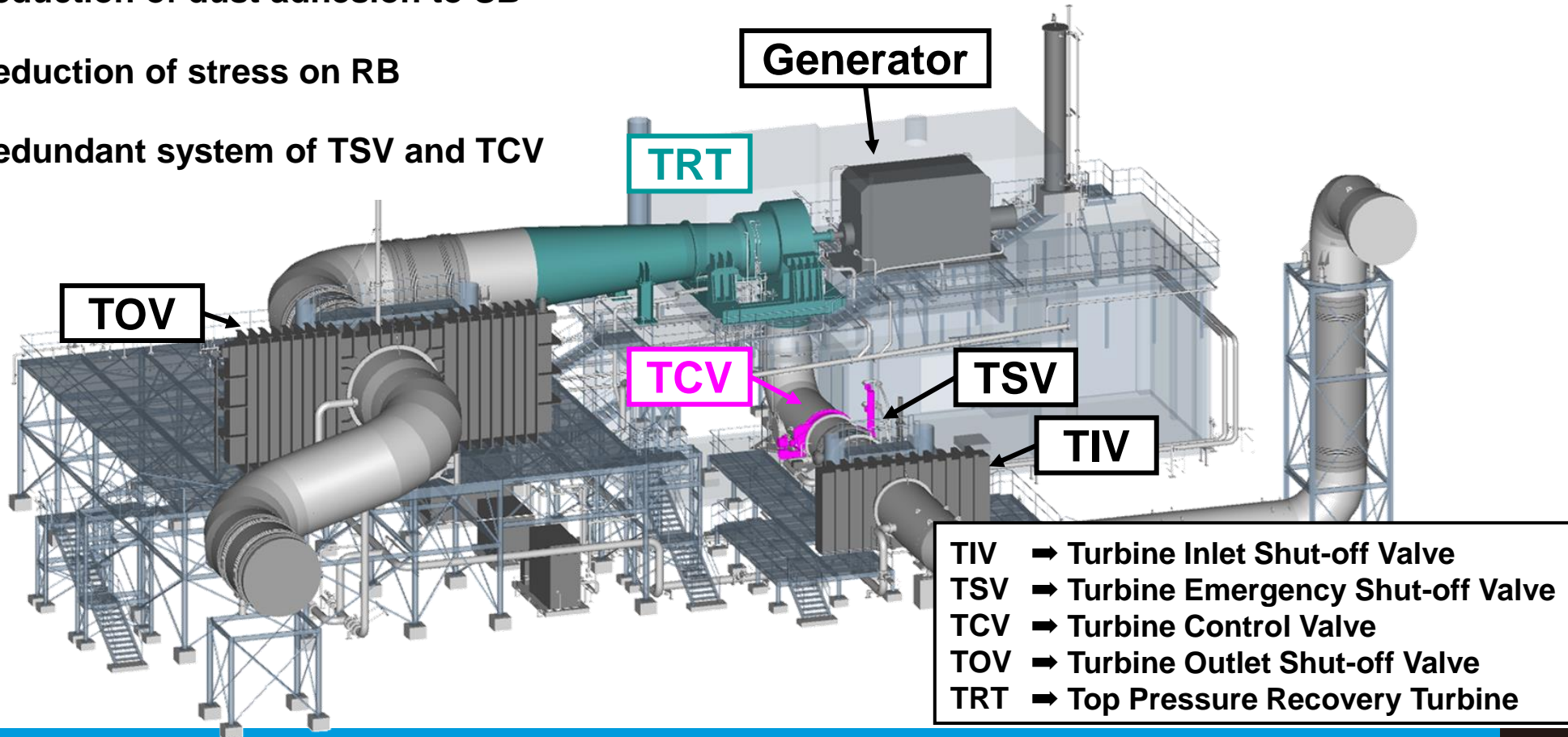
Gas flow can be regulated precisely corresponding to the fluctuation by [adjustable stator blade mechanism](#).



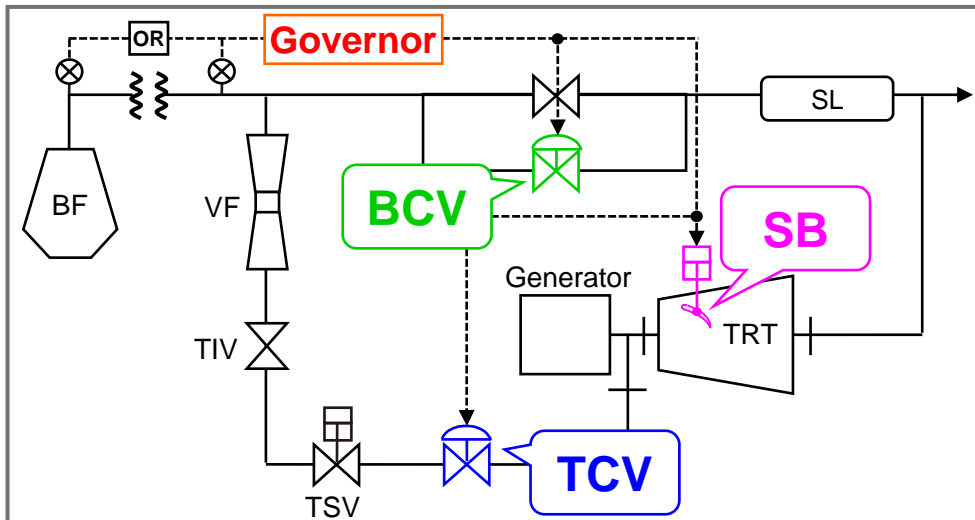
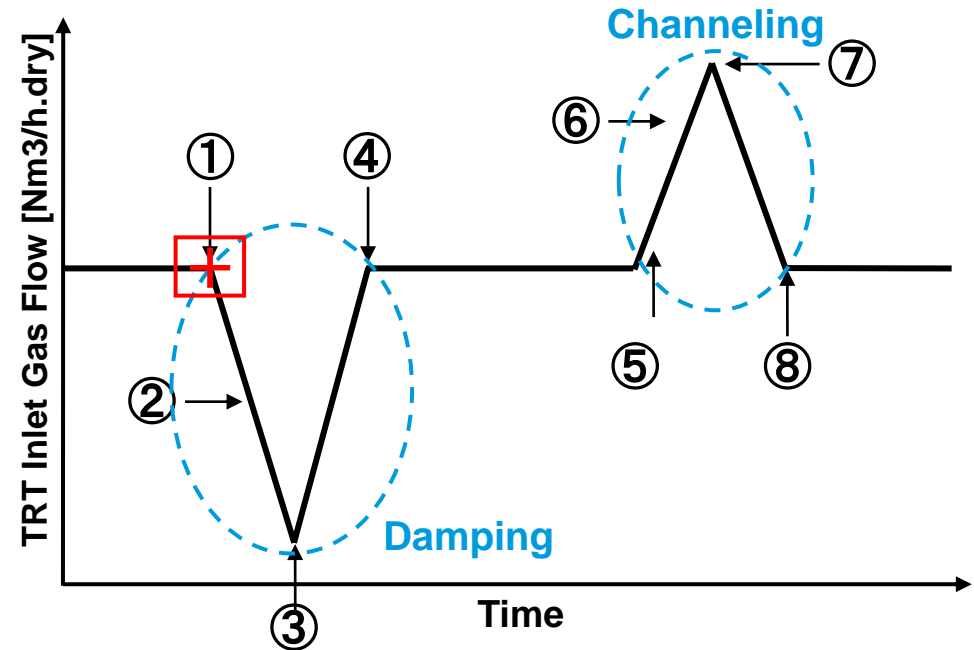
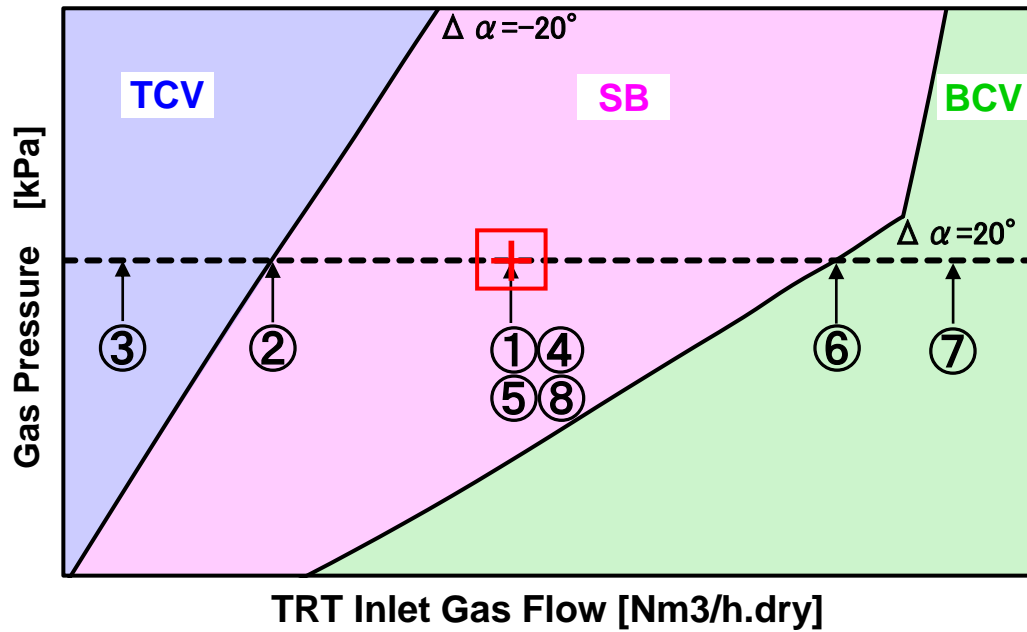
Advantages of Turbine Control Valve (TCV)

Our company installs TCV in order to achieve high efficiency & long lifespan of entire TRT system.

- ▮ Stable pressure control
- ▮ Reduction of dust adhesion to SB
- ▮ Reduction of stress on RB
- ▮ Redundant system of TSV and TCV

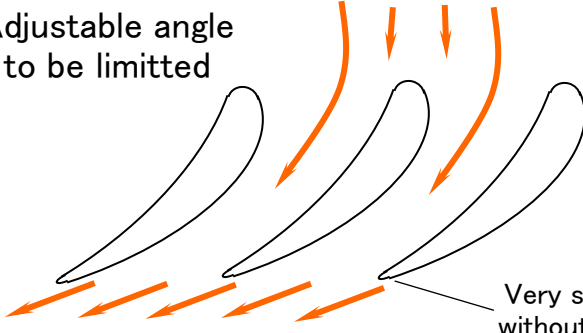
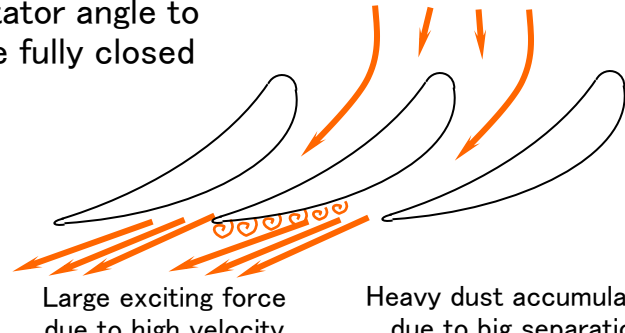


Pressure Control



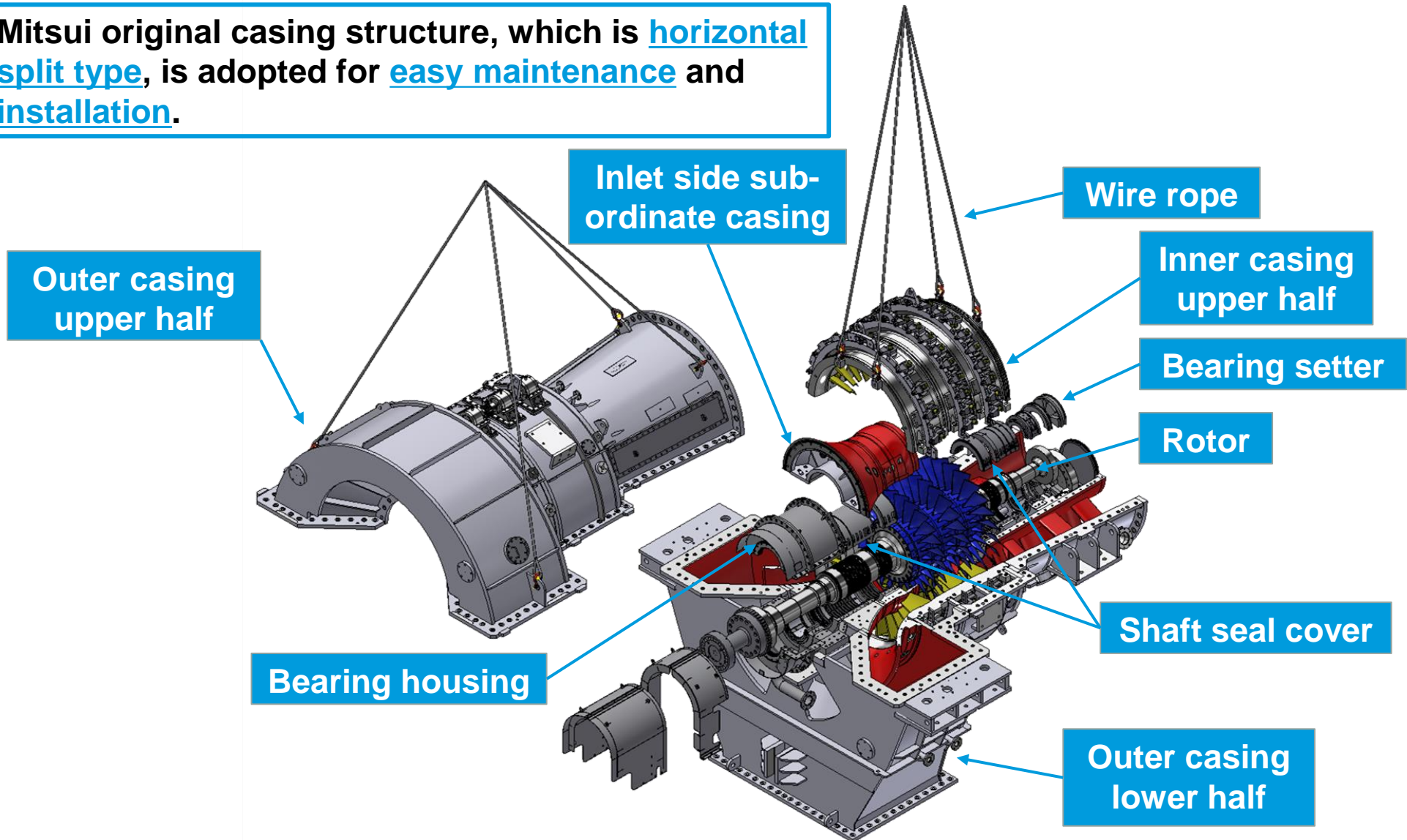
During normal operation, the pressure is controlled by stator blades. However, when there is an extremely large damping or other factors that cause large gas flow fluctuations, both stator blades and TCV will be used to keep the pressure remain constant. By using TCV, which responds quicker than stator blades, it is possible to stabilize the pressure and reduce the gas flow fluctuations.

Comparison between Mitsui TRT and Others

Mitsui TRT (All stage stator adjustable +TCV)			Other TRT (Only single (1st) stage stator adjustable)	
<p>Adjustable angle to be limited</p>  <p>Very smooth flow without separation</p>			<p>Stator angle to be fully closed</p>  <p>Large exciting force due to high velocity Heavy dust accumulation due to big separation</p>	
○	Less Efficiency Loss due to smooth flow deflection by adjusting all stator	Partload performance	△	High Efficiency Loss due to excess flow deflection
○	Less Dust Accumulation due to less flow separation. resulting improved efficiency loss and require less quantity of water spray	Dust accumulation	△	More Dust Accumulation due to more flow separation. resulting more efficiency loss and require more quantity of water spray
○	Less Blade Erosion due to less dust accumulation and less water spray	Blade erosion	△	More Blade Erosion due to more dust accumulation and more water spray
○	Less Vibration Stress due to less excitation force because of less dust accumulation and low flow velocity	Vibration stress to rotor blades	△	Severe Vibration Stress due to more excitation force because of more dust accumulation and high flow velocity
○	High Reliability due to redundant system (TSV+TCV) against over speed risk	Safety at emergency trip	✘	Lower Reliability due to single TSV system against over speed risk

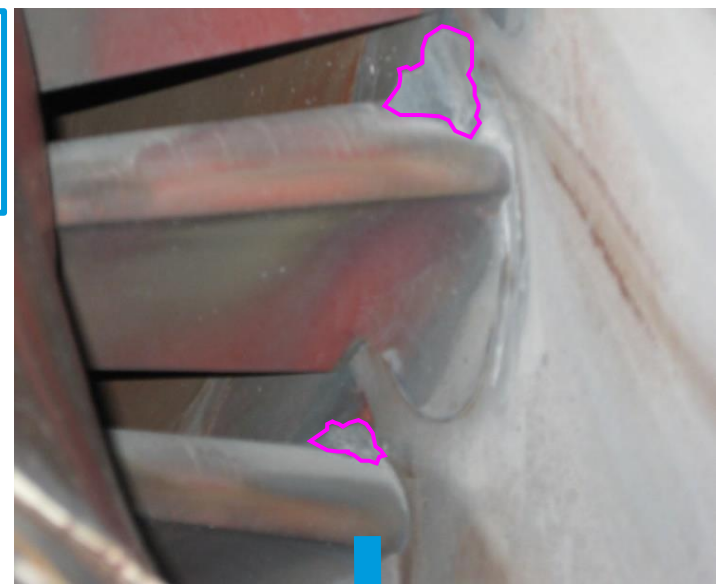
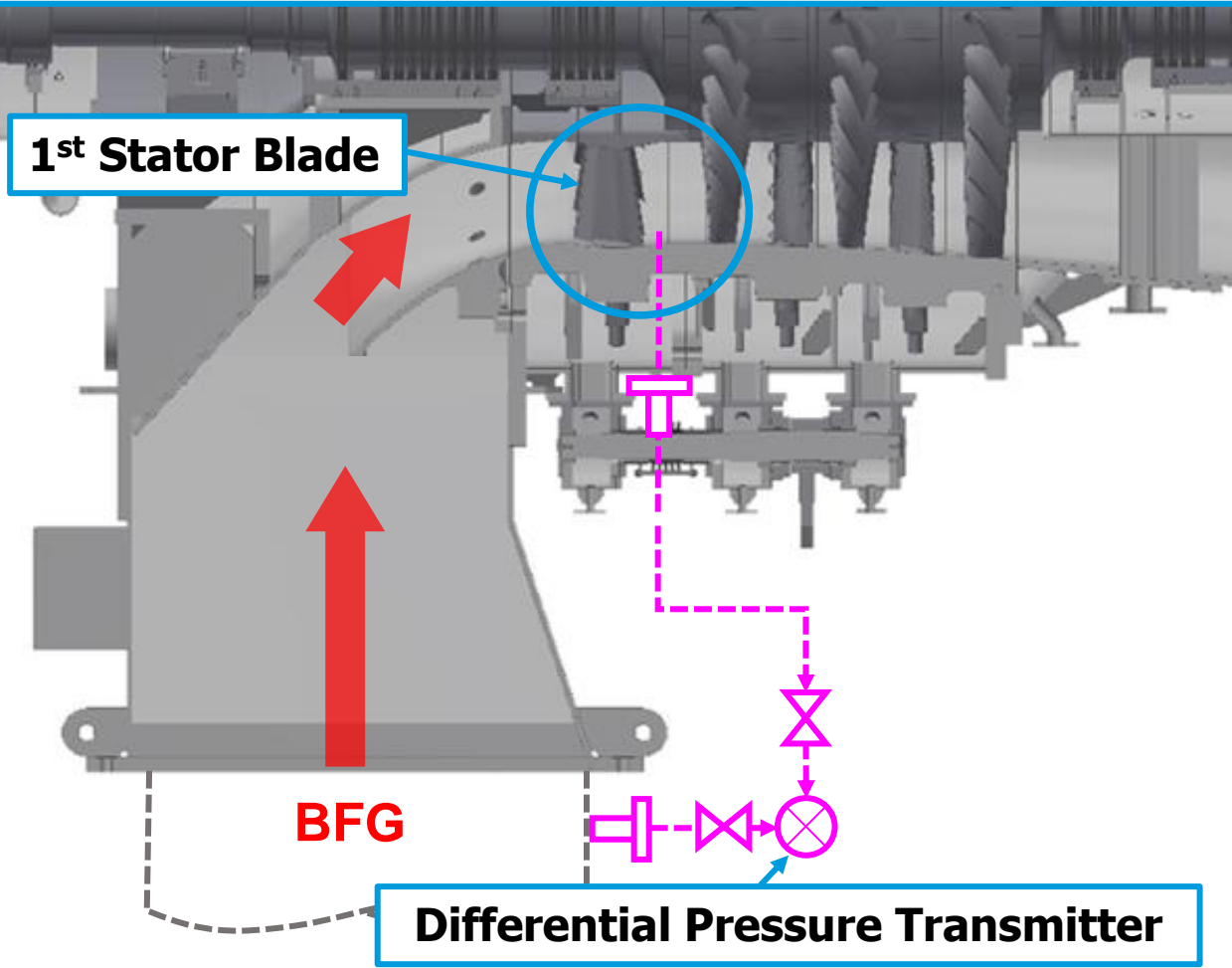
Easy Maintenance

Mitsui original casing structure, which is horizontal split type, is adopted for easy maintenance and installation.



Detection of Dust Accumulation

The intensity of dust accumulation is observed by the differential pressure monitoring system.
The blade cleaning can be done during BF shutdown time.

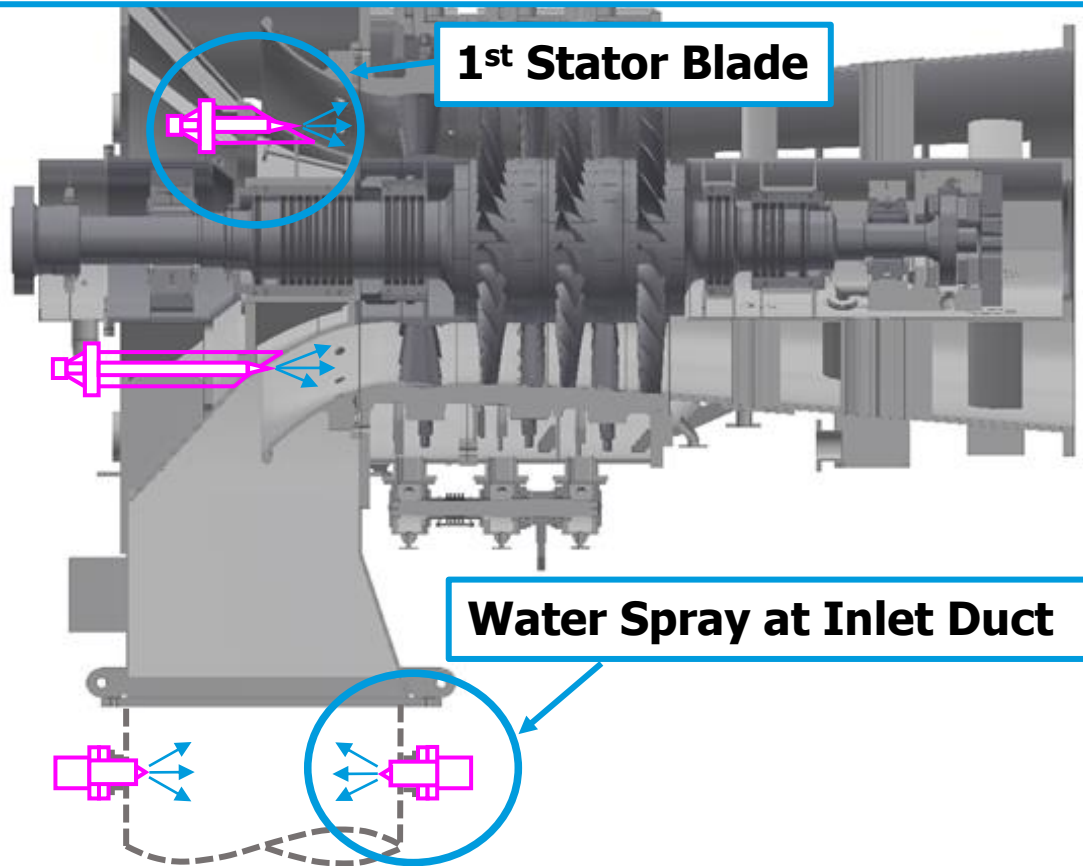


Dust Accumulation on 1st Stator Blade

Water Injection System

Water injection system is to prevent dust accumulation.

- ① **Prevents Stator Blade from dust accumulation by coating SB with water.**
- ② **Washes away the attached dust.**
- ③ **Agglomerate the dust contained in BFG by cooling down.**



Water Spray Nozzle for WET type TRT

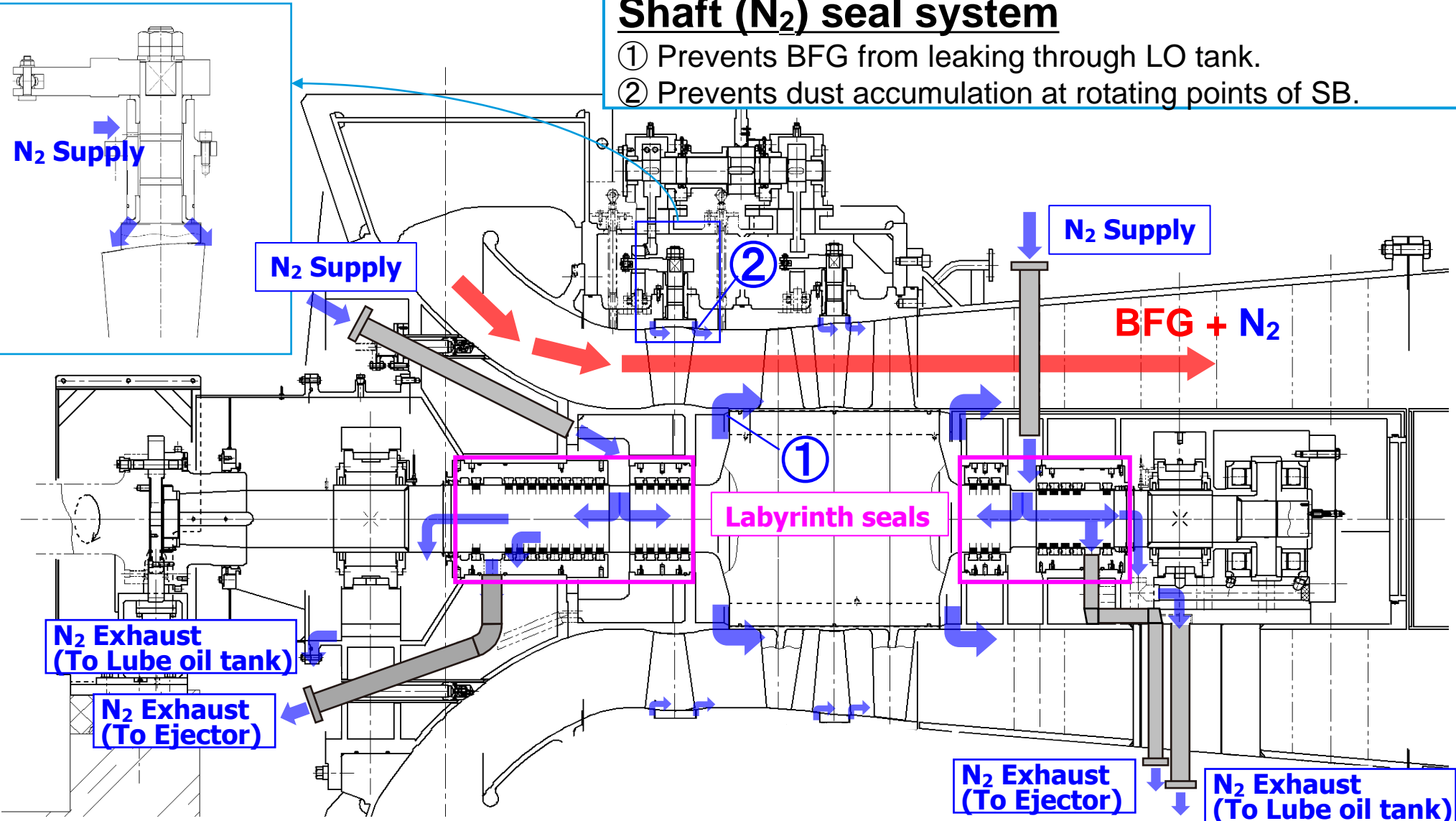


CFD Analysis of Sprayed Water

Shaft Seal (by N₂ injection)

Shaft (N₂) seal system

- ① Prevents BFG from leaking through LO tank.
- ② Prevents dust accumulation at rotating points of SB.



Anticorrosion paint for TRT

Anticorrosion paint is a preventive measure to protect TRT against extremely high corrosive environment. As a solution, we developed optimum anticorrosion paint pattern through accumulated knowledge and large number of experiments.

WET type

SantomodHX

Coating	Name	Color
Primer coat	K1	Red
Middle coat	807	Red
Top coat	807	Red

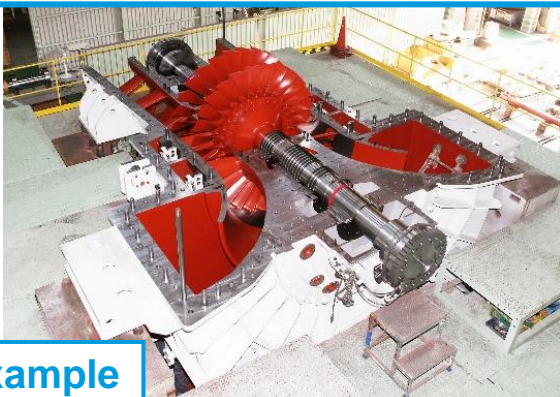
DRY type

SantomodHX

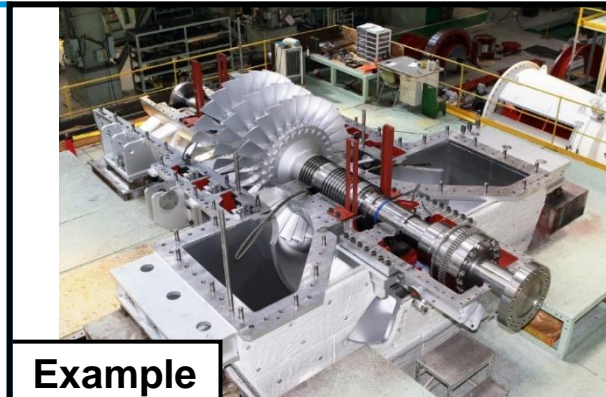
Coating	Name	Color
Primer coat	K1	Red
Middle coat	807	Red
Top coat	M1	Grey

Neogoze#200clear

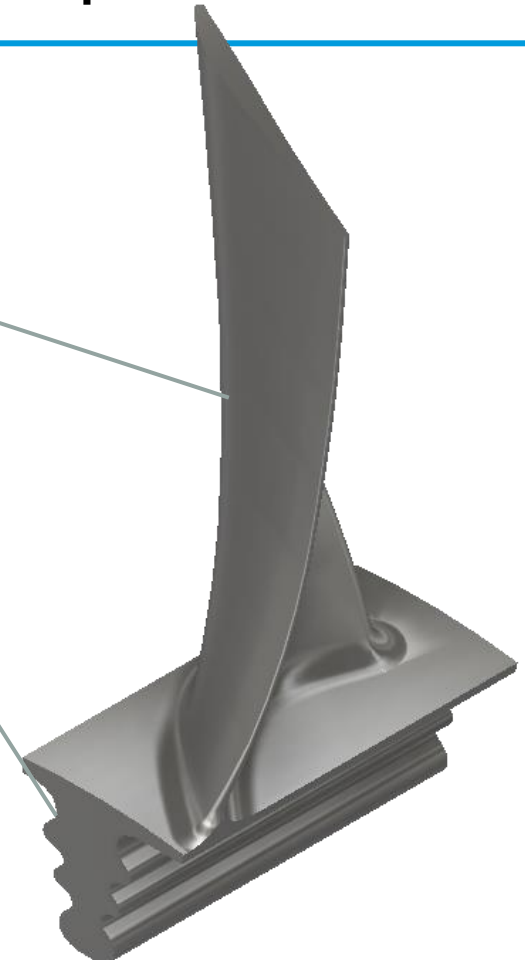
Epoxy silicone varnish



Example

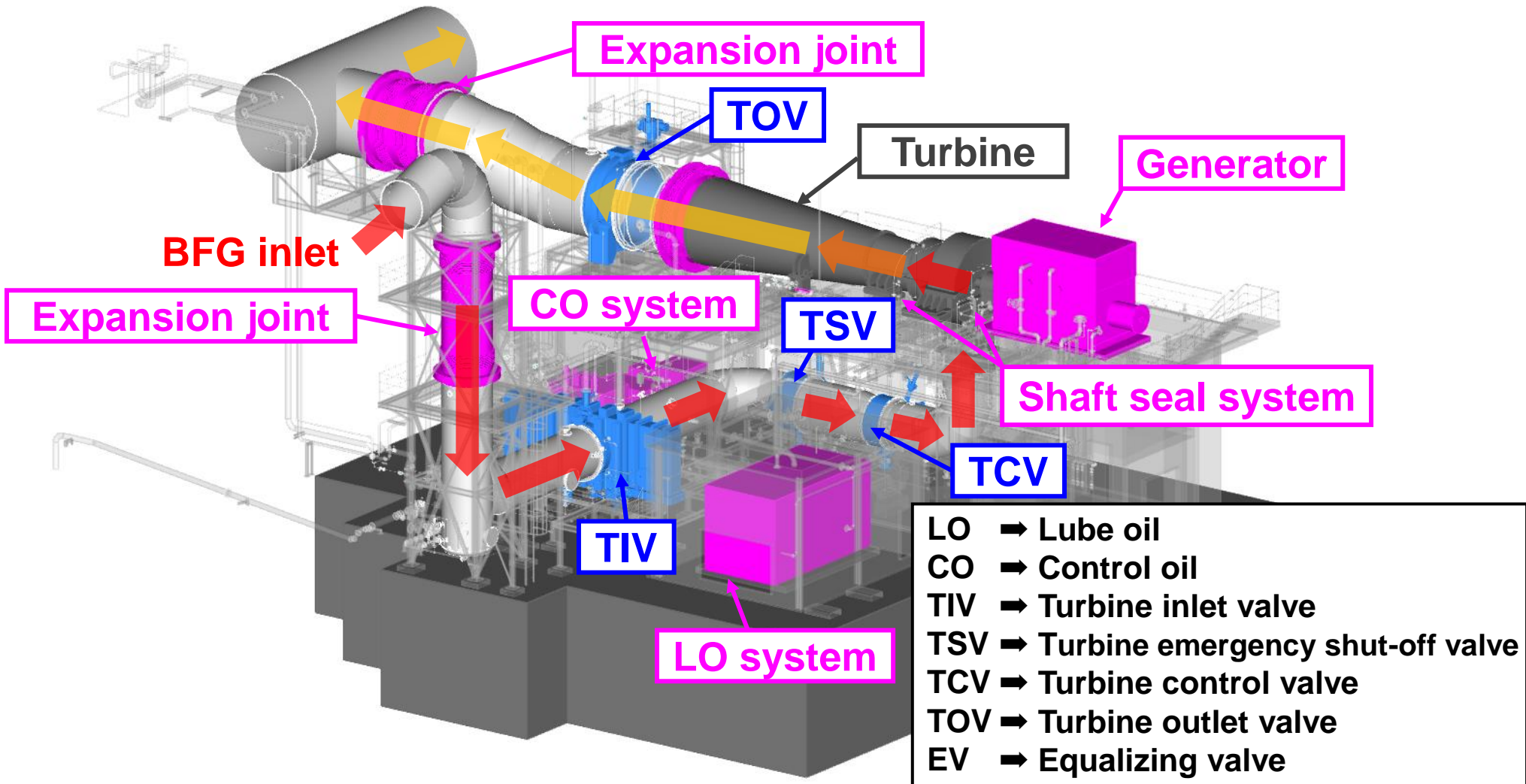


Example

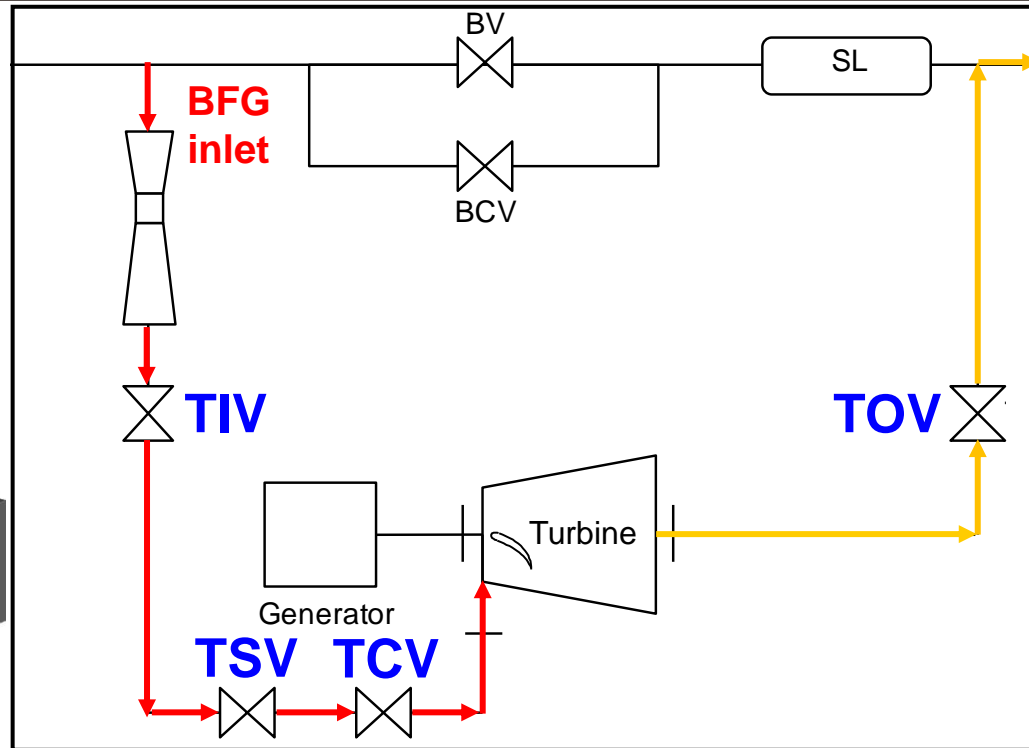
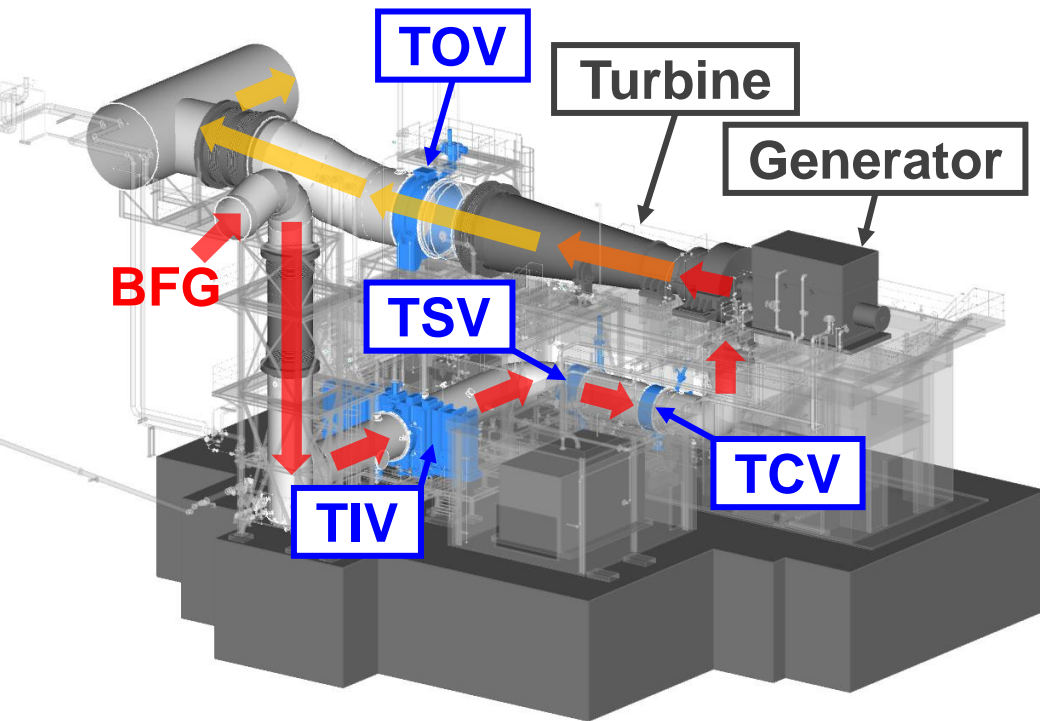


3D Installation Model

MES can provide entire plant design as well as TRT design.

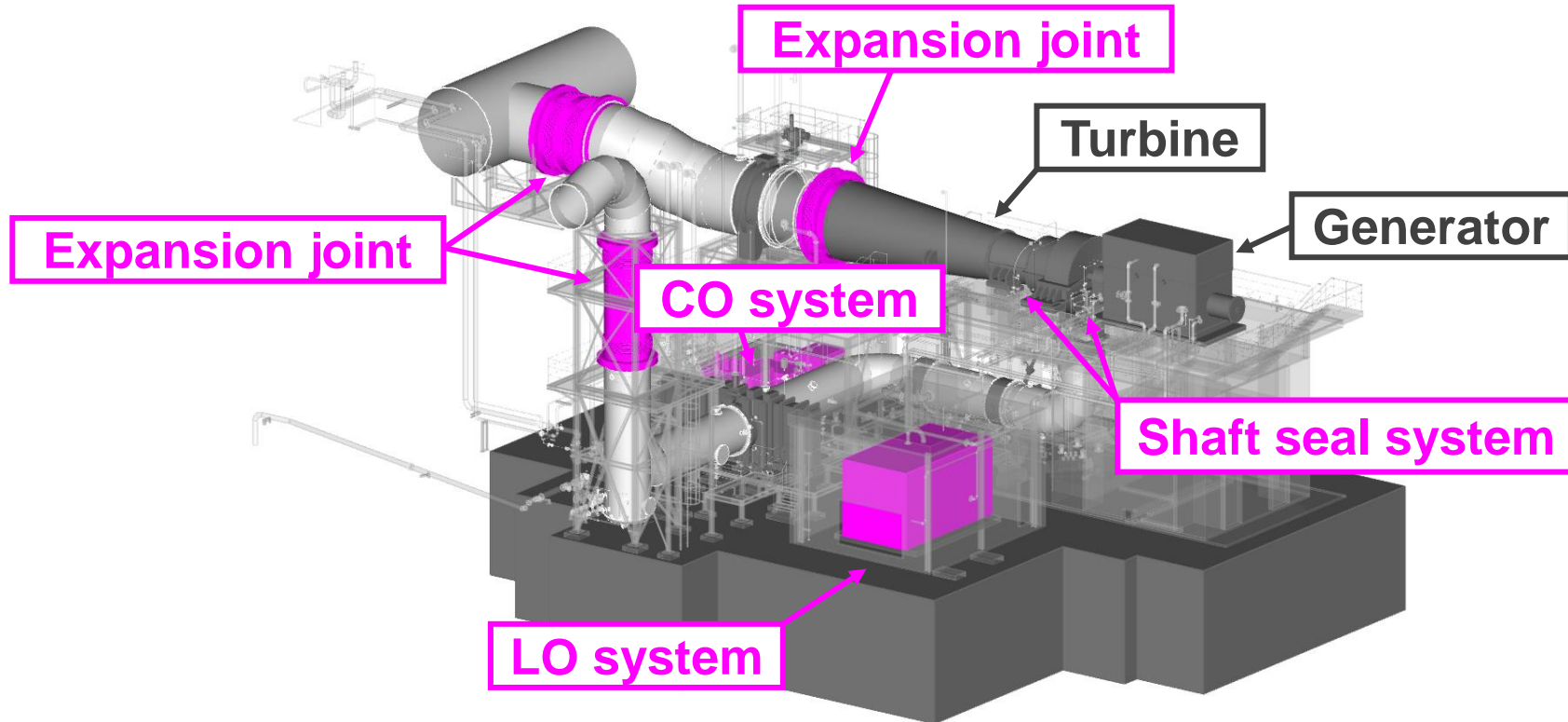


Major Valves and Flow Diagram



Notation	Name	Valve Type	Function
TIV	Turbine inlet shut-off valve	Goggle valve	Changes over BFG flow from main line to TRT line as "STOP valve". Open/Close action takes about 2 minute.
TSV	Turbine emergency shut-off valve	Butterfly Valve	Stops TRT immediately in emergency case, such as bearing temperature high. This valve can be closed within 0.5 second controlled by Trip Signal. For further safety, TCV is also closed corresponding TSV as its redundant system.
TCV	Turbine control valve	Butterfly Valve	Controls turbine rotation by open/close action.
TOV	Turbine outlet shut-off valve	Goggle valve/ Water seal valve	Blocks BFG same as TIV for TRT maintenance and inspection.

Major Auxiliaries of TRT



Name	Function
Expansion joint	Absorbs heat expansion of pipes.
Lube oil system	Provides lube oil to each bearing of TRT and Generator to prevent them from burning out.
Control oil system	Provides high pressure control oil to each actuator cylinders of TIV, TOV, TCV, TSV and Adjustable stator blade mechanism.
Shaft seal system	<ul style="list-style-type: none"> ① Prevents BFG from leaking through LO tank. ② Prevents dust accumulation at rotating points of stator blades.

Example of Mitsui Conventional TRT Installation

MAT180W-2 x 22.5MW

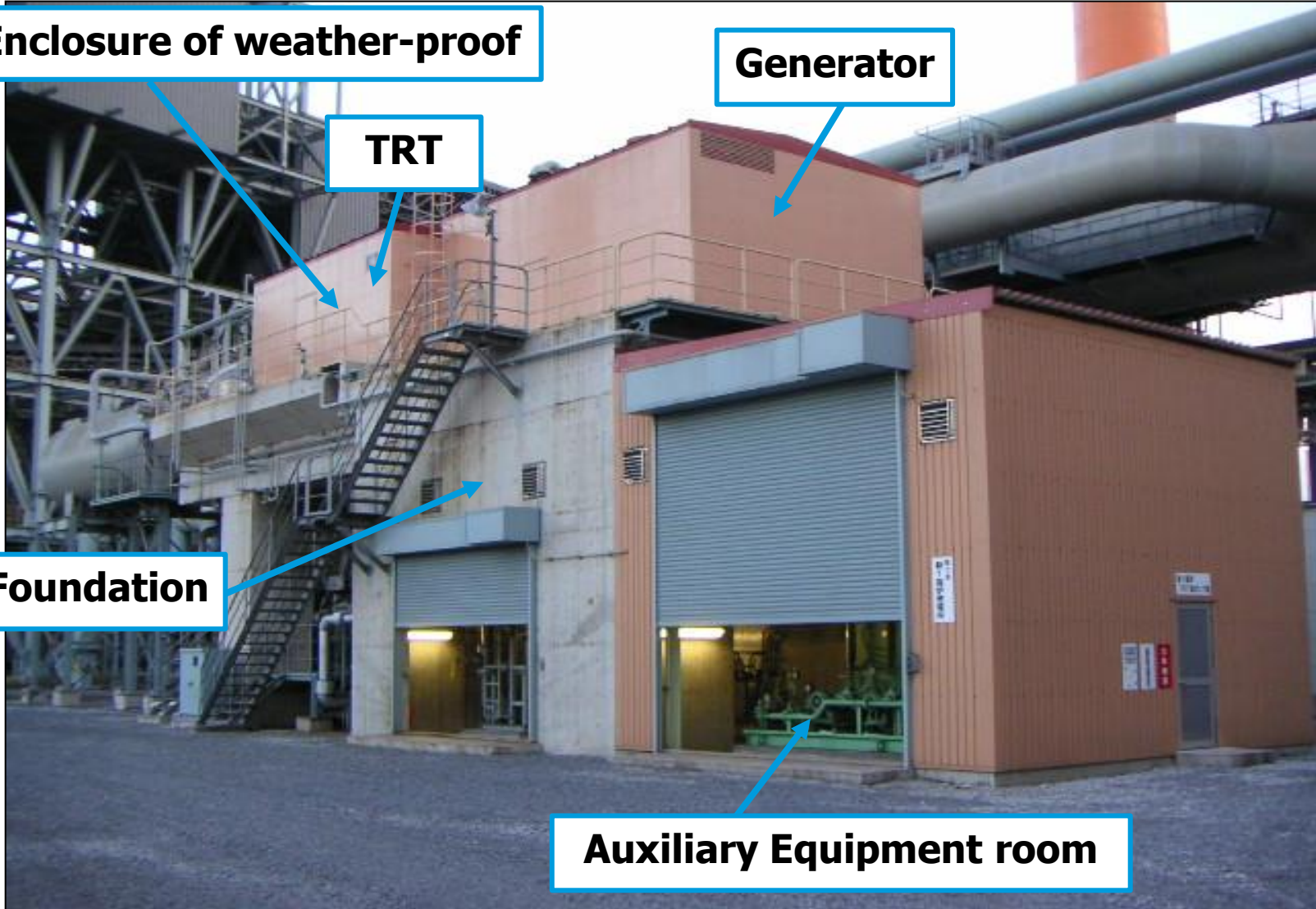
Acoustic Enclosure of weather-proof

Generator

TRT

Elevated Foundation

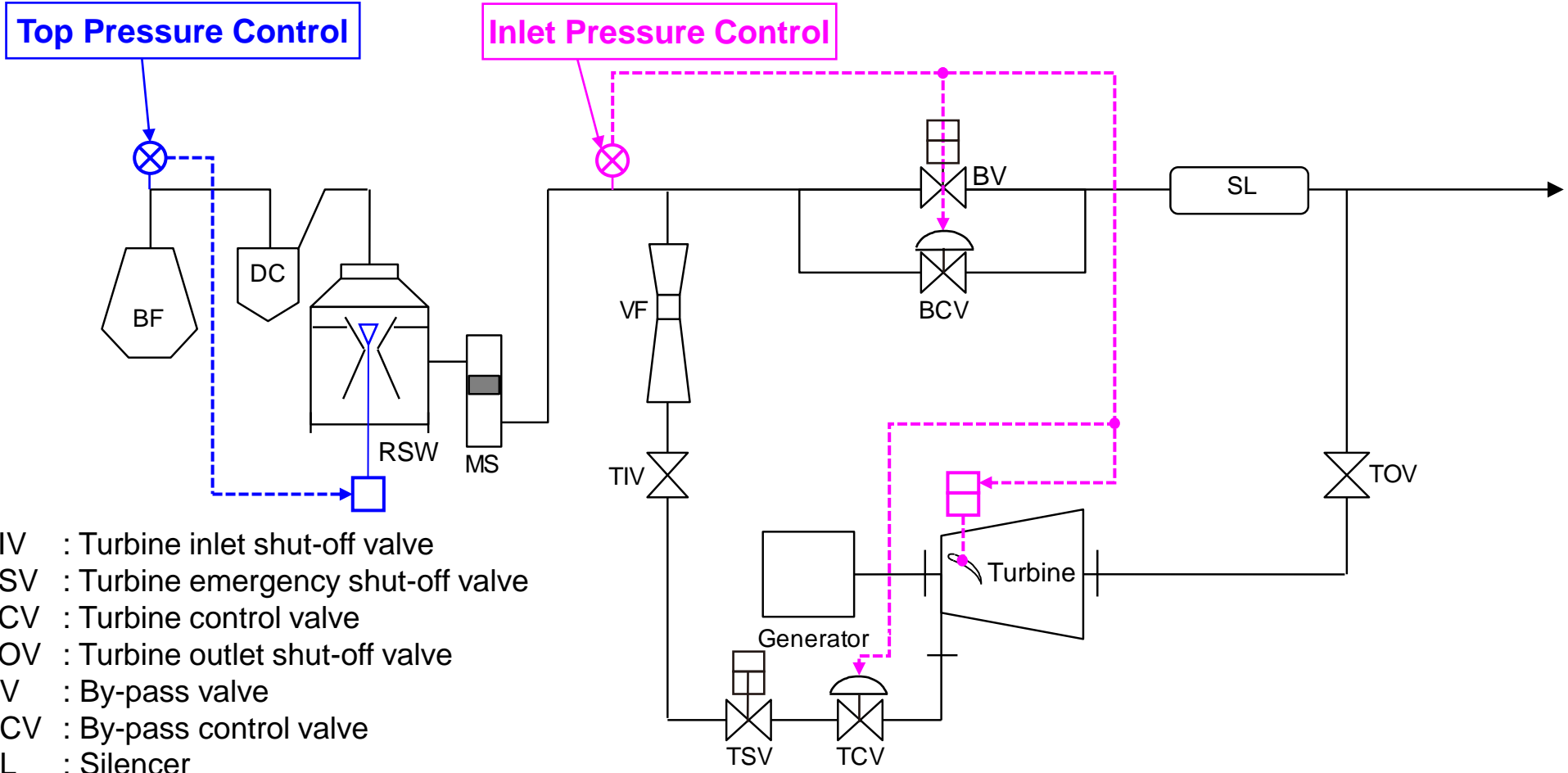
Auxiliary Equipment room



Major Control System

- 1. Pressure control (Top pressure or Turbine inlet pressure)**
- 2. Revolution speed control**
- 3. Load control**
- 4. Turbine generator Start-up/Stop sequence**
- 5. Turbine emergency shut-off valve control (Trip line)**
- 6. Turbine shaft N2 seal constant flow control**
- 7. Inlet pipe drain pot and seal tank level control**
- 8. Gas purge system**

Top Pressure Control (Typical Wet Type)

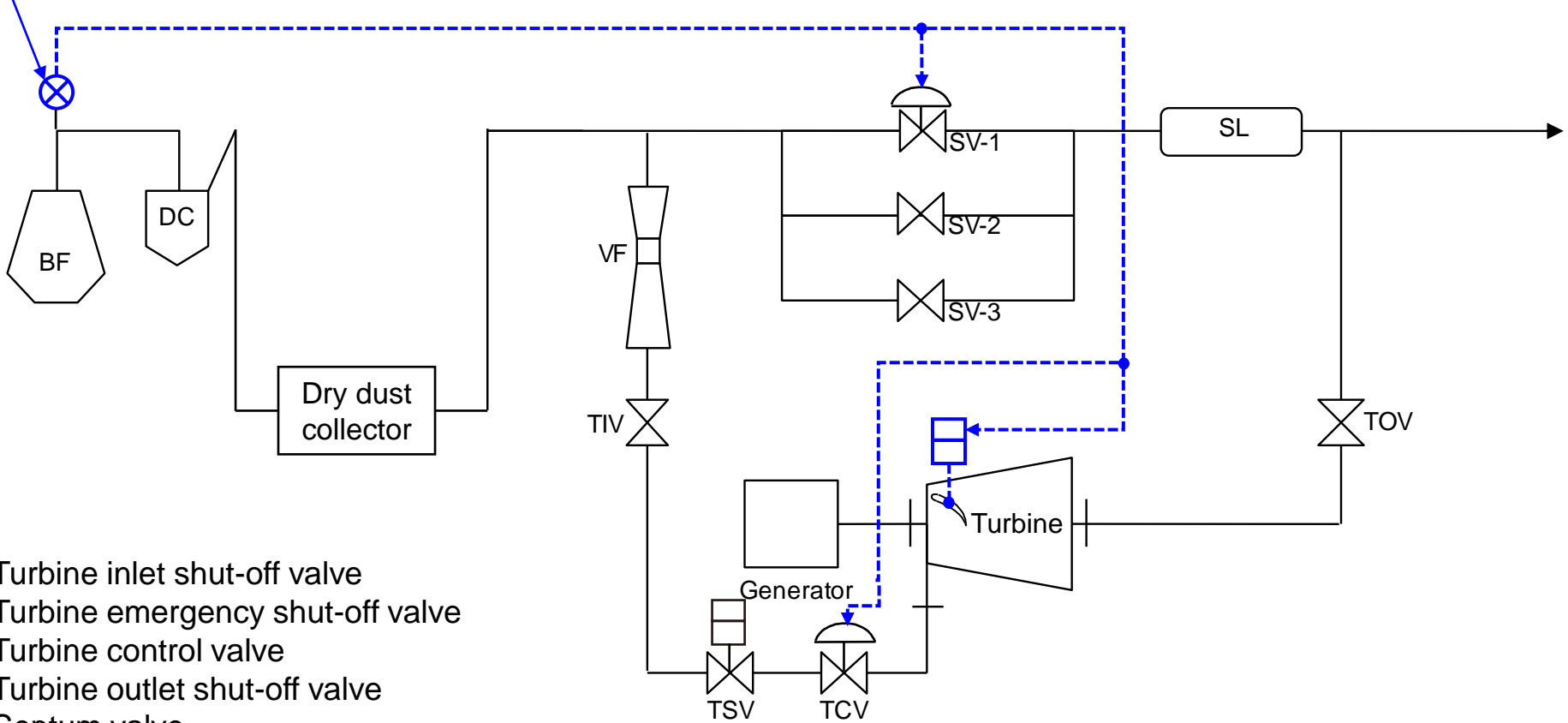


- TIV : Turbine inlet shut-off valve
- TSV : Turbine emergency shut-off valve
- TCV : Turbine control valve
- TOV : Turbine outlet shut-off valve
- BV : By-pass valve
- BCV : By-pass control valve
- SL : Silencer
- BF : Blast furnace
- DC : Dust catcher
- VF : Venturi flow meter
- RSW : Ring slit washer
- MS : Mist separator

Wet TRT(RSW type)
**Top pressure is controlled with RSW,
 while inlet pressure is controlled by TRT.**

Top Pressure Control (Typical Dry Type)

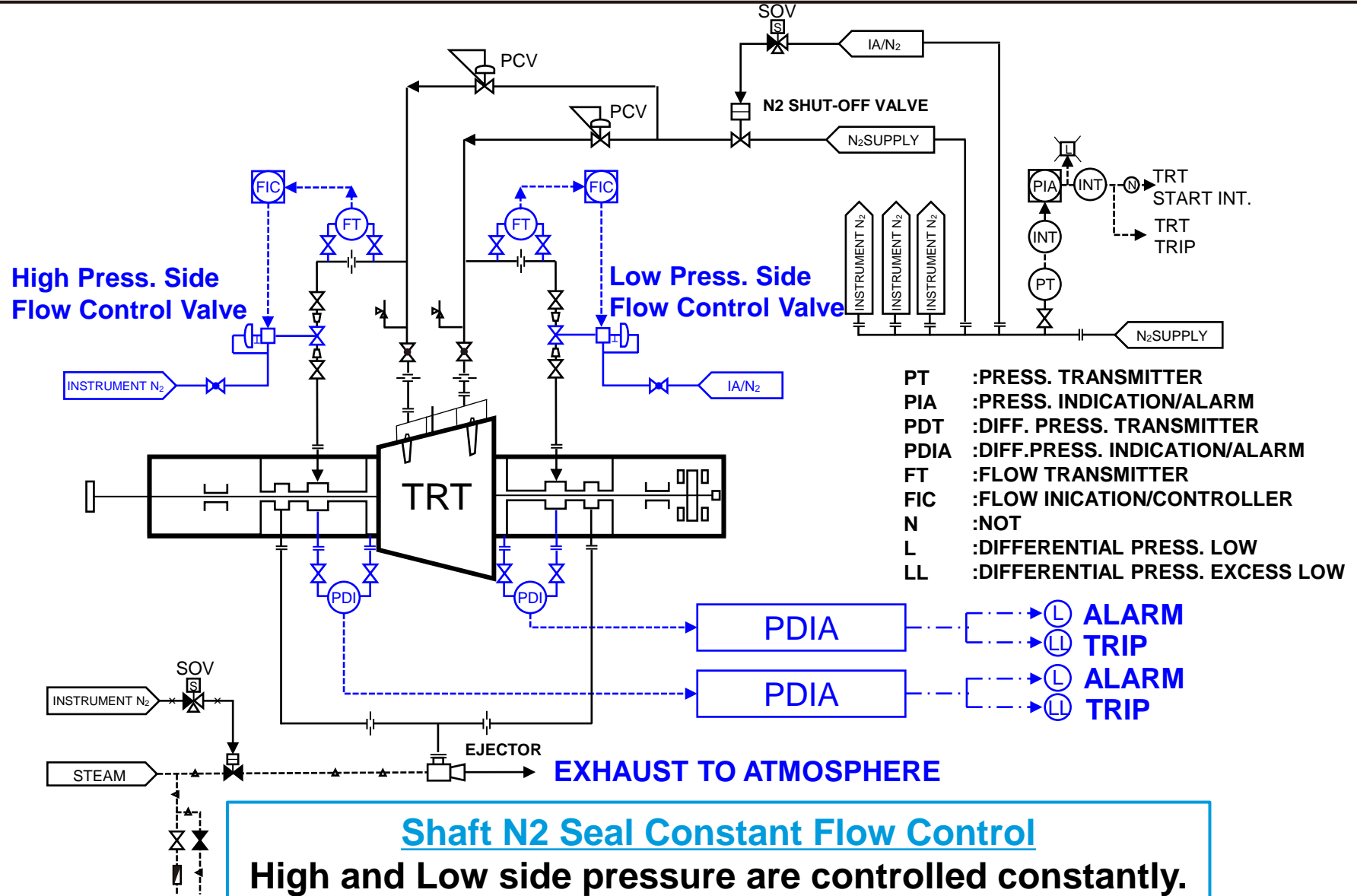
Top Pressure Control



- TIV : Turbine inlet shut-off valve
- TSV : Turbine emergency shut-off valve
- TCV : Turbine control valve
- TOV : Turbine outlet shut-off valve
- SV : Septum valve
- BF : Blast furnace
- VF : Venturi flow meter
- DC : Dust catcher
- CDC : Dry dust collector

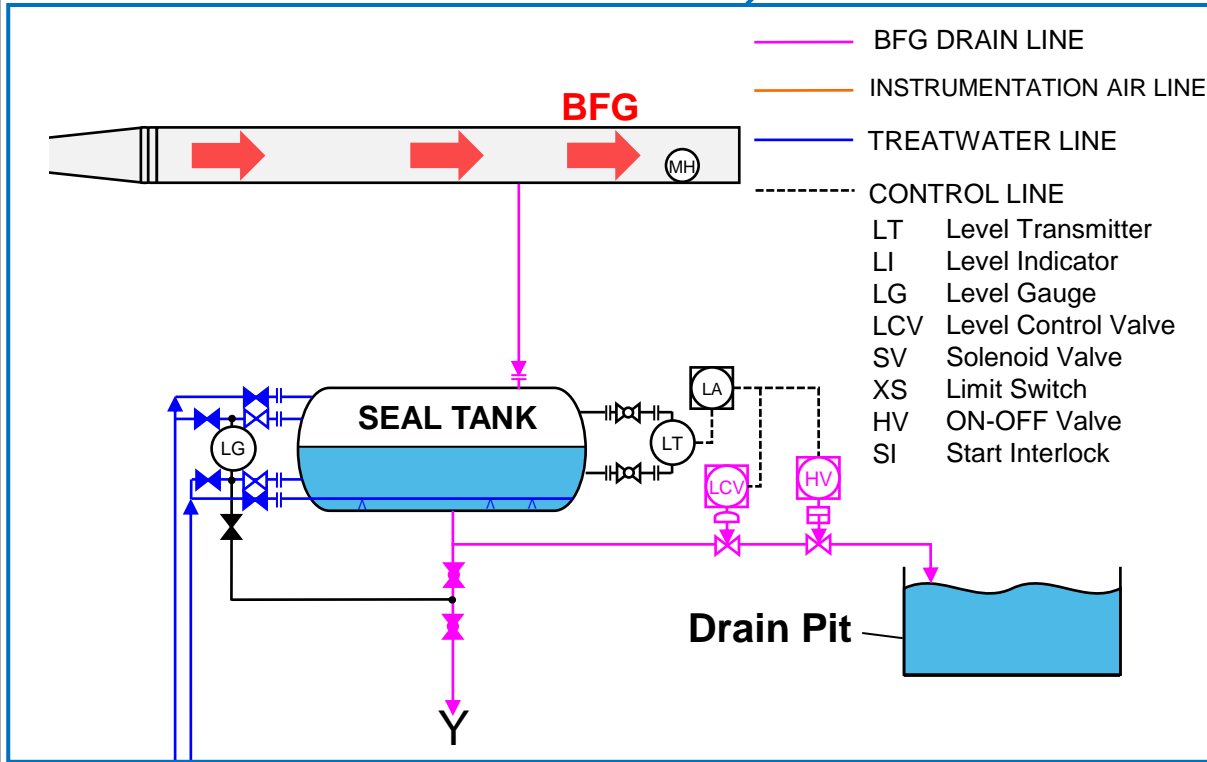
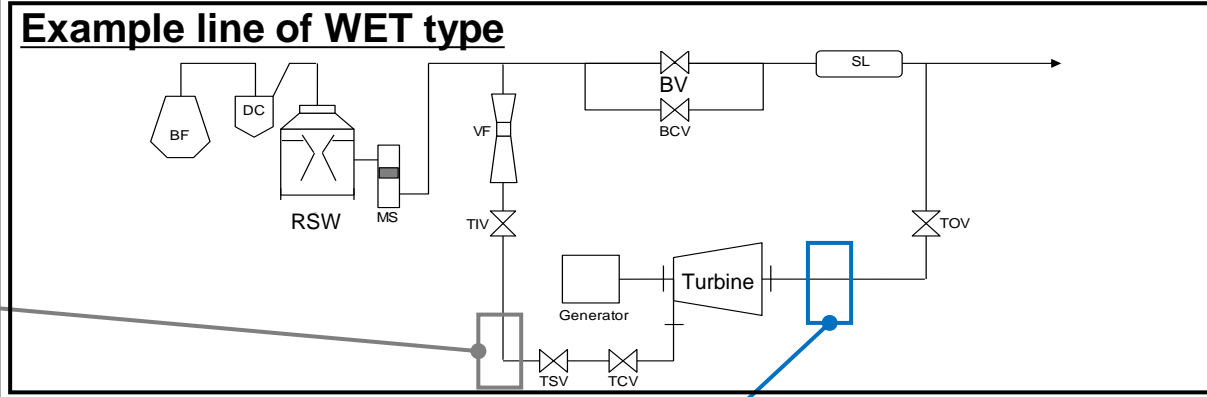
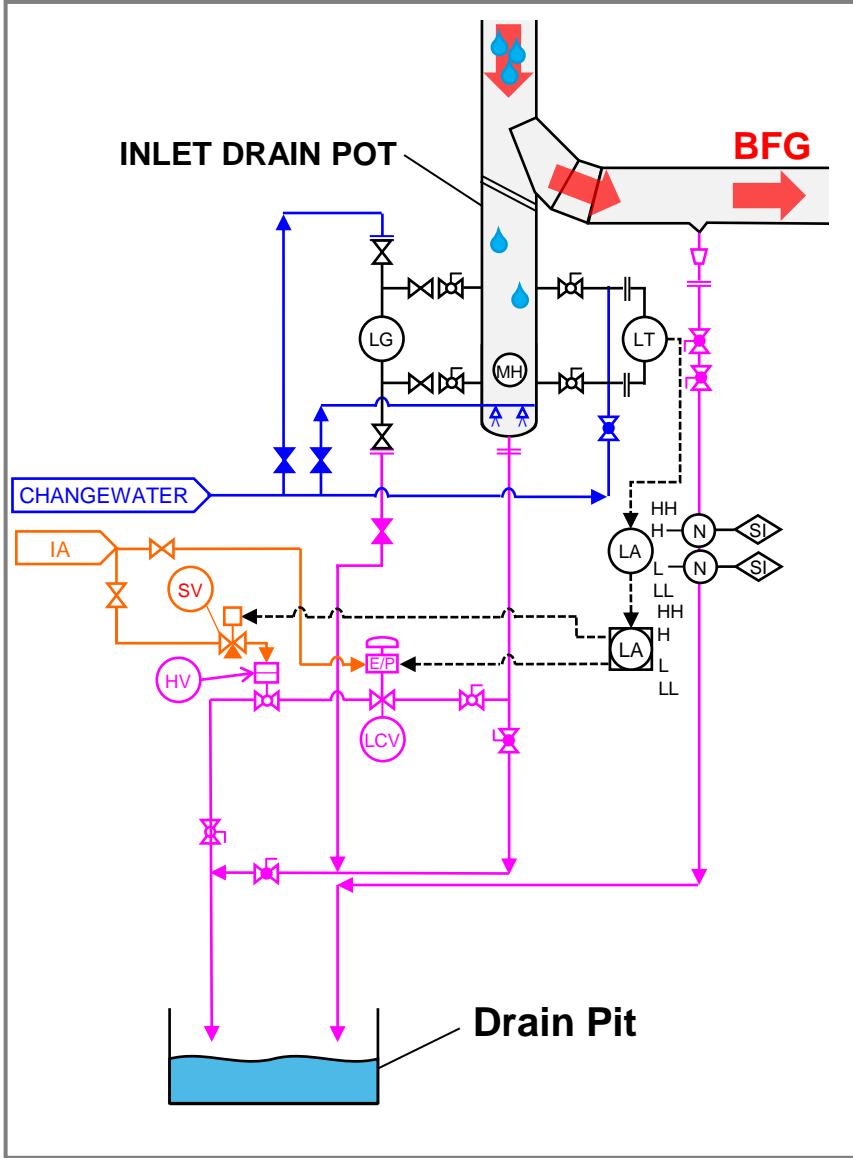
Dry TRT(Dry dust collector)
Top pressure is controlled with TCV, SV, and SB

Turbine Shaft (N₂) Seal Constant Flow Control



Shaft N₂ Seal Constant Flow Control
High and Low side pressure are controlled constantly.

Inlet Pipe Drain Pot and Seal Tank Level Control



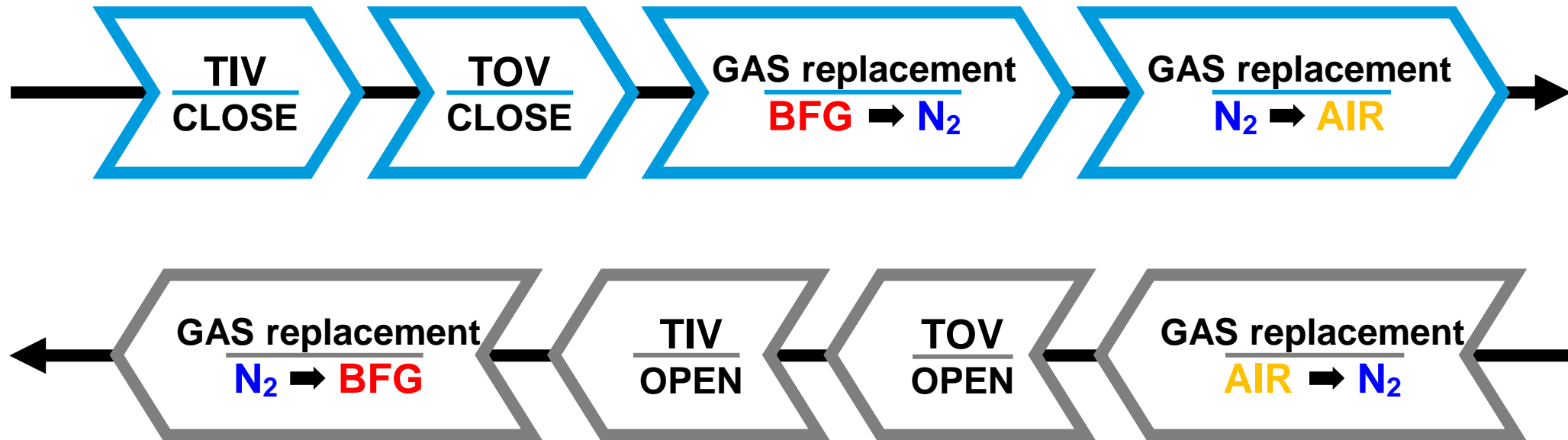
- BFG DRAIN LINE
- INSTRUMENTATION AIR LINE
- TREATWATER LINE
- - - CONTROL LINE
- LT Level Transmitter
- LI Level Indicator
- LG Level Gauge
- LCV Level Control Valve
- SV Solenoid Valve
- XS Limit Switch
- HV ON-OFF Valve
- SI Start Interlock

Gas Purge System

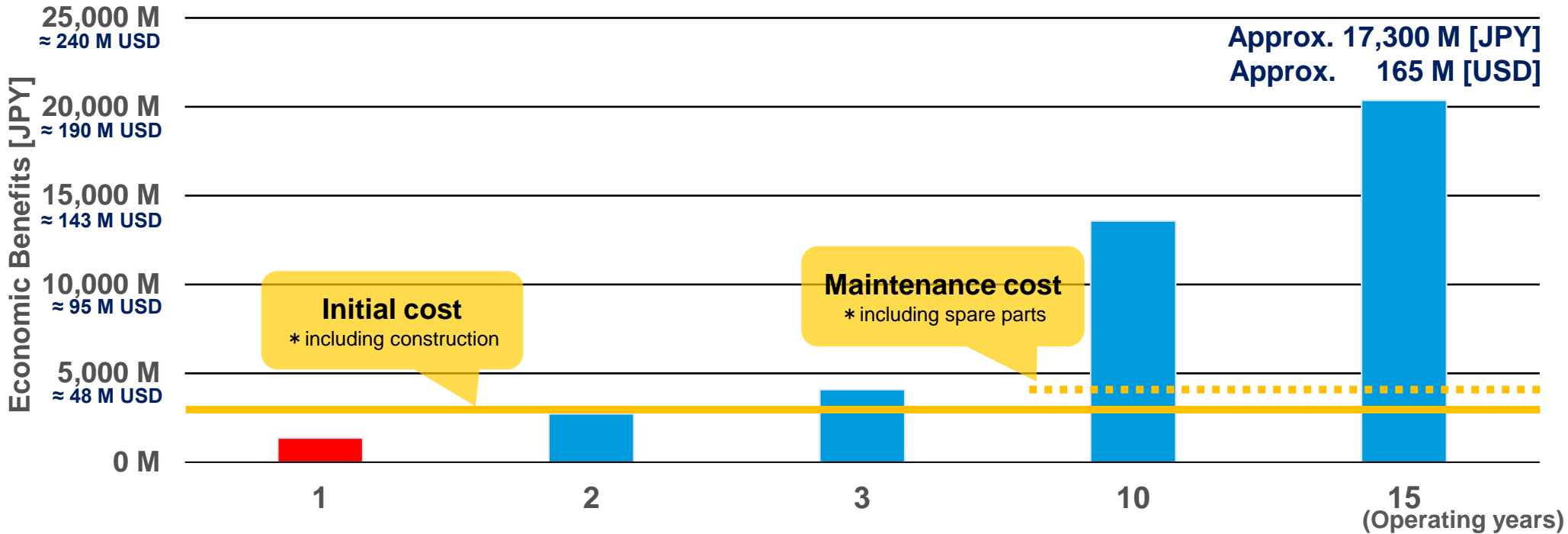
Gas purge system

For safe gas replacement, in case of maintenance or start-up, BFG needs to be replaced with N₂ first, and then Air. We can offer safe gas purge system satisfying customer request.

GAS PURGE FLOW



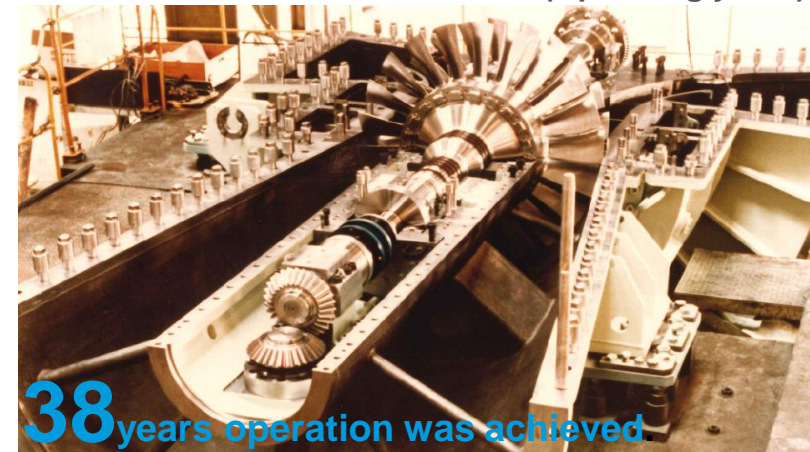
Economic Benefits of TRT “Installation”



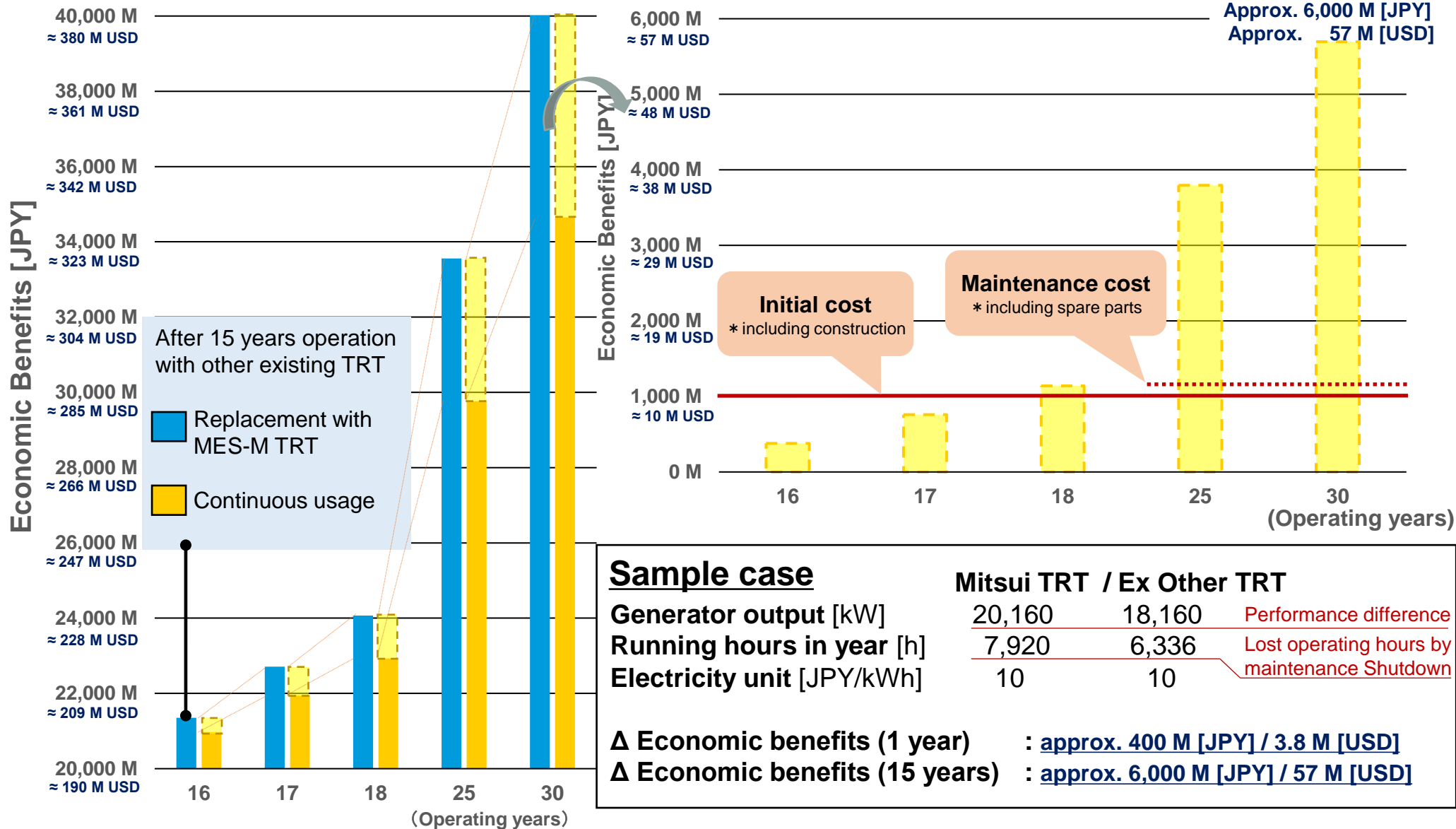
Sample case

Type : MAT160W-2
 Blast furnace capacity : 4,300m³
 Generator output : 20,160 [kW]
 Running hours in year : 7,920 [h]
 Electricity unit : 10 [JPY/kWh]

Economic benefits (1 year) : **approx. 1,300 M [JPY] / 13 M [USD]**
 Economic benefits (15 years) : **approx. 17,300 M [JPY] / 164 M [USD]**



Economic Benefits of TRT "Replacement"



A large industrial turbine, specifically a packaged top pressure recovery turbine, is shown in a factory setting. The turbine is mounted on a green base and has a large, circular, red-painted section. The background shows the factory's steel structure and various equipment.

PACKAGED TOP PRESSURE RECOVERY TURBINE

Advantages of Packaged TRT

1. Easy installation and inspection

2. Built-in type auxiliary equipment

(Lubricating oil / control oil unit, valve stand, N2 seal, spray water system, air / N2 purging)

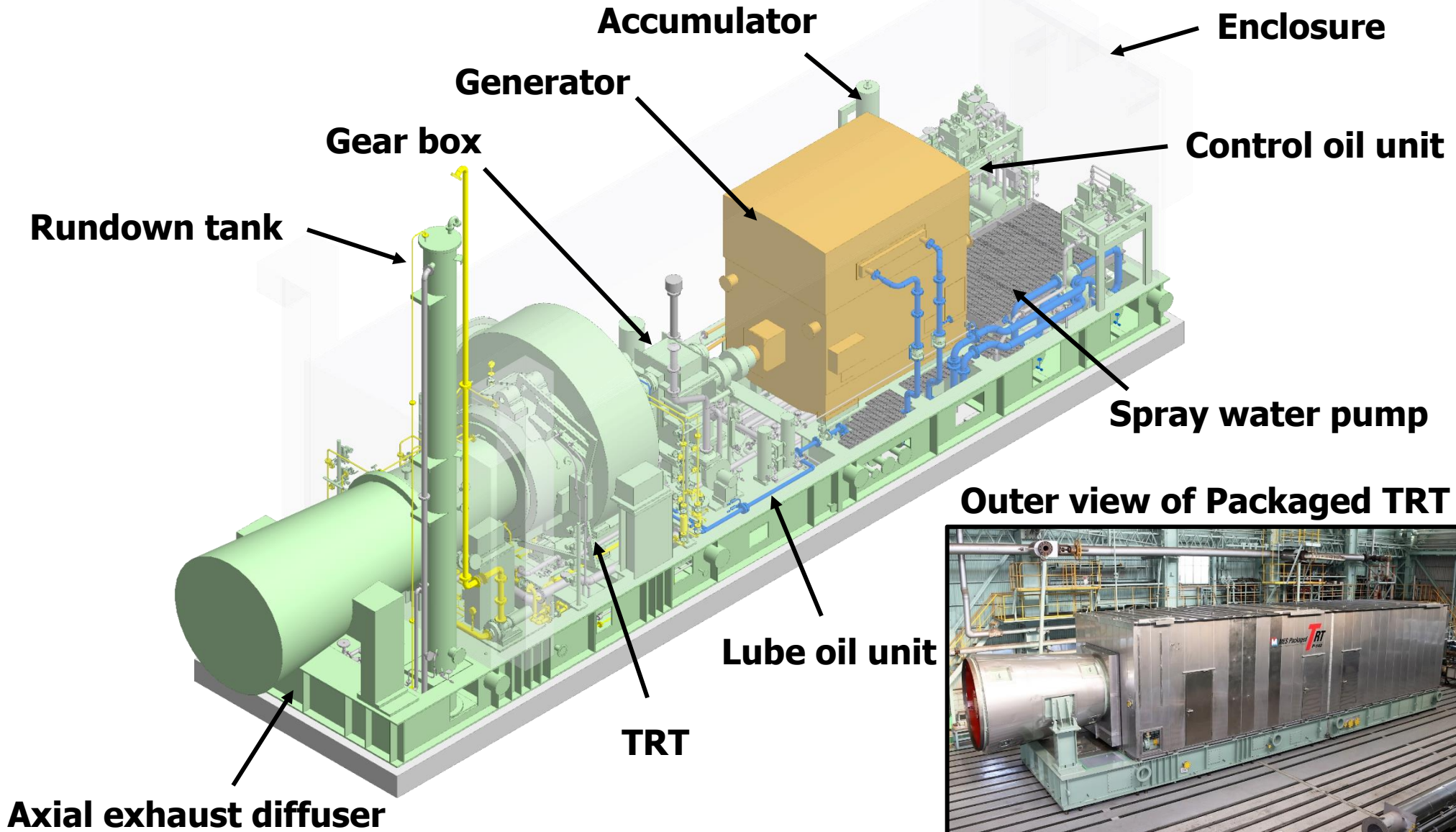
3. Save installation and commissioning time

(Reduces the cost required for the site work)

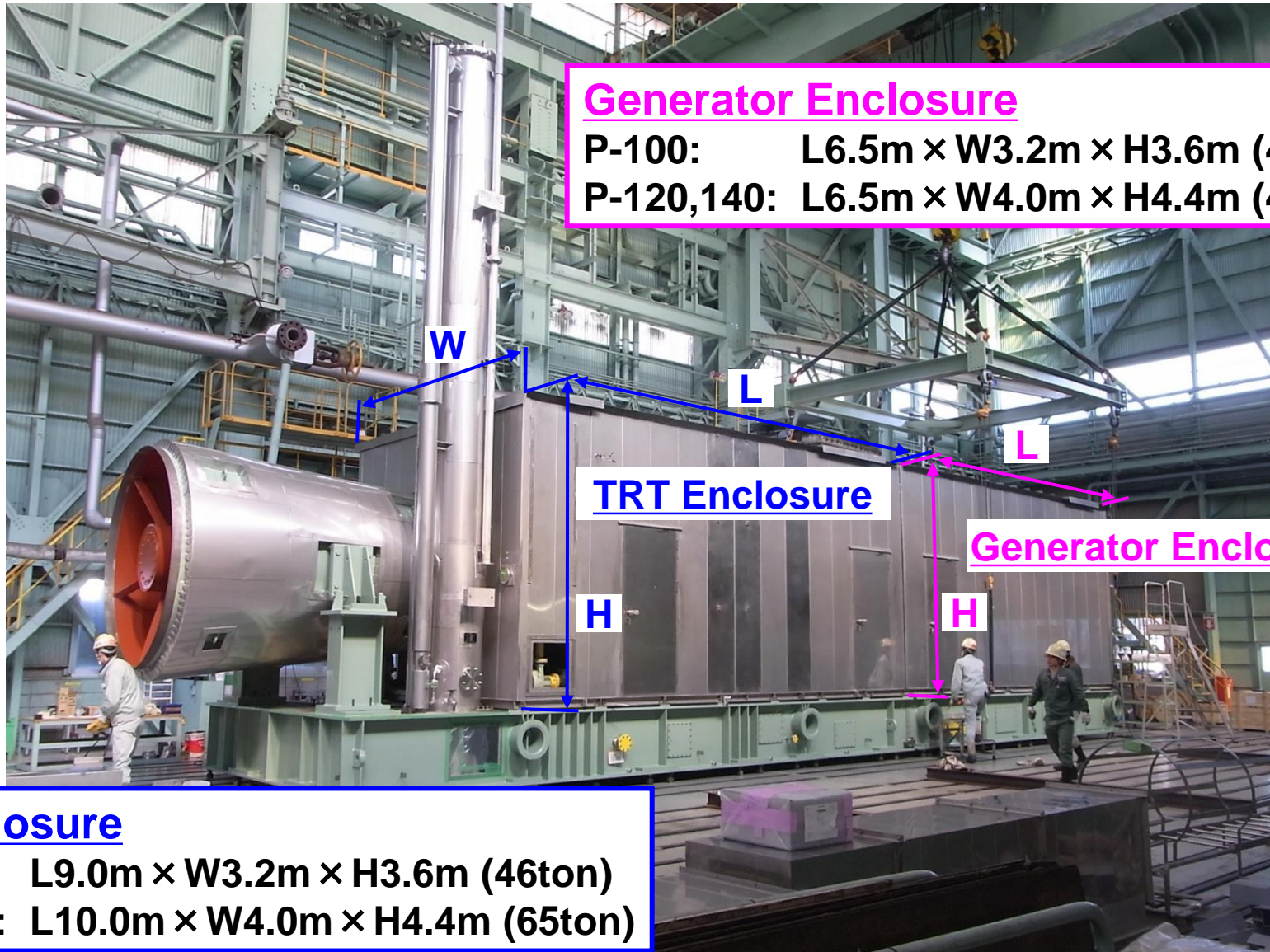
4. Can be newly installed in a space-saving size

(26 m x 18 m)

3D-CAD Model of Packaged TRT



Measurement of Packaged TRT



Generator Enclosure

P-100: L6.5m × W3.2m × H3.6m (41ton)

P-120,140: L6.5m × W4.0m × H4.4m (45ton)

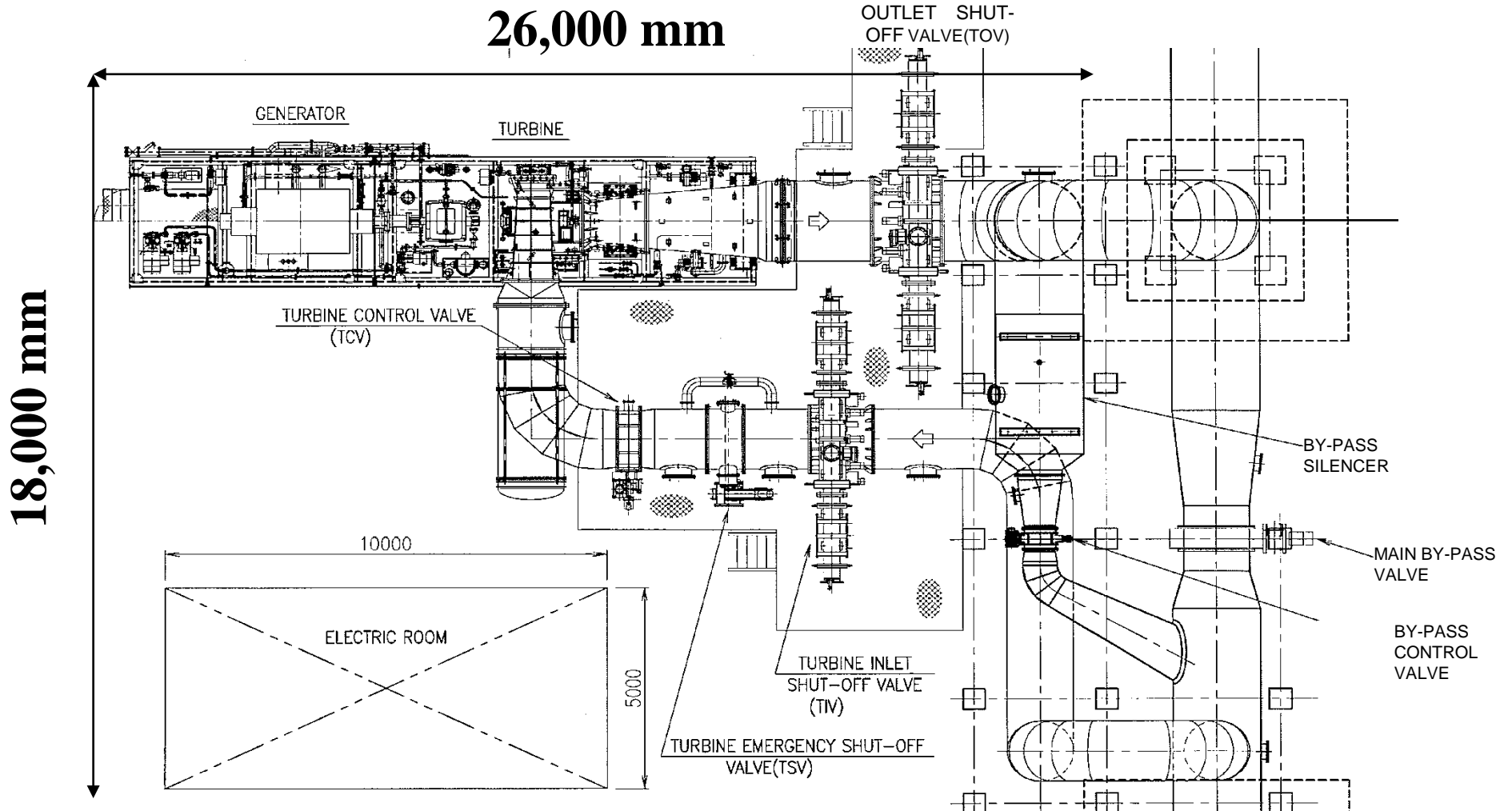
TRT Enclosure

TRT Enclosure

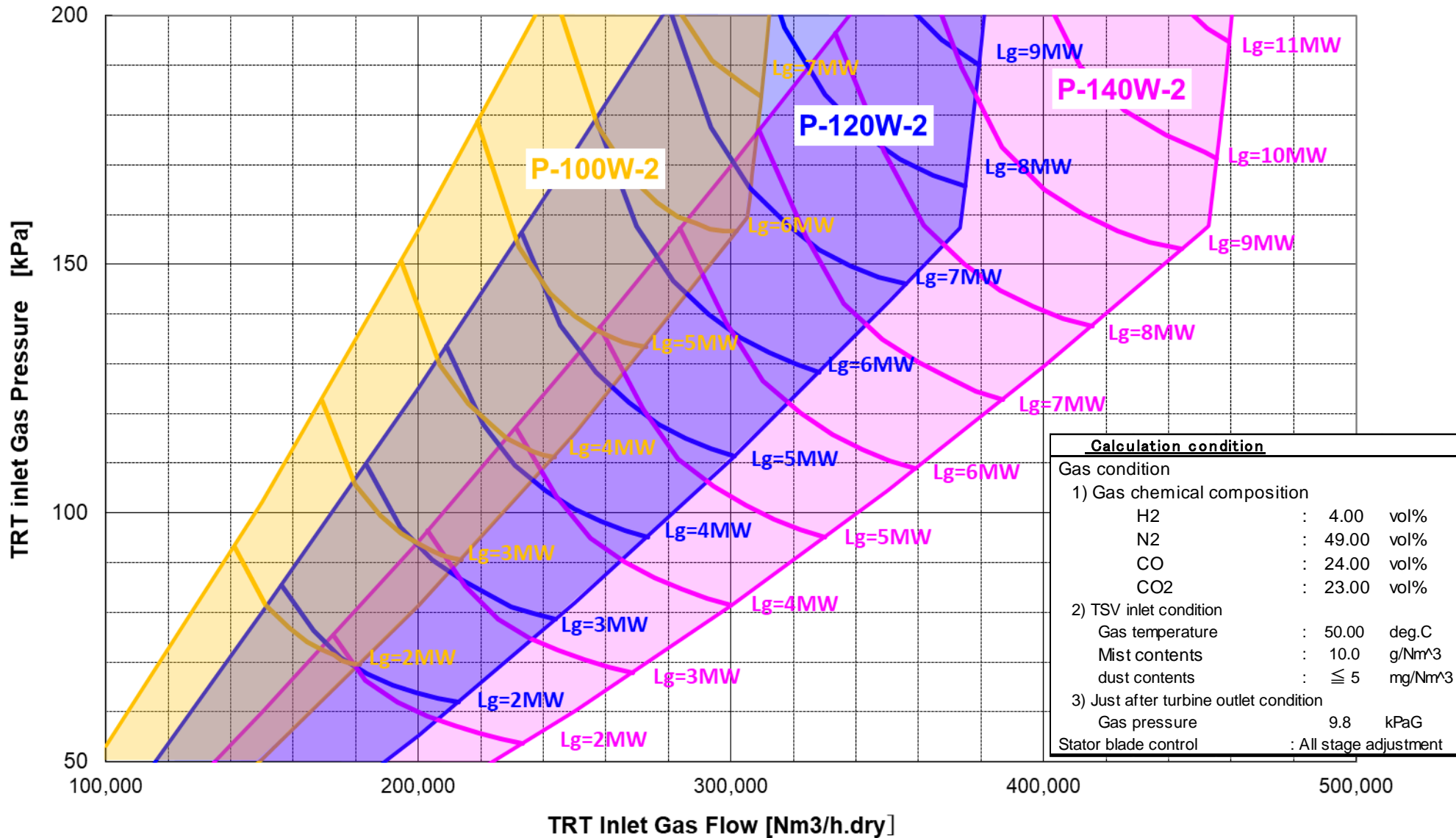
P-100: L9.0m × W3.2m × H3.6m (46ton)

P-120,140: L10.0m × W4.0m × H4.4m (65ton)

Plant Layout of Packaged TRT (Example)



Performance Curve of Packaged TRT (Example)



Example of Packaged TRT



- ❑ Turning device: Not provided
- ❑ Type: WET type Axial flow reaction
- ❑ No. of stage: 2 stage
- ❑ Shaft Speed: 3,600 rpm
- ❑ Rated power: 13,000kW
- ❑ Stator type: All adjustable automatically
- ❑ Journal bearing: Tilting pad
- ❑ Thrust bearing: Tilting pad



Thank you