Gas Turbine Components

SGT400

Handout Version 2.9

Product Training
Firth Road
Lincoln
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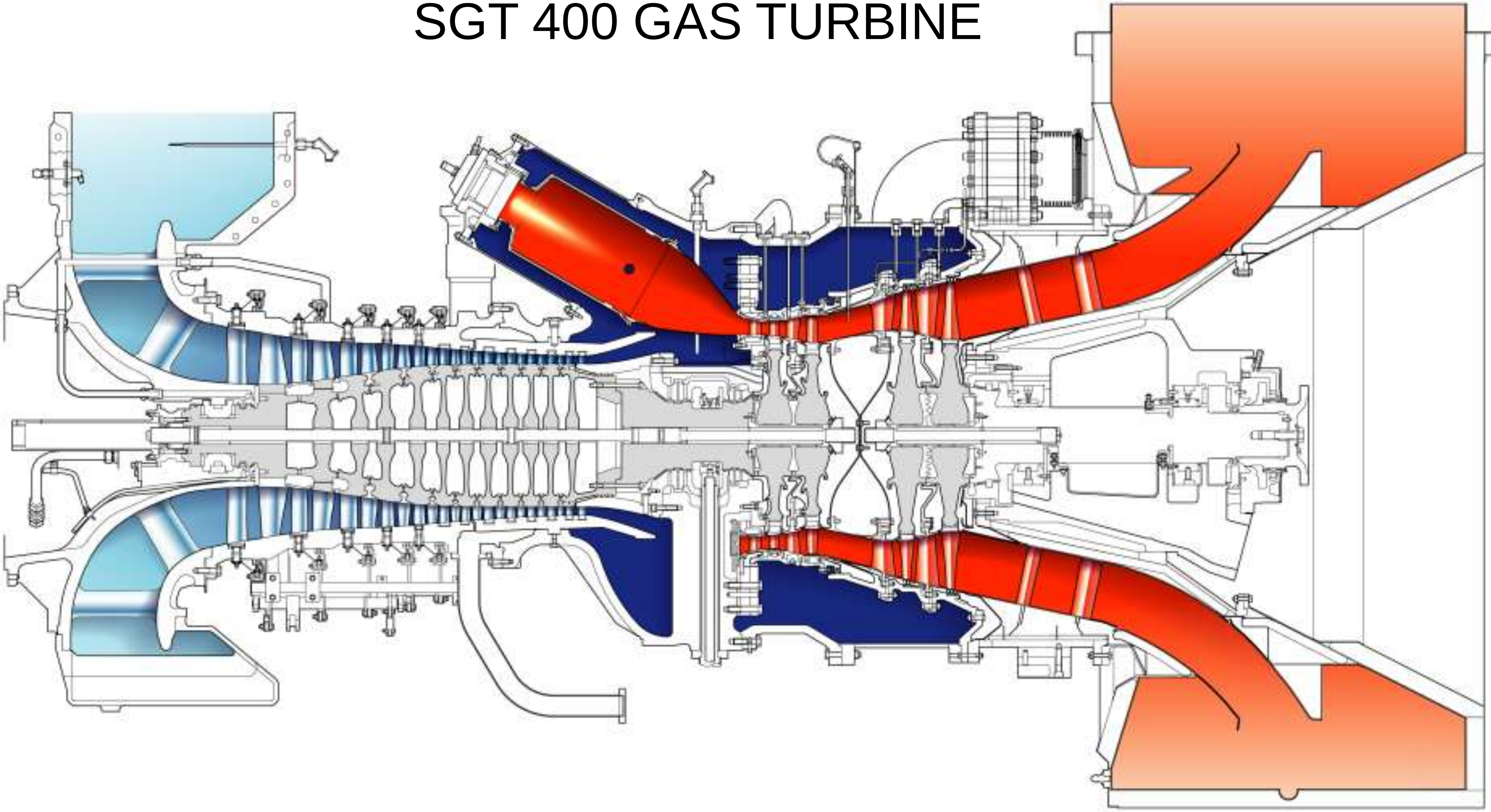
This module of Basic Gas Turbines will introduce the delegate to the various major components of the gas turbine.

The delegate will understand the need of the following components and will be familiar with their use:-

- The Air Inlet.
- The Compressor, VGV’s & Interstage Bleed Valves (BOV).
- The Combustion System & Fuel Burners.
- The Compressor Turbine section.
- The Power Turbine.
- The Exhaust System.

SGT 400 GAS TURBINE

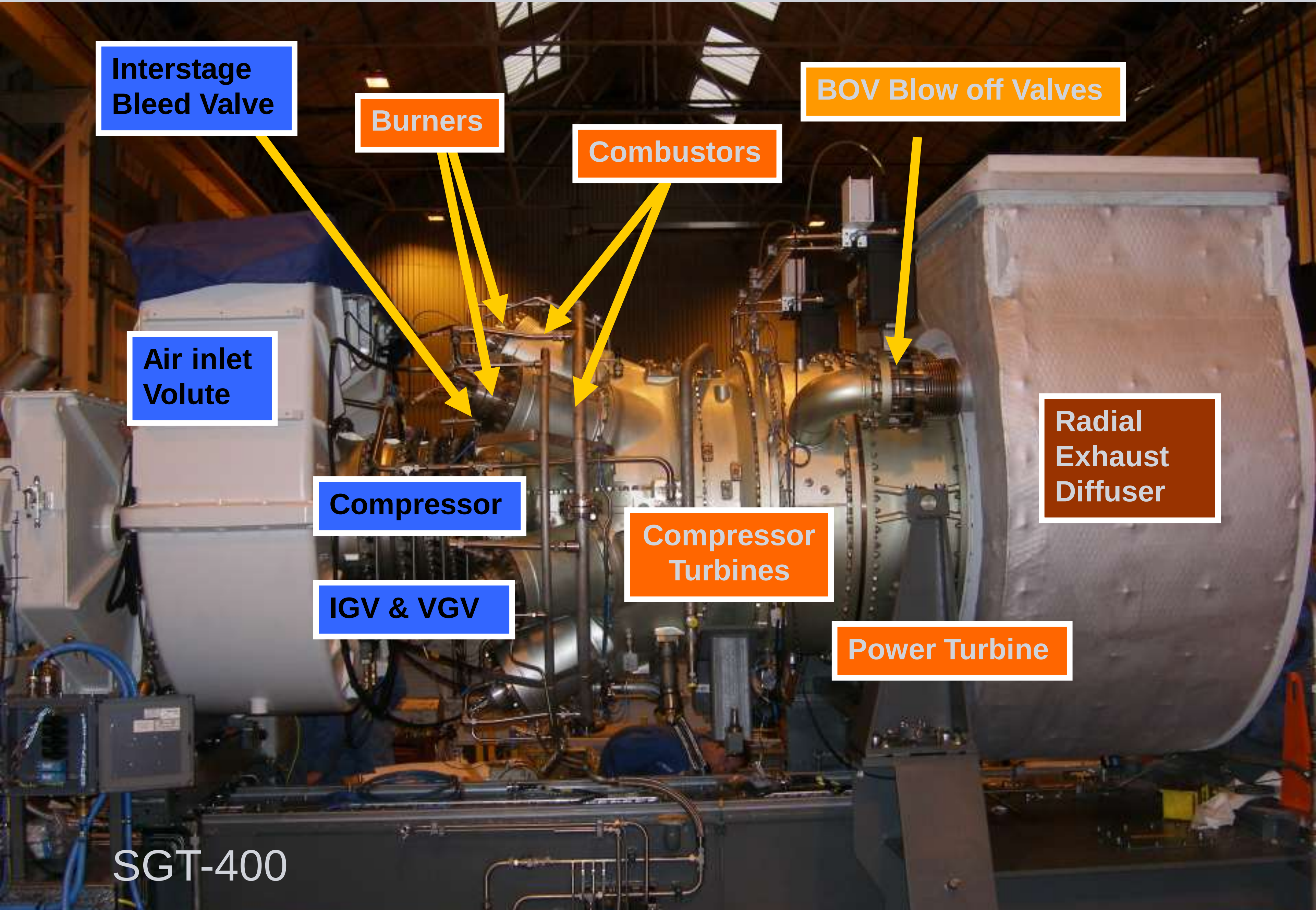


SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

MW - CO

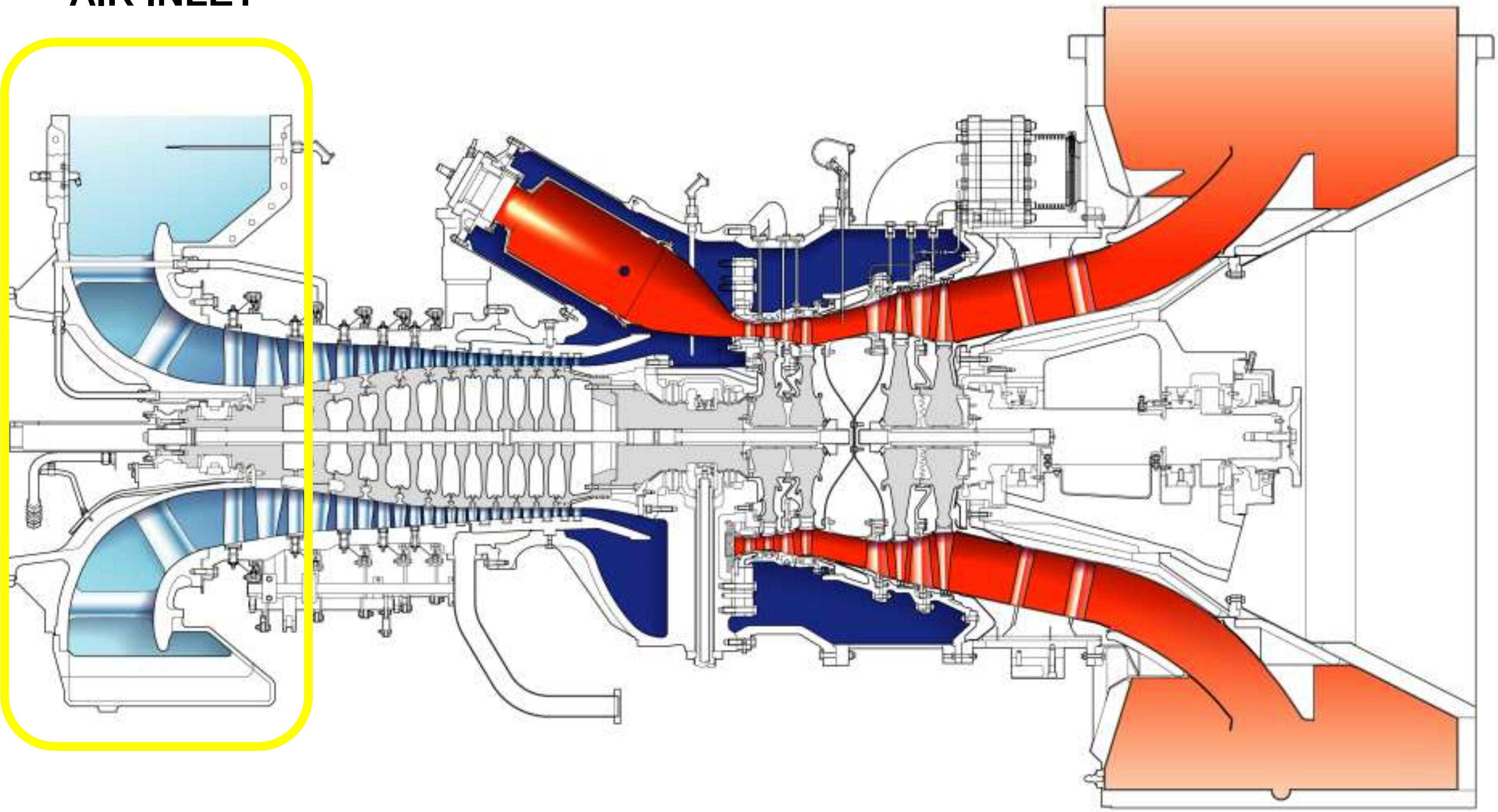
Gas Turbine components

Radial Exhaust Diffuser



The Air Inlet & Filtration system

AIR INLET

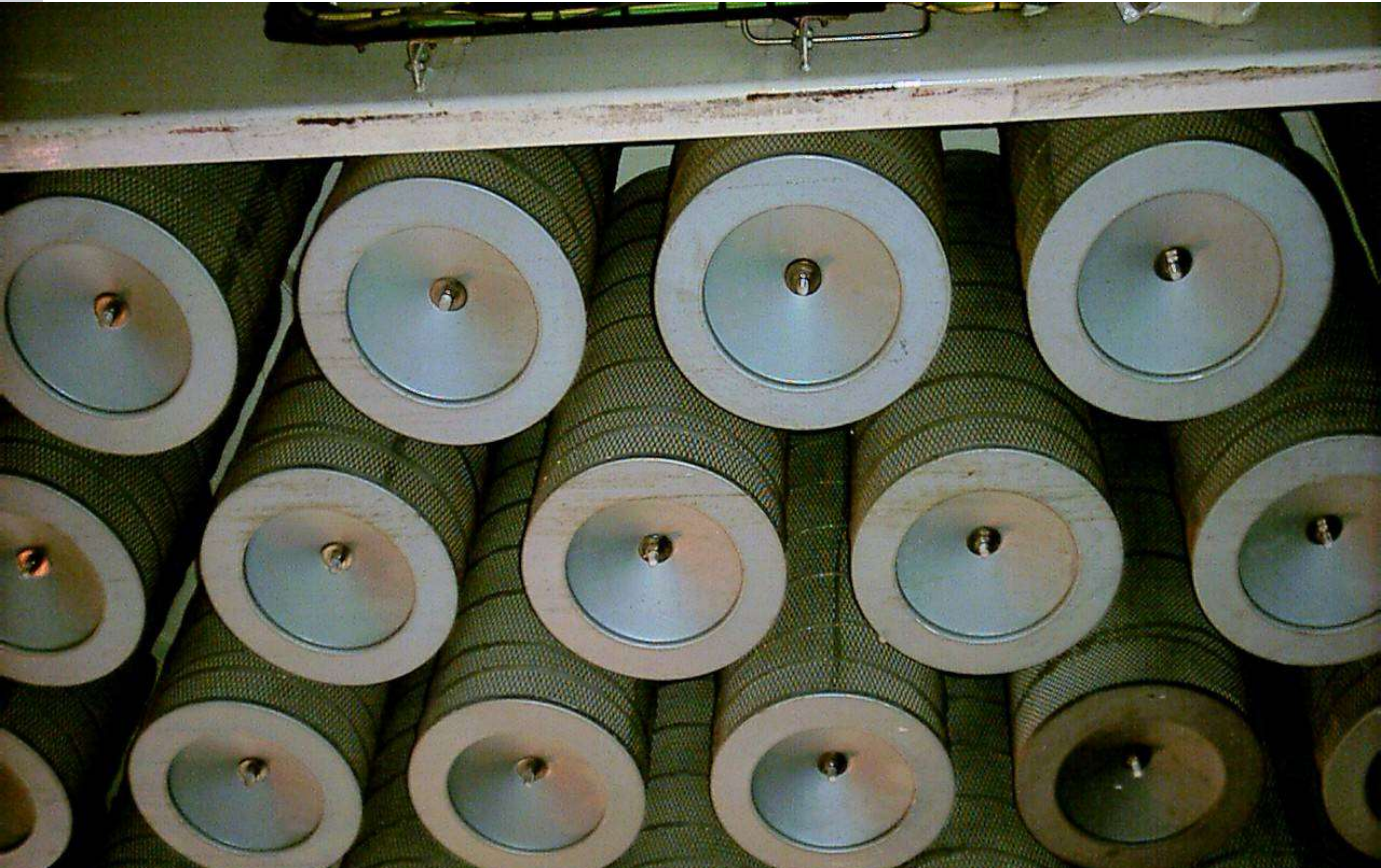


SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

Combustion air inlet Filter system.

Combustion air inlet Filter system.

Pulse Filter Pack (vertical type)



Pulse Inlet Filter Cartridge.

SIEMENS

Air flow to Turbine (Typical Example)

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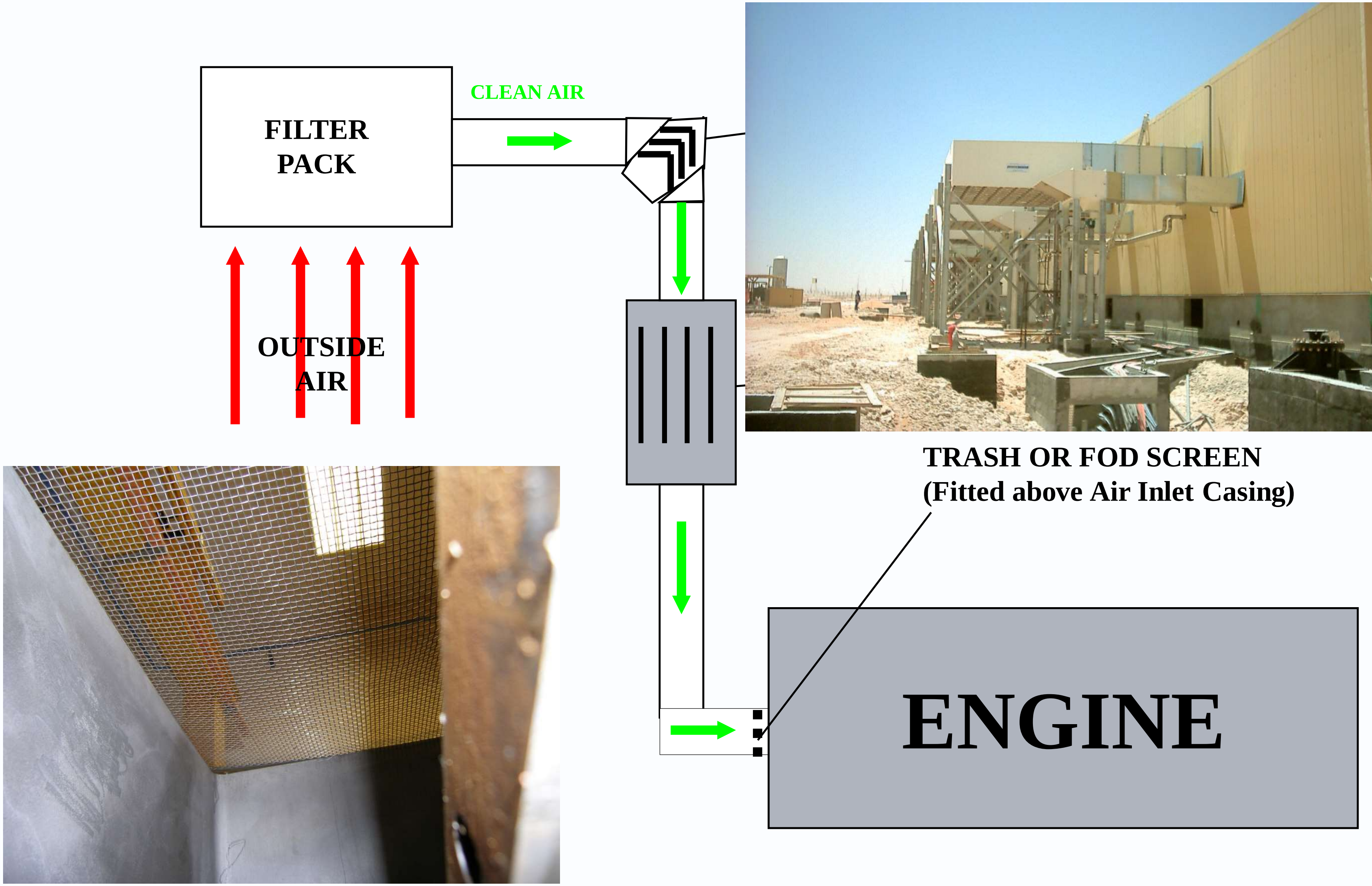
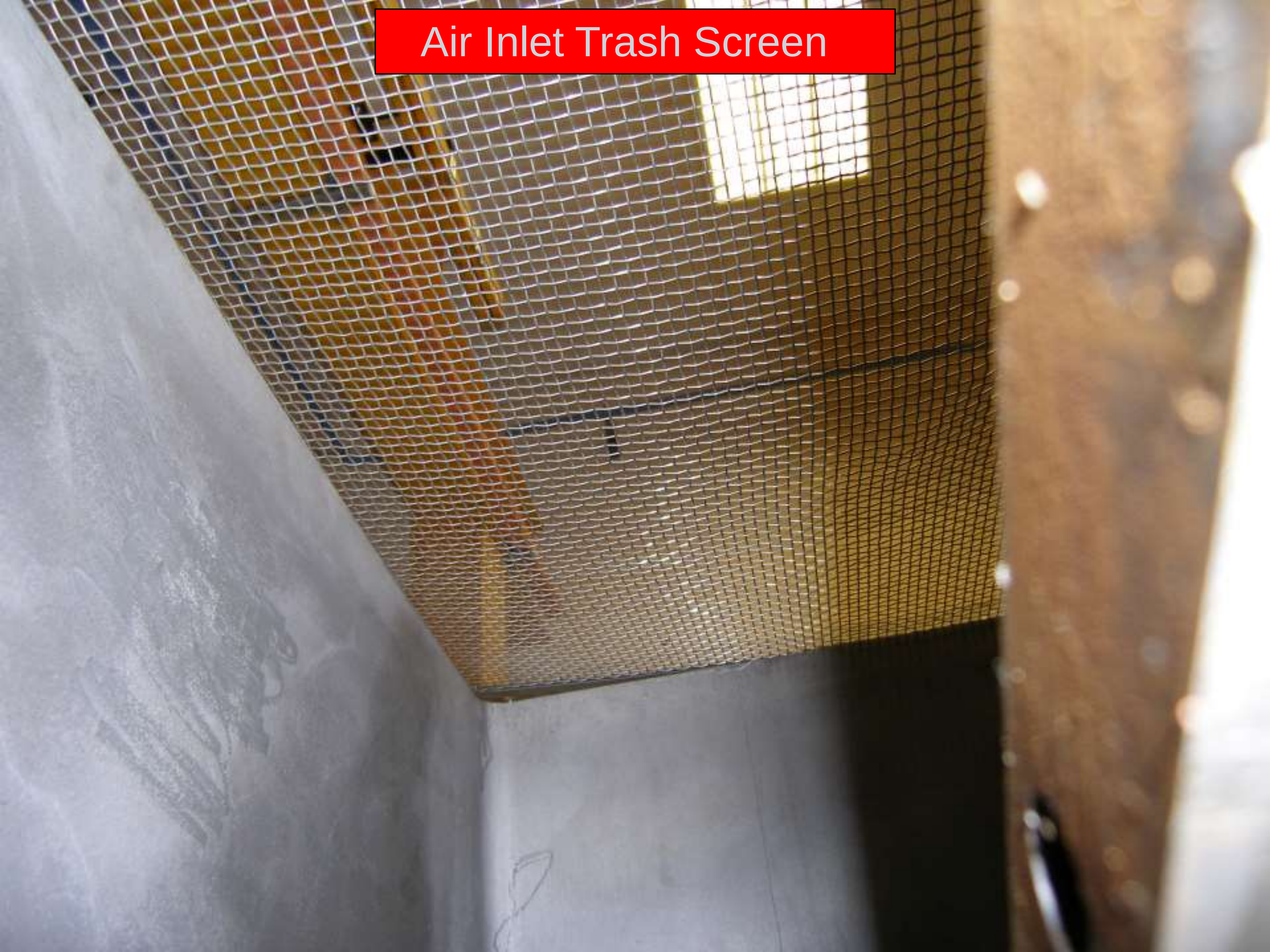


Air Inlet Trash Screen



Typical Combustion Air Inlet Silencer

Multi stage filters.

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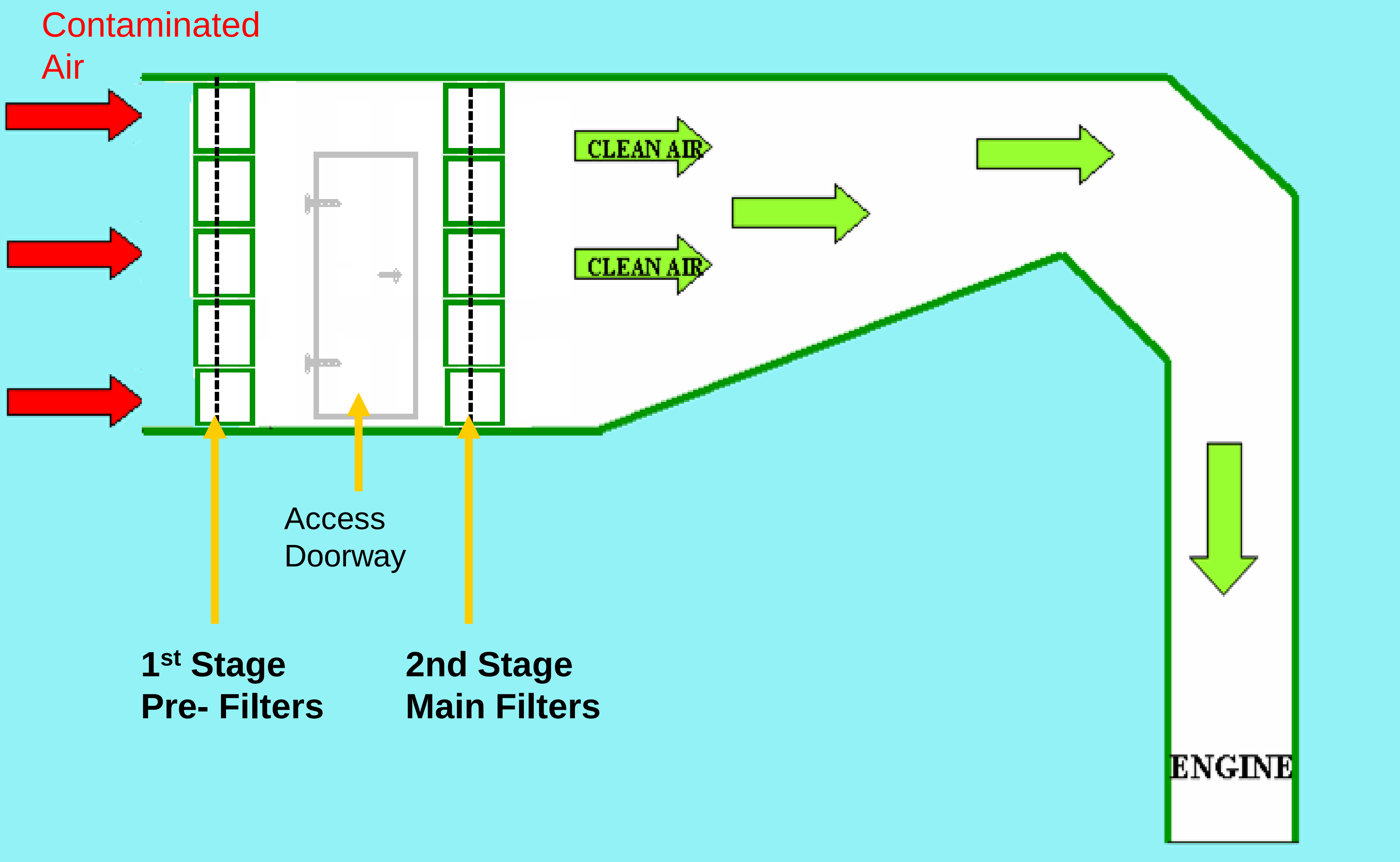
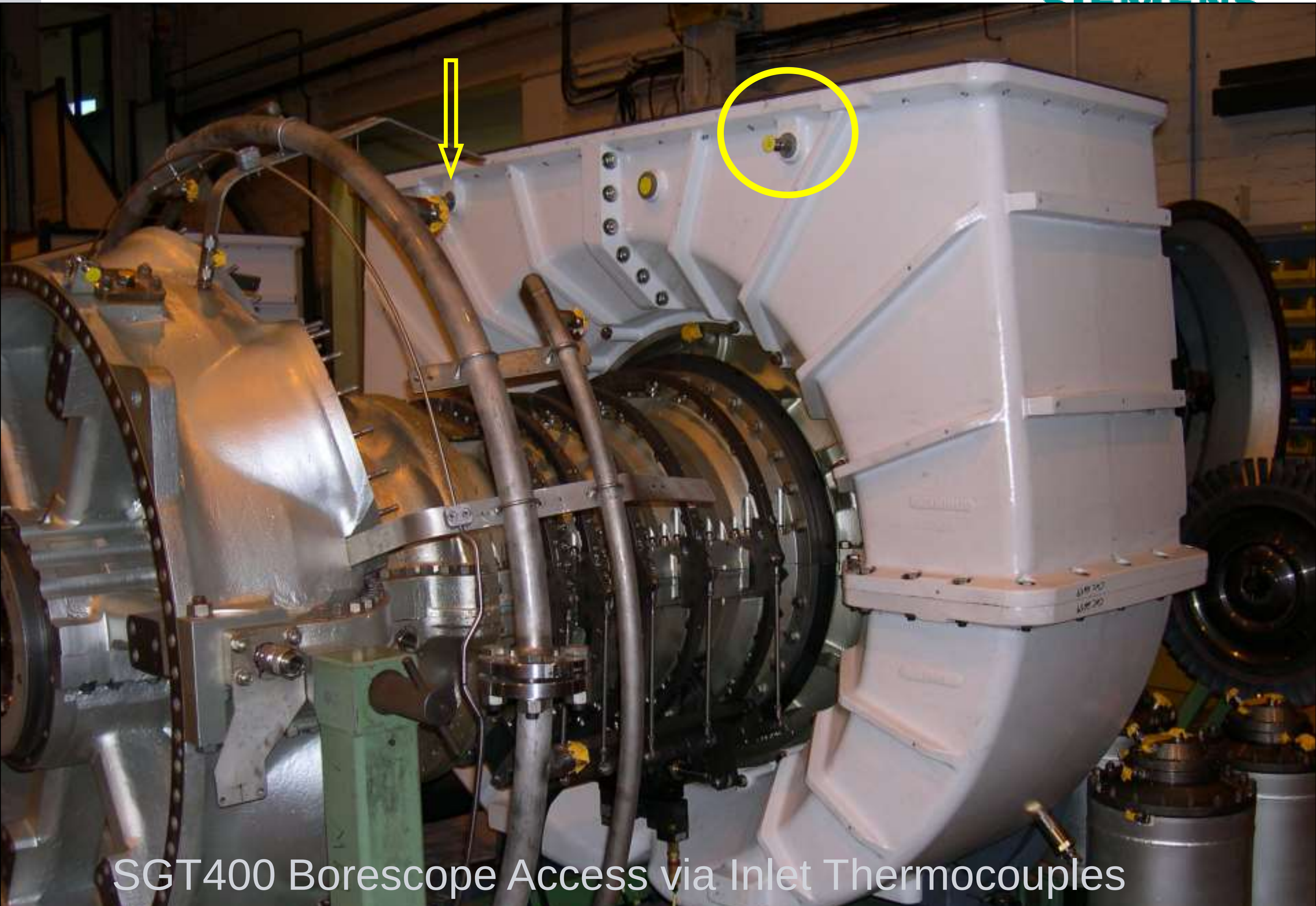


Access for Borescope inspection



SGT400 Borescope Access via Inlet Thermocouples

Slide showing how Inlet Casings can be removed.

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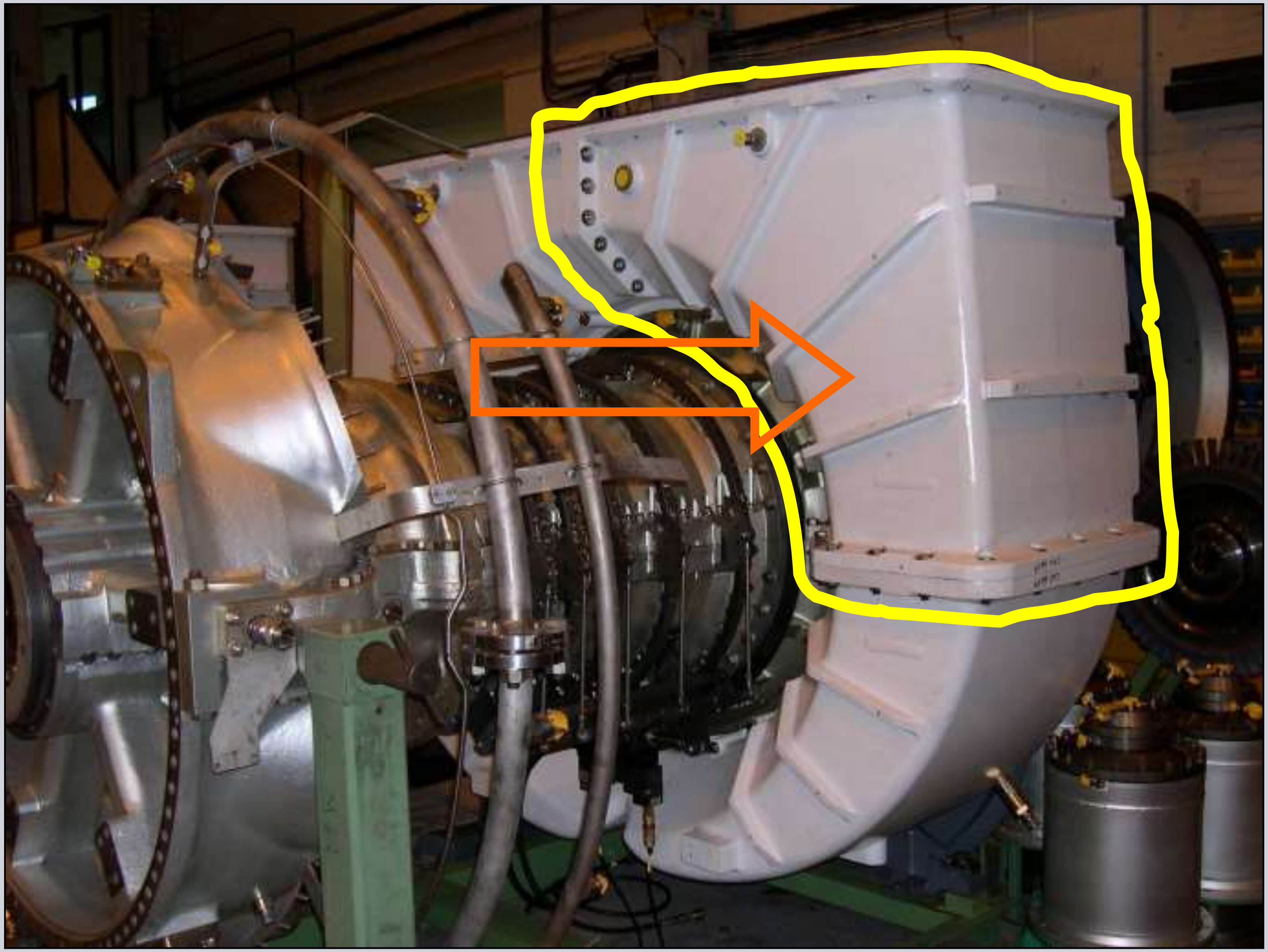
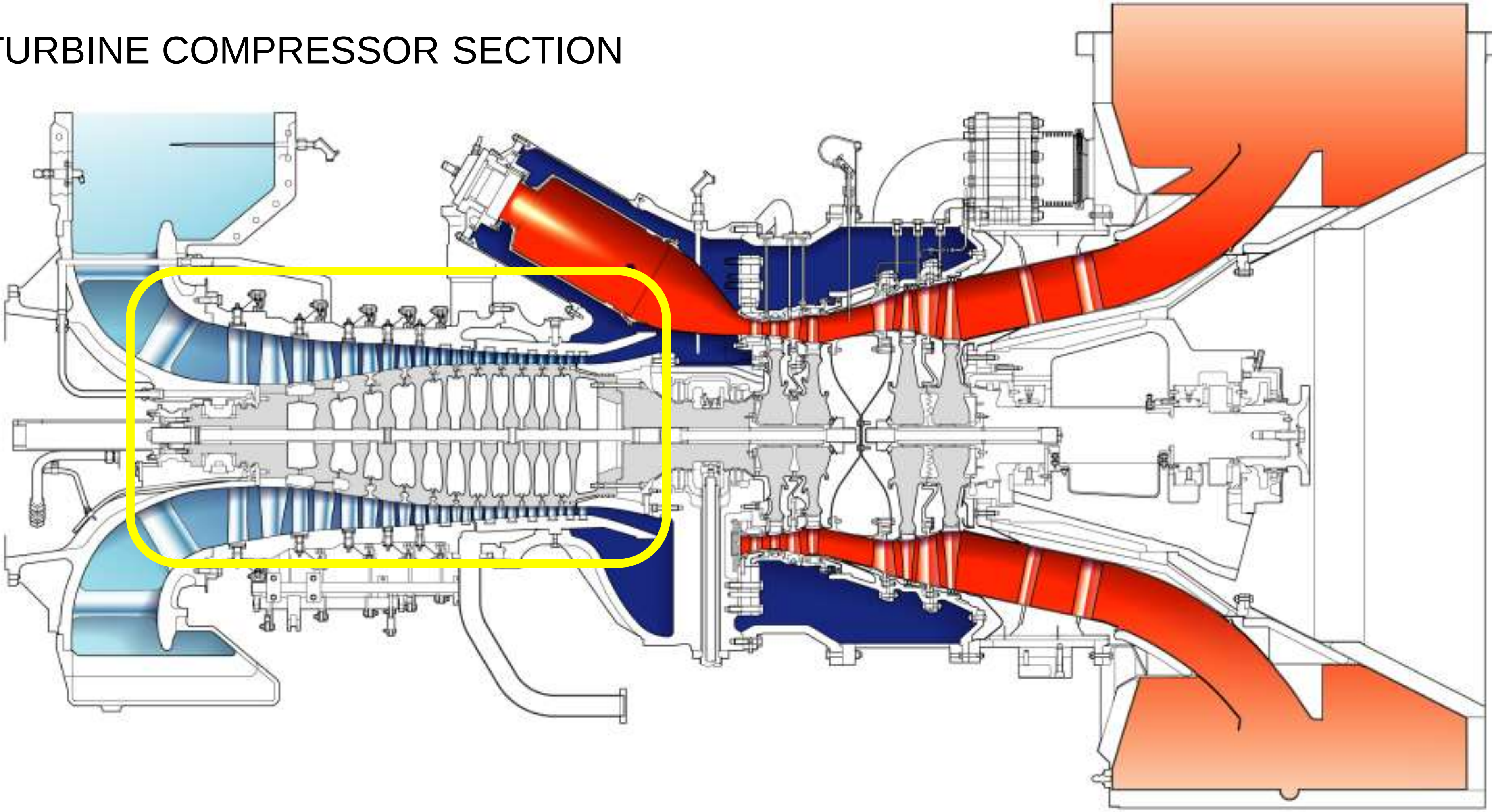


The Compressor, vgv & Interstage bleed valve.

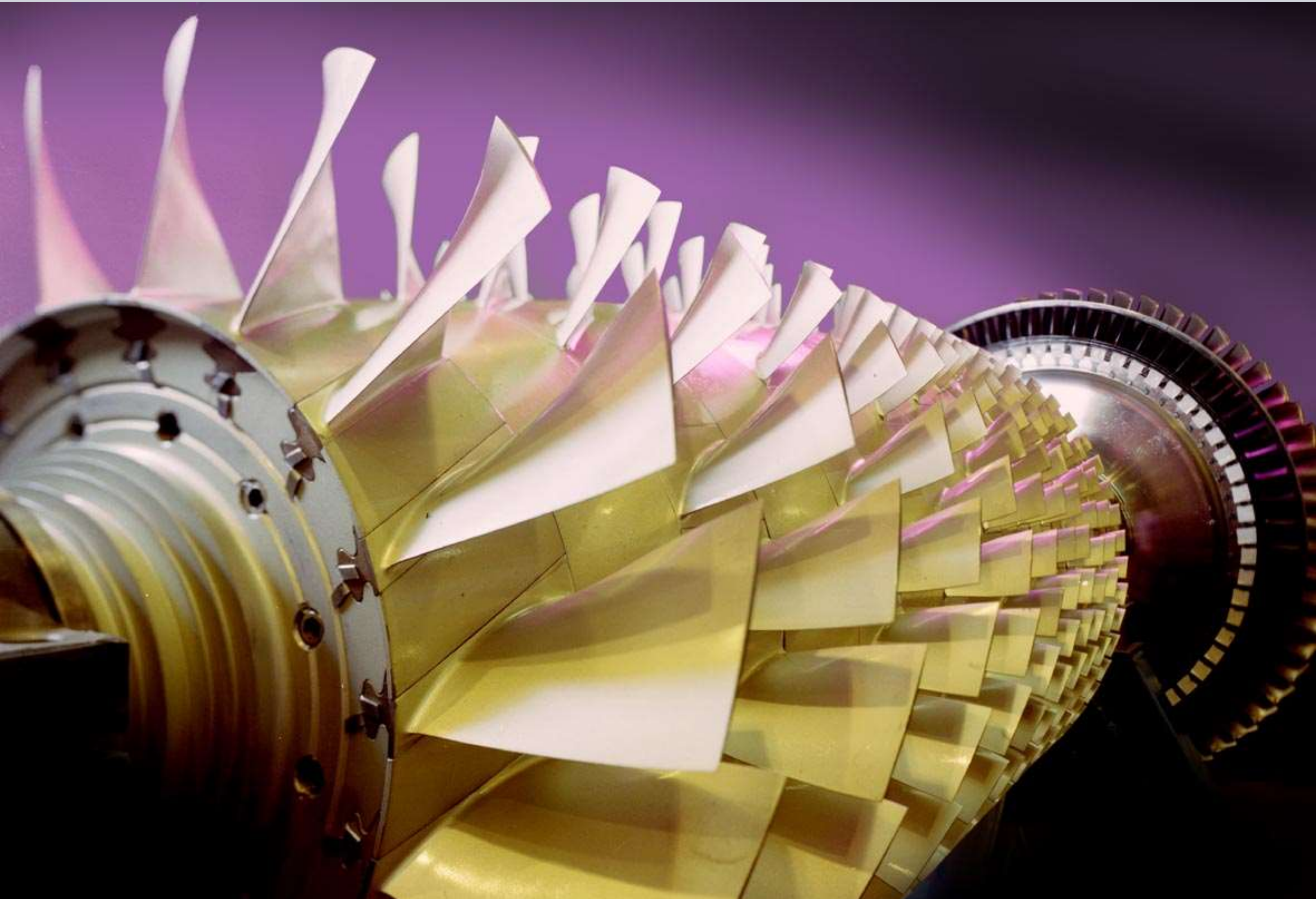
TURBINE COMPRESSOR SECTION



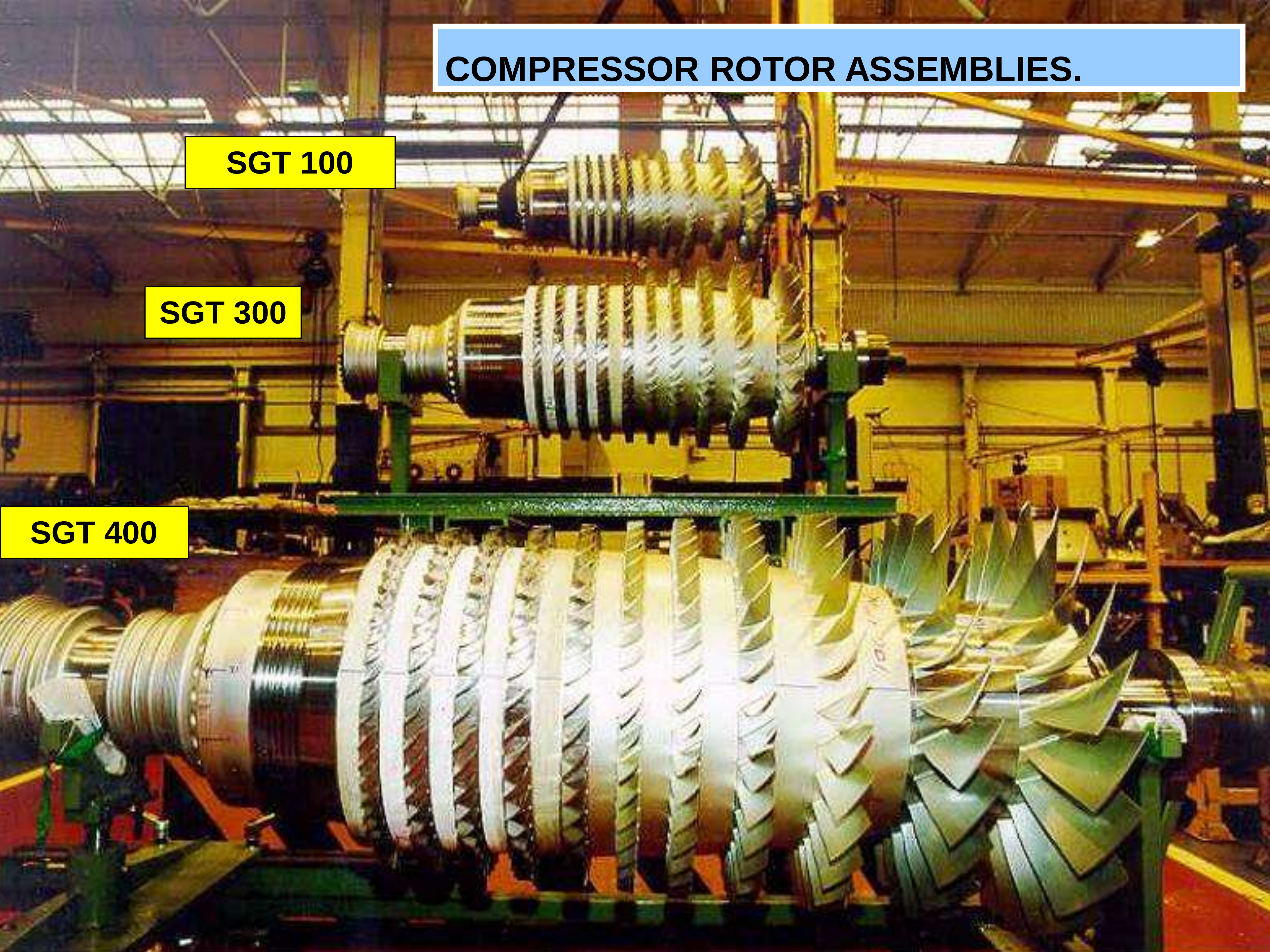
SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

MW - CO

Compressor Rotor assembly



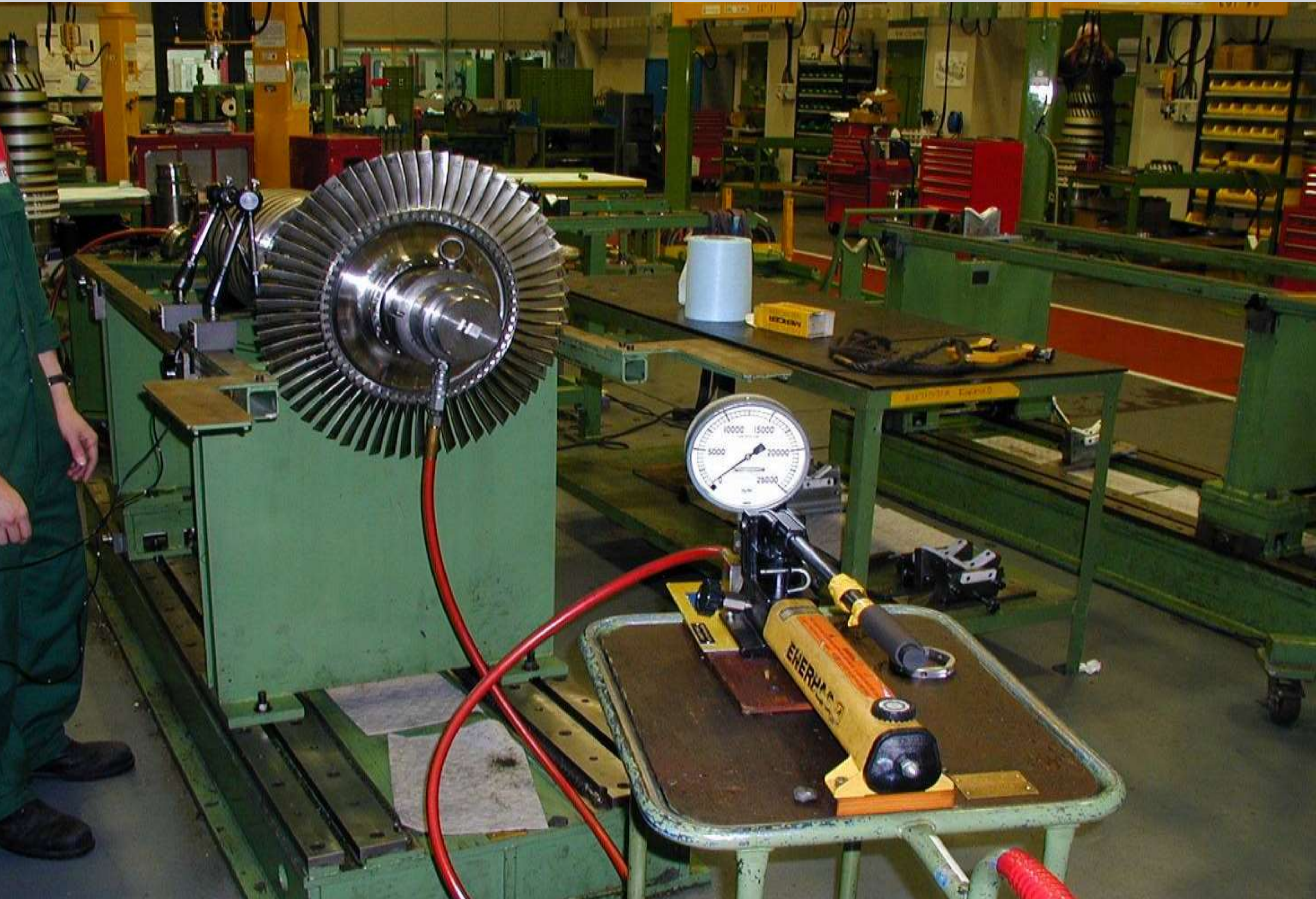
COMPRESSOR ROTOR ASSEMBLIES.



Compressor Rotor initial build.

Disc & Rotor concentricity check

Rotor bolt stretch CT rotor assembly



Rotor balance facility

Power Turbine assembly balance

Rotor over-speed test facility (Main Works)

Compressor Blades and Coatings.

Serme Tel Coating.

- What is Serme Tel coating ?

A complicated process of treating blades with an Aluminium and ceramic coating

- Why is it used?

-To protect the blades from corrosion

-To help prevent the adhesion of dust particles

-To assist in the action of water wash

Coated Compressor Rotor Blades (Various)

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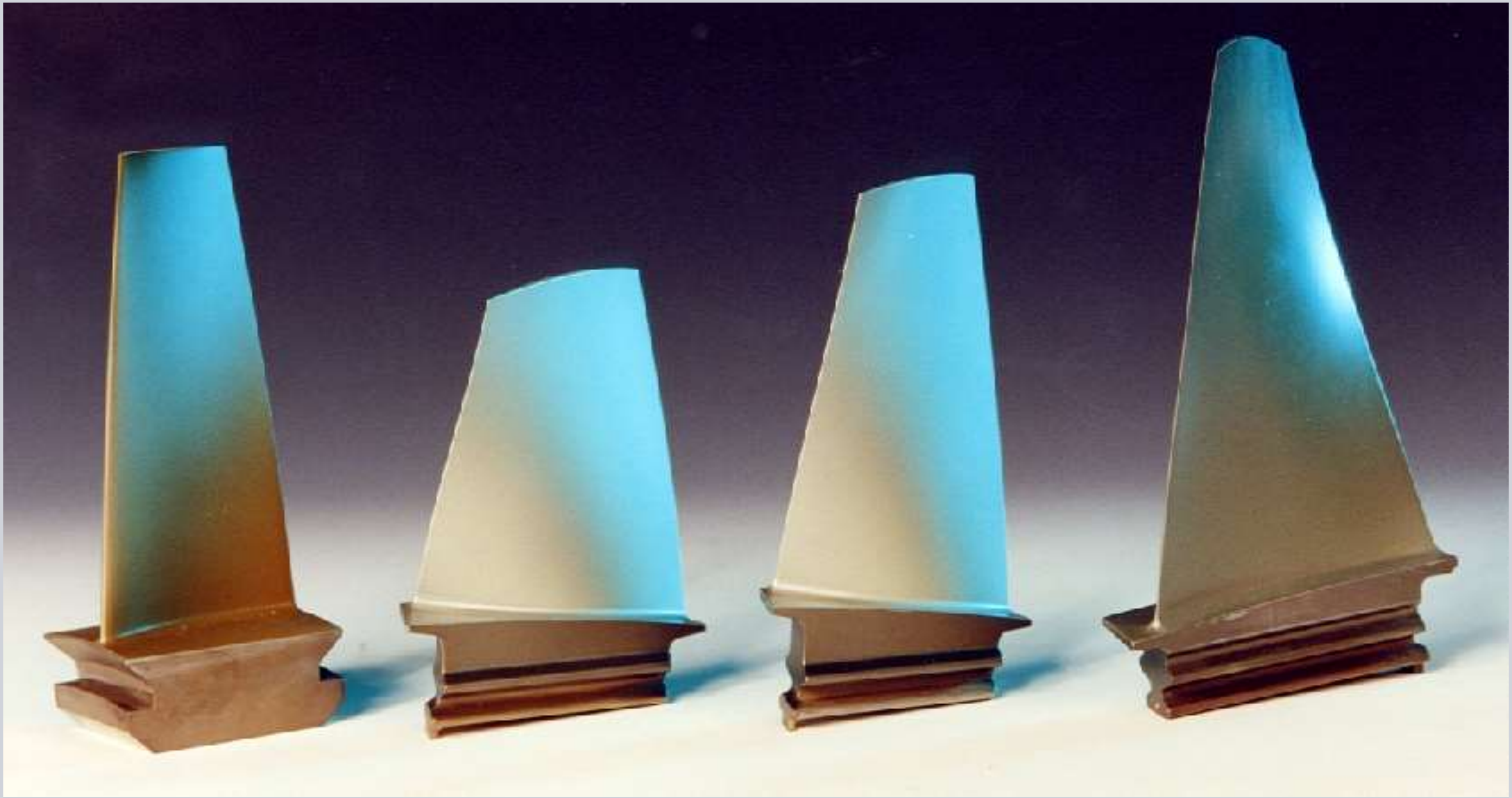
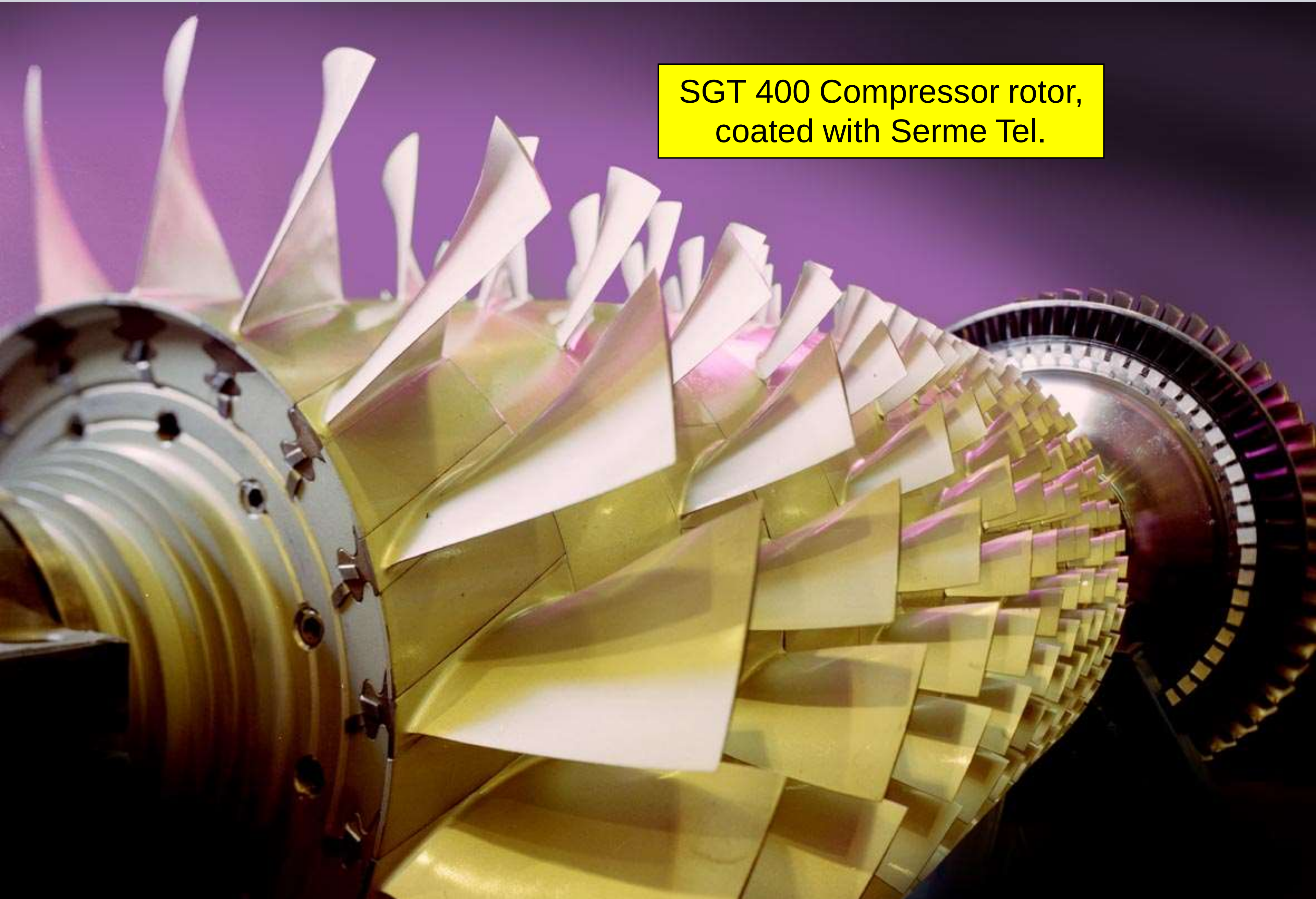
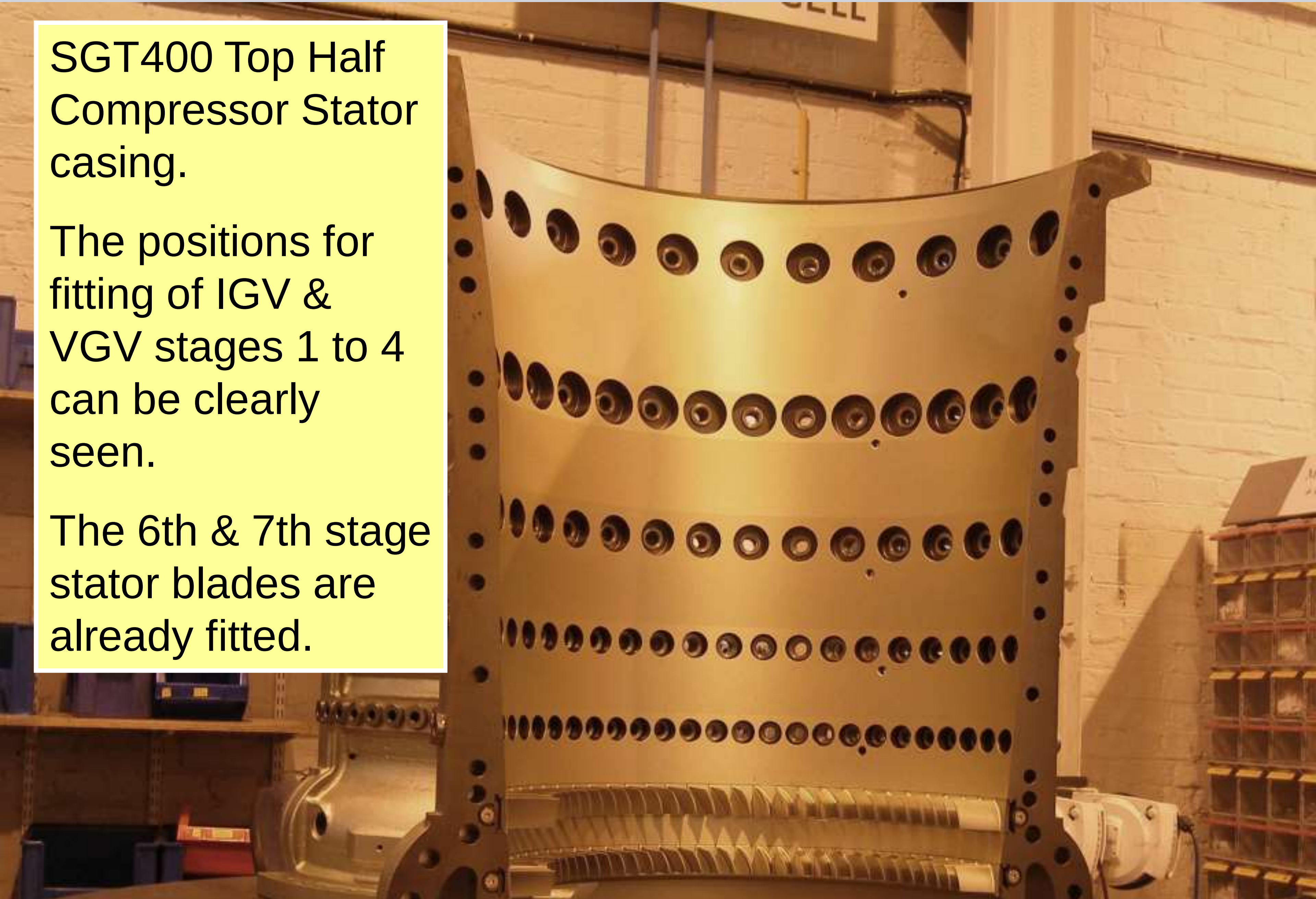


SGT 200. **SGT 100** **SGT 300** **SGT 400**

Serme Tel Coating



IGV & VGV pre assembly



SGT400 Top Half Compressor Stator casing.

The positions for fitting of IGV & VGV stages 1 to 4 can be clearly seen.

The 6th & 7th stage stator blades are already fitted.

Variable guide vanes.

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Typical IGV & VGV blades

IGV & VGV assembly

SGT400 lower half Compressor Stator casing during assembly.

The IGV & VGV stages 1 to 4 are now fitted.

The fifth & sixth stage stator blades have been packed with plasticine prior to finishing, by Tip Grinding the completed assembly.

Inlet Guide Vanes and Compressor Rotor

IGV Inlet guide vanes & Compressor Rotor

IGV & VGV compressor stator blades

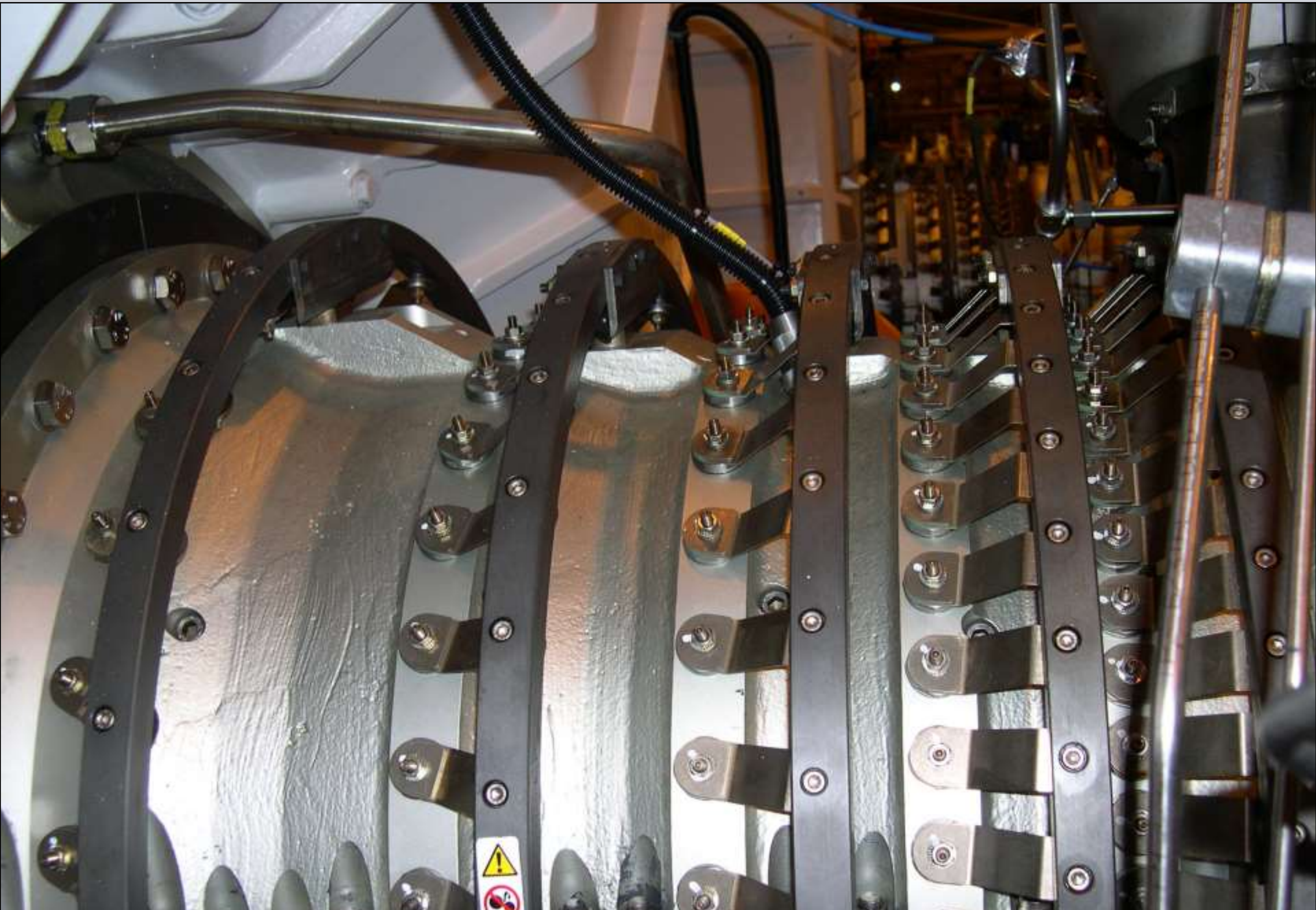
Completed SGT400 Bottom Half Compressor Stator casing.

Inlet Guide Vanes

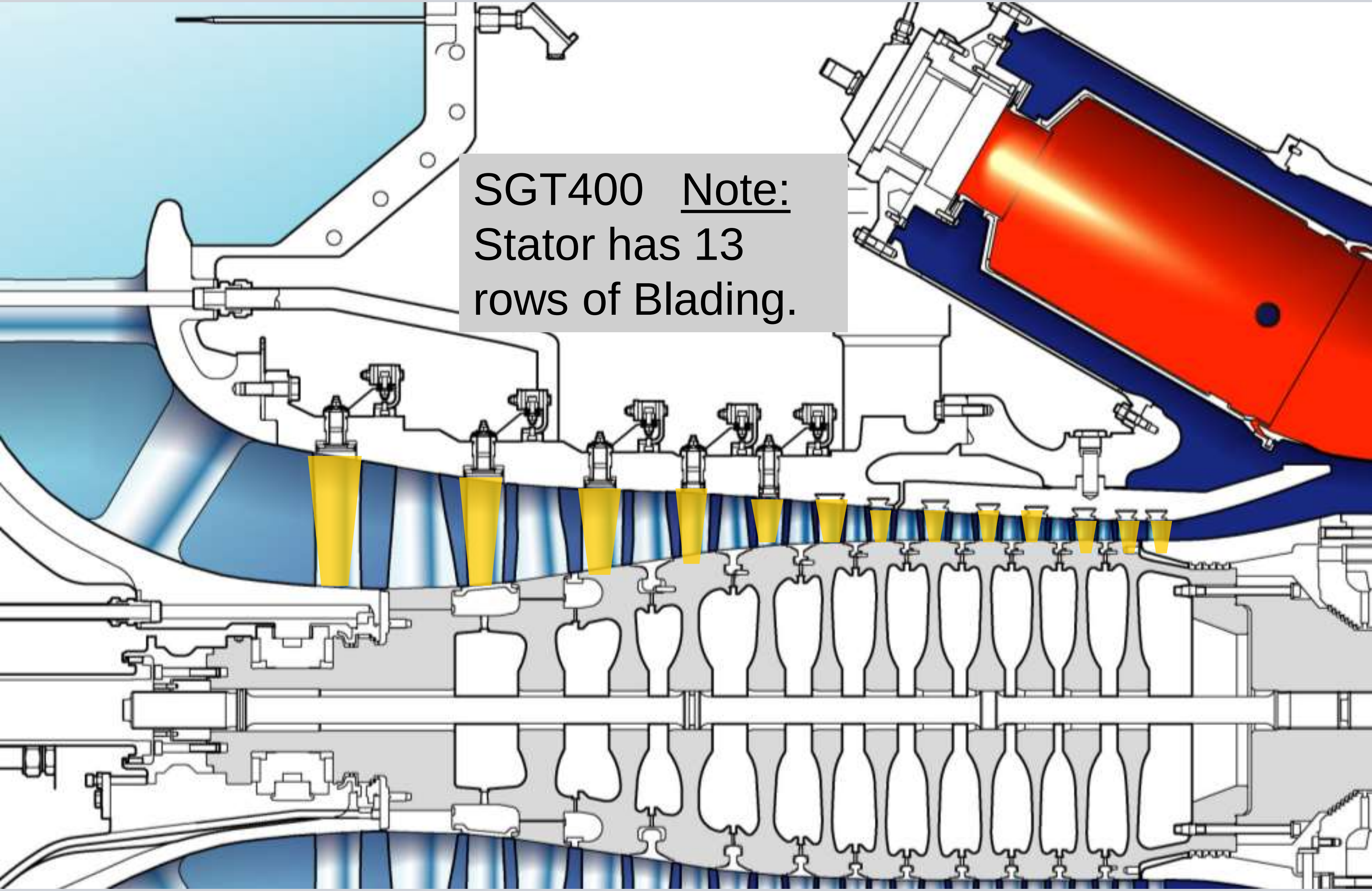
Variable Guide Vanes

The IGV & VGV stages 1 to 4 can be clearly seen.

Compressor unision rings and VGV levers

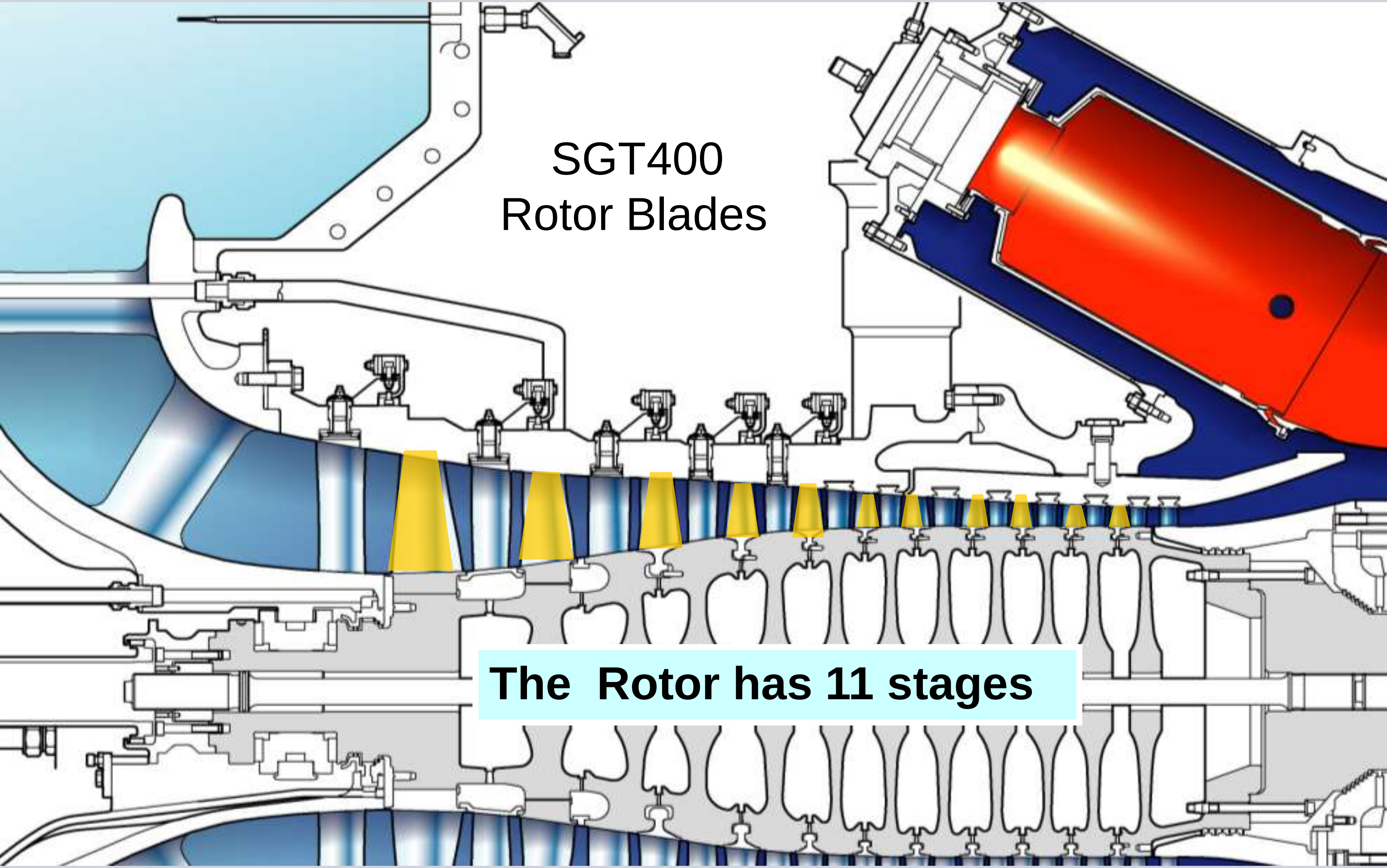


Sectional view of SGT400 compressor area.



SGT 400 Compressor Section

Sectional view of SGT400 compressor area.



SGT 400 Compressor Section

Assembly of **SGT100** Top Half LP Compressor Stator casing.

IGV

VGV 1, 2 & 3

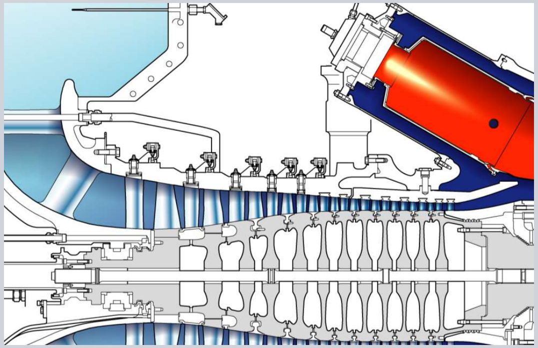
Stator Blades stages 4 & 5.

On the SGT100 rows 7 to 12 are attached to a separate casing segment.

Exit end of SGT400 H P compressor stator.

Compressor Rotor & Stator

Assembly clearance is extremely tight therefore great care must be taken when installing the Compressor Rotor assembly into the Stator.



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What is stall?

A Stall is the aero dynamic breakdown of the airflow within the Compressor section of the Gas Turbine.

Forward air flow is disrupted and becomes unstable. The volume of air entering the inlet stages of the Compressor far exceeds the amount leaving the Compressor exit.

The result of this may be a violent reversal of air flow within the Compressor itself.

This reversal of air flow is called a **Surge**.

What is a Surge.

A surge is the result of an extreme Stall condition.

As the Airflow breaks down over the diminishing stages of the Compressor the airflow to the Combustors is reduced.

The fuel to air ratio rapidly increases as does the combustor pressure.

The combustor pressure overcomes the failing P2 pressure and rapid air oscillation develops within the compressor. This condition is known as a surge.

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Compressor Surge continued

What is Surging.

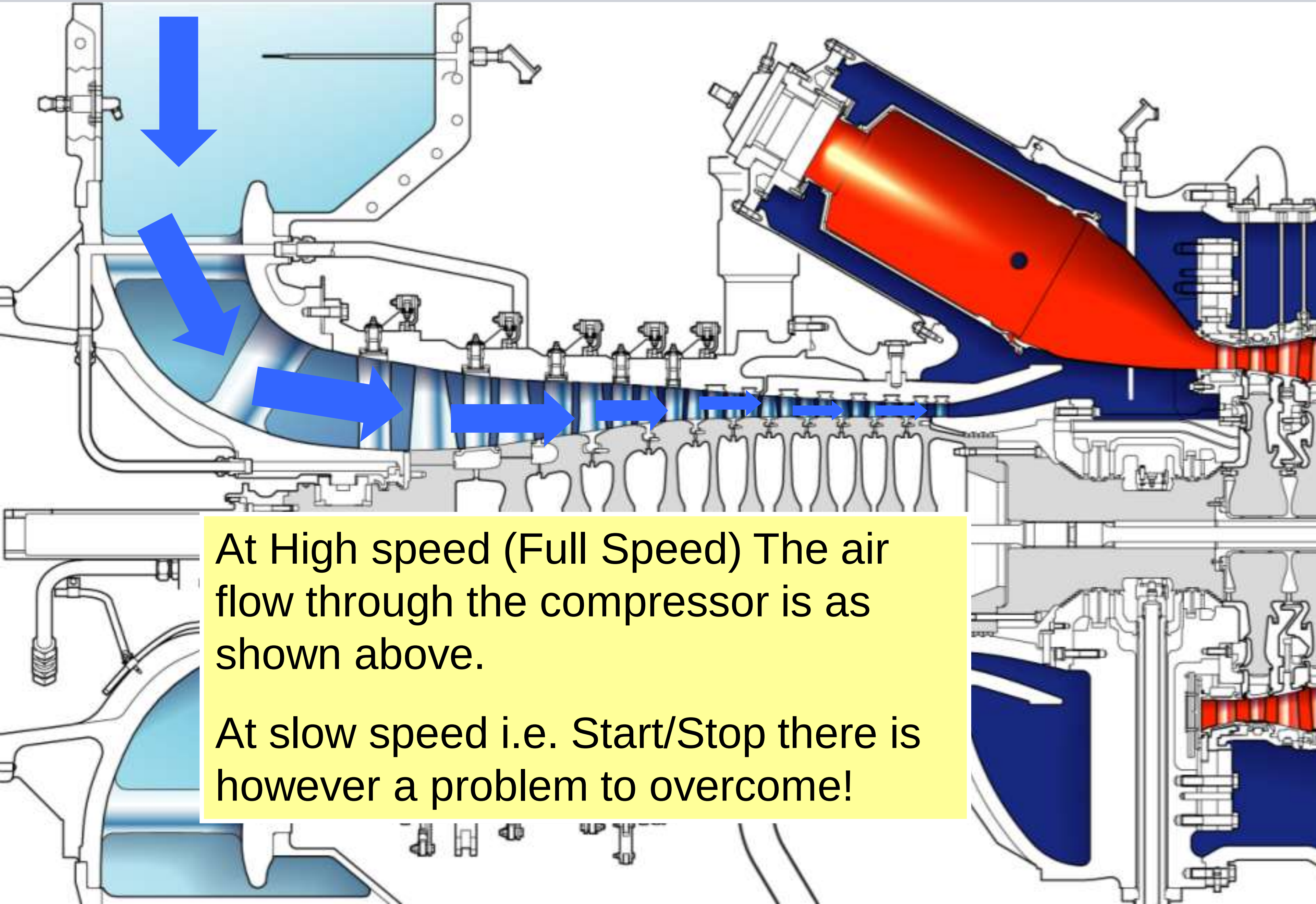
The air oscillation changes very rapidly between forward and reverse air flow.

As the forward air pressure depletes this is overcome by the higher combustion pressure.

As the higher combustion pressure diminishes this again is overcome by the forward compressor pressure and so rapid oscillation commences

This oscillation is also accompanied by loud repetitive bangs emanating from within the inlet ductwork

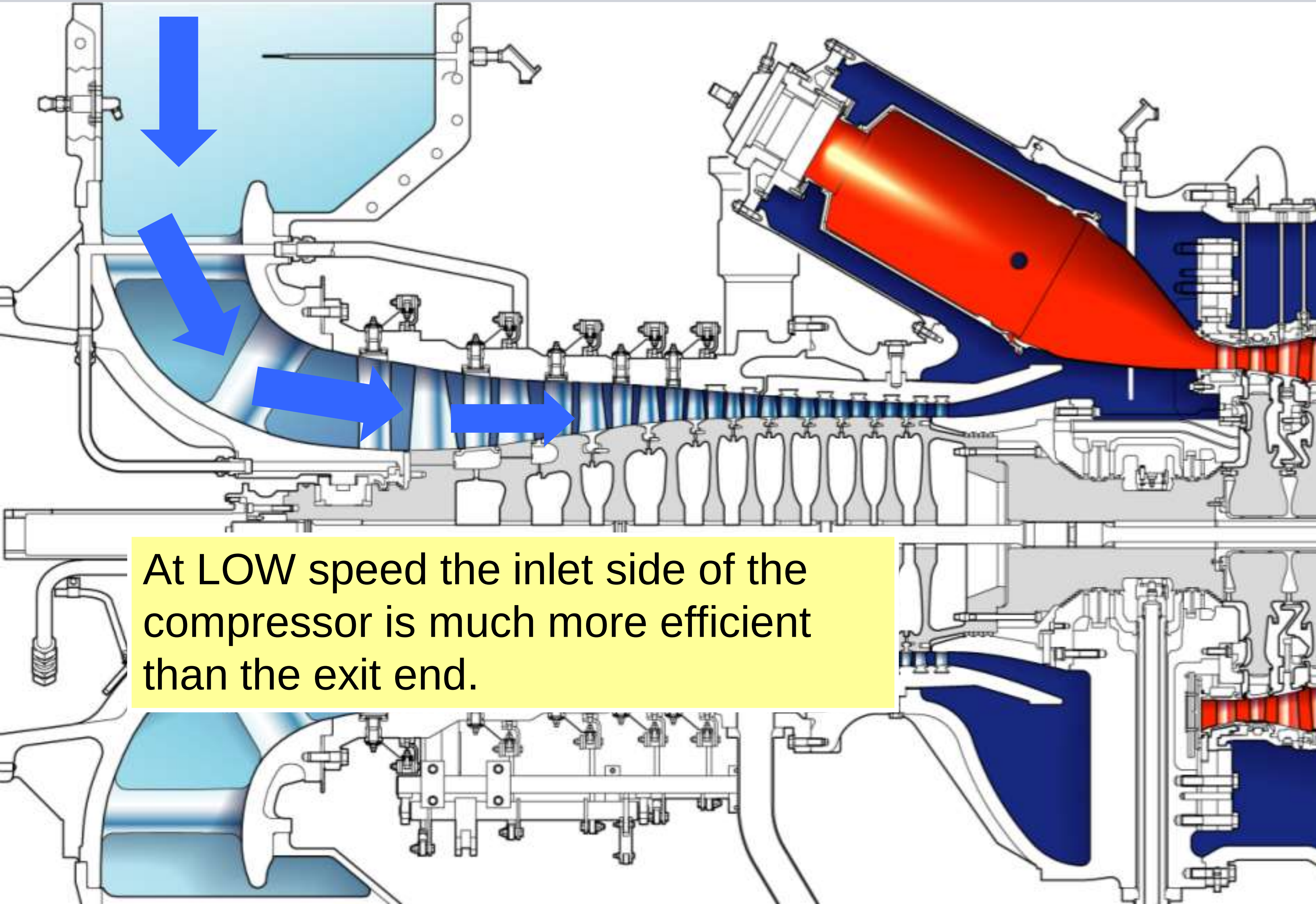
The need for IGV, VGV & Inter-stage Bleed Valve.



At High speed (Full Speed) The air flow through the compressor is as shown above.

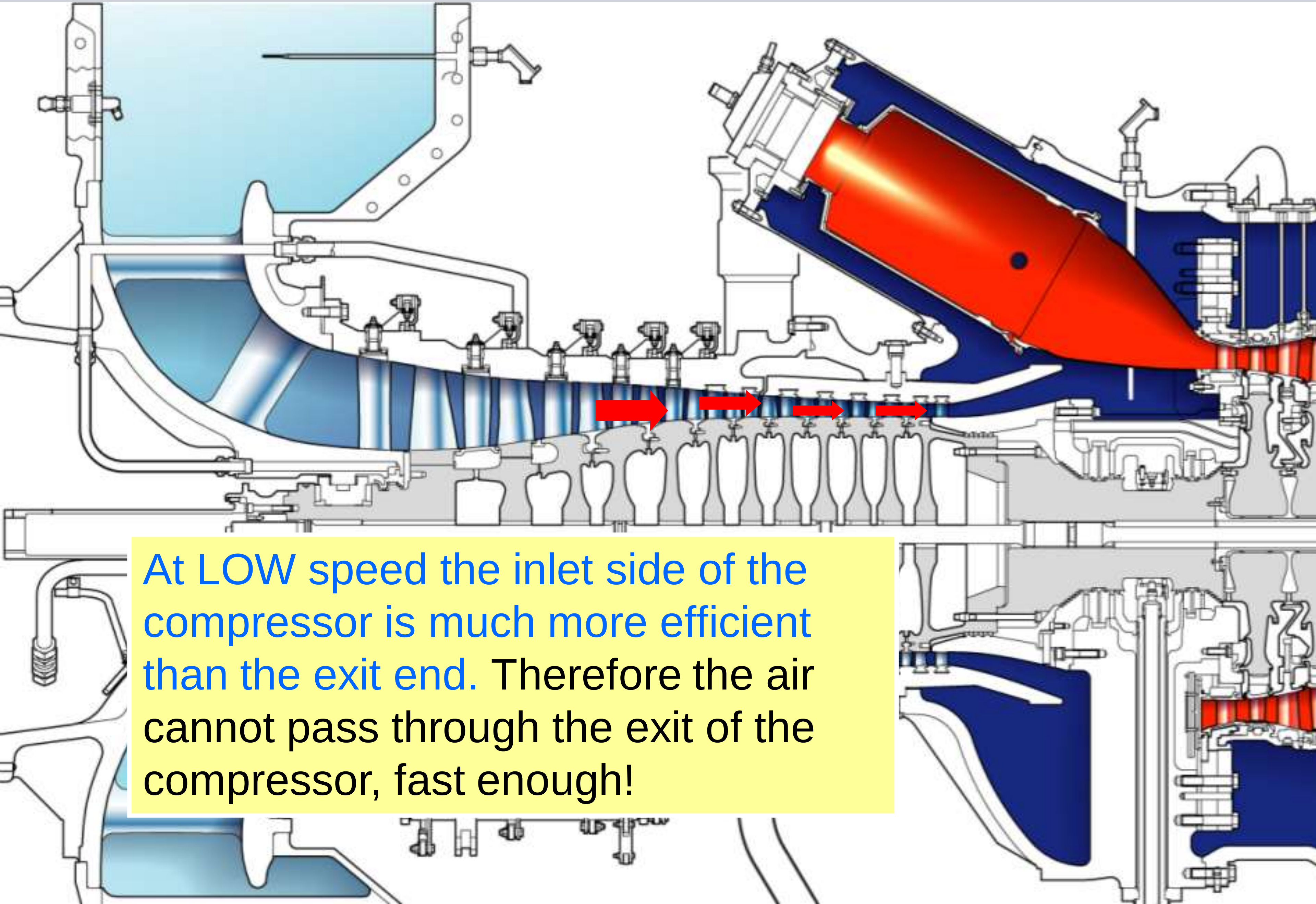
At slow speed i.e. Start/Stop there is however a problem to overcome!

The need for IGV, VGV & Inter-stage Bleed Valve.



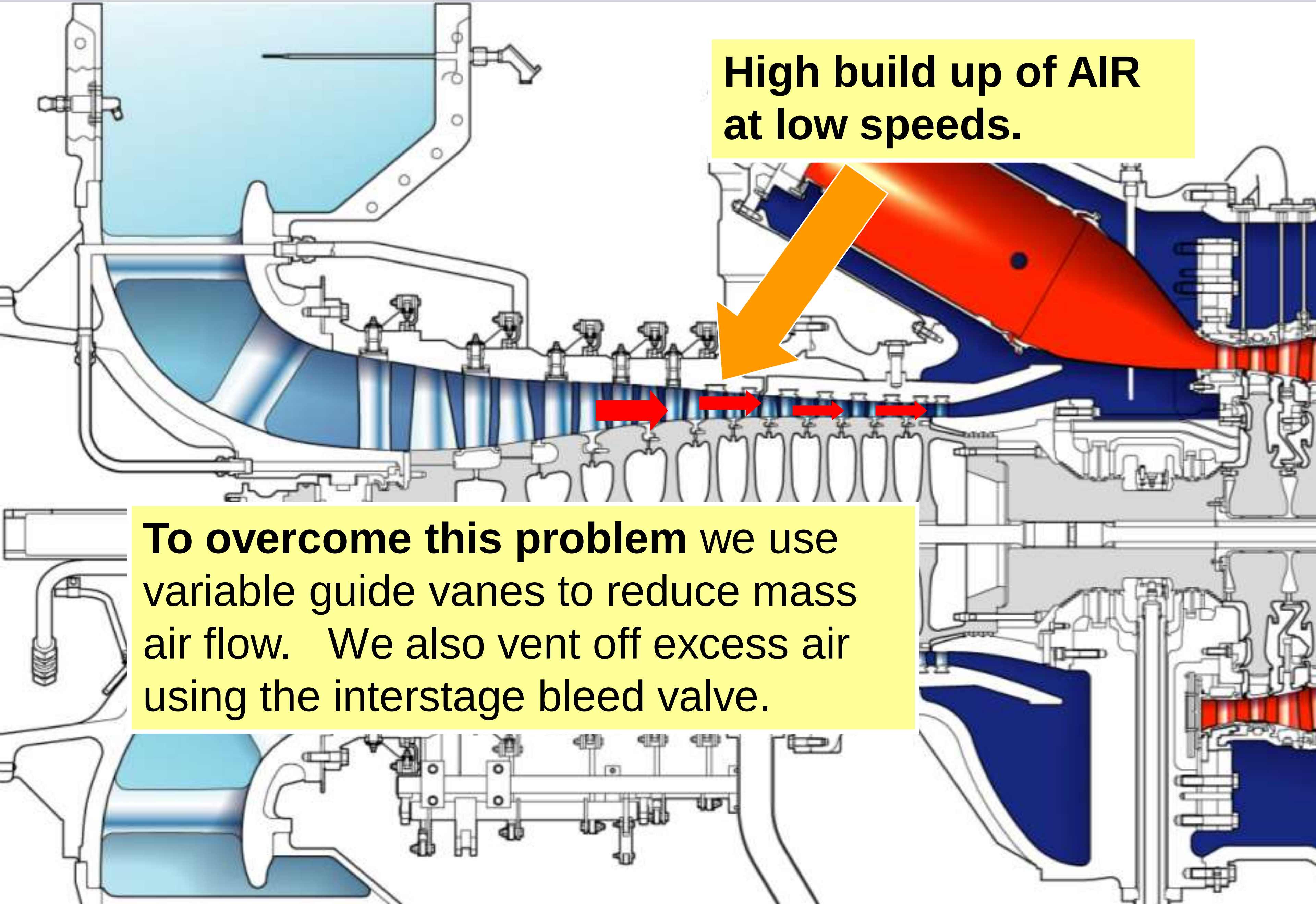
At LOW speed the inlet side of the compressor is much more efficient than the exit end.

The need for IGV, VGV & Inter-stage Bleed Valve.



At LOW speed the inlet side of the compressor is much more efficient than the exit end. Therefore the air cannot pass through the exit of the compressor, fast enough!

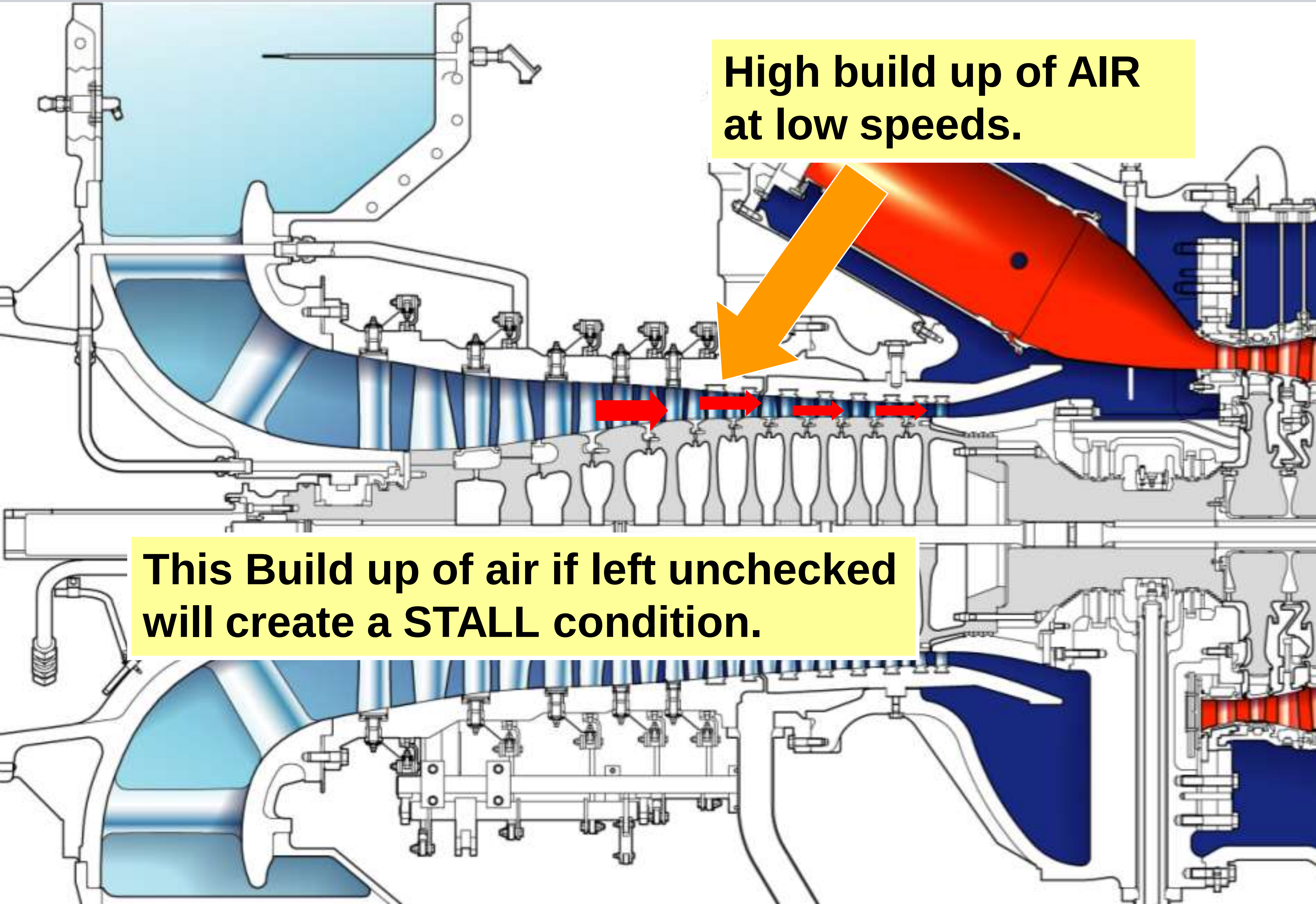
The need for IGV, VGV & Inter-stage Bleed Valve.



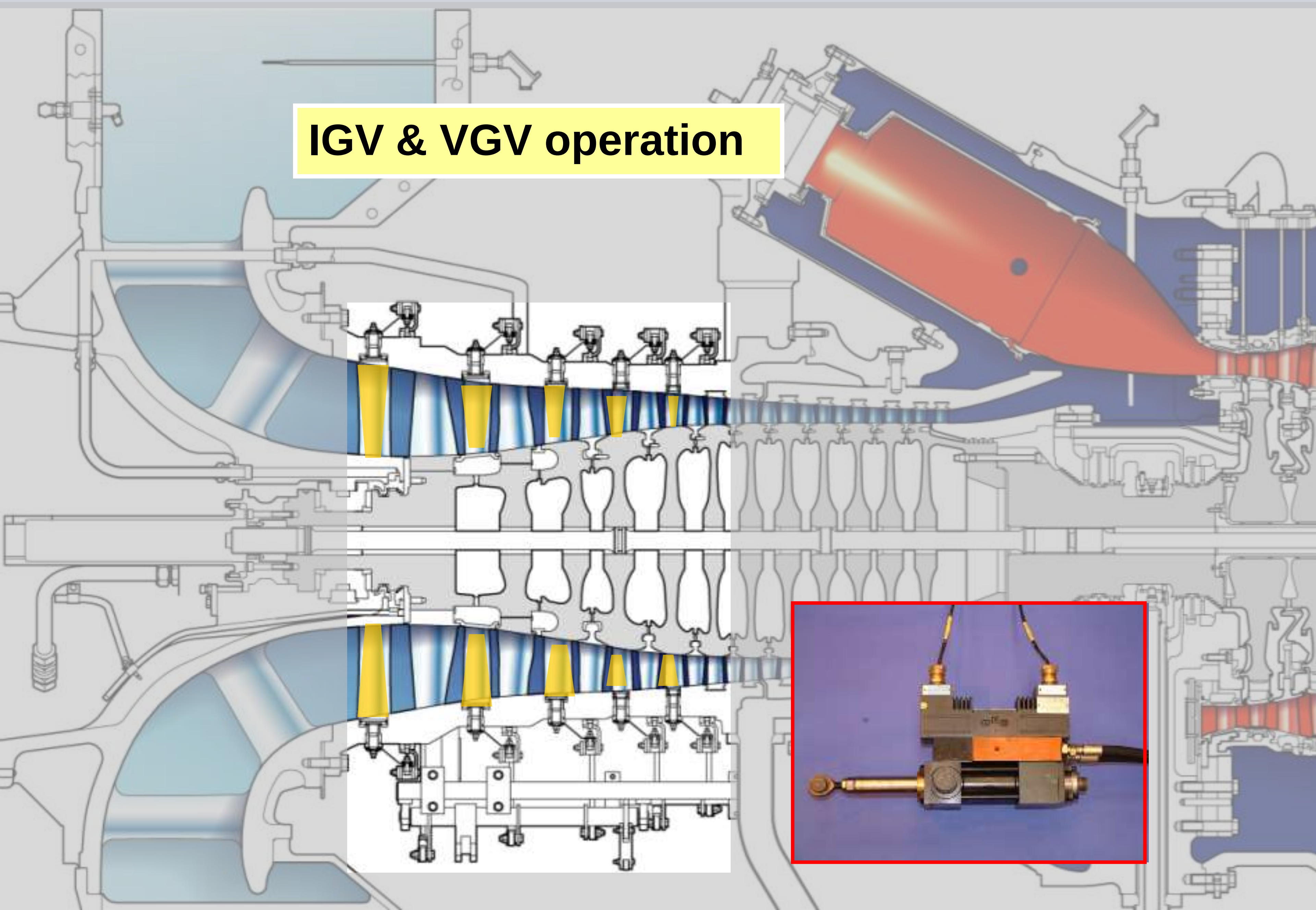
High build up of AIR at low speeds.

To overcome this problem we use variable guide vanes to reduce mass air flow. We also vent off excess air using the interstage bleed valve.

The need for IGV, VGV & Inter-stage Bleed Valve.



The need for IGV, VGV & Inter-stage Bleed Valve.



VGV Hydraulic actuator

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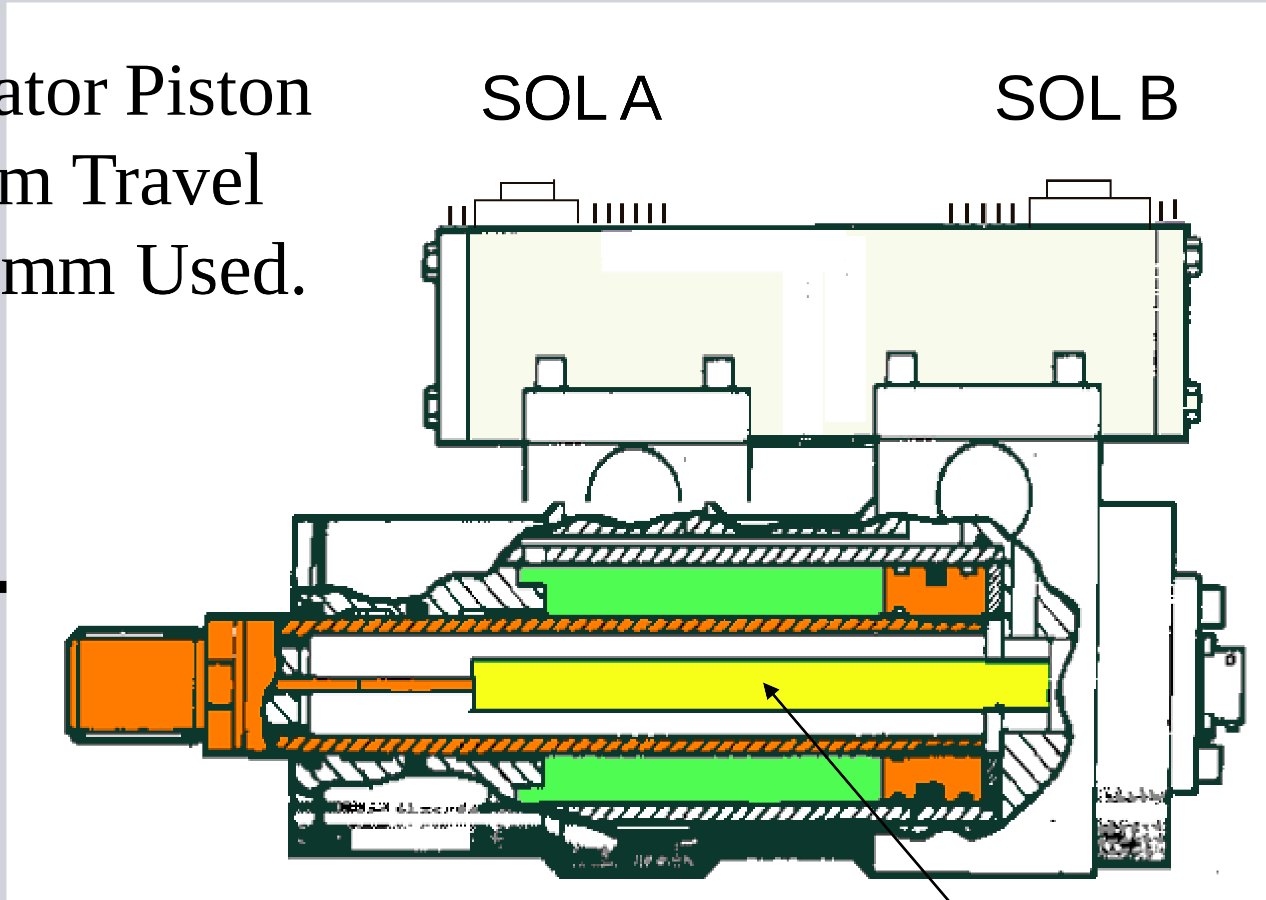
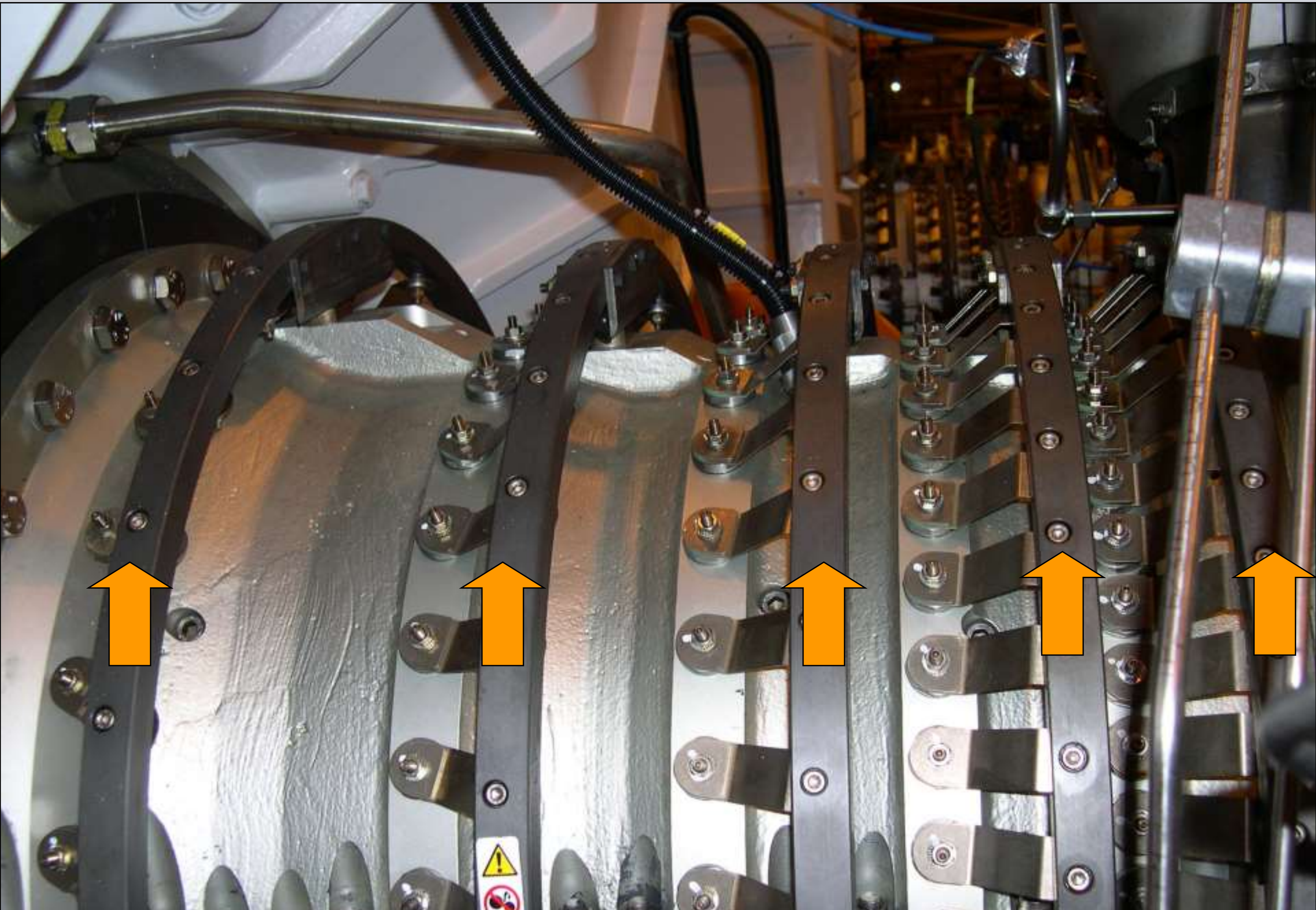
Actuator Piston
52 mm Travel
0-48 mm Used.



4-20ma Feedback Device

Top casing showing Unision rings for VGV operation



SGT 400 VGV'S ready for start.

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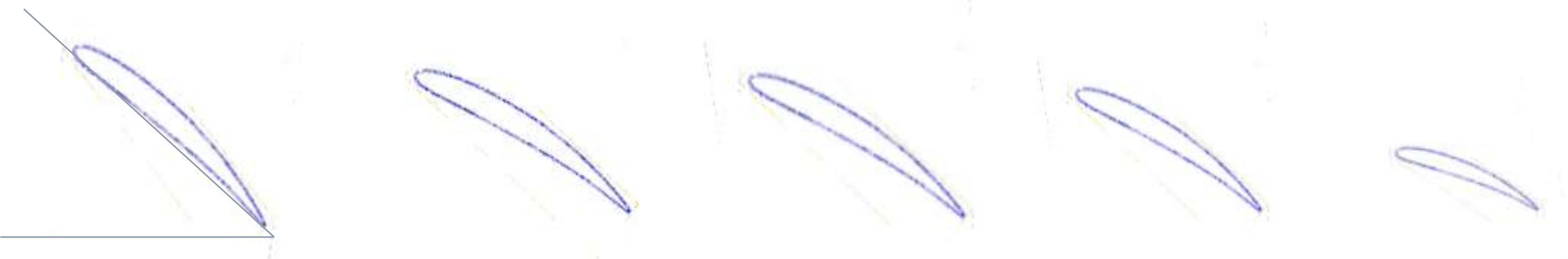
*** Also Engine shut down position.**

Variable Inlet Guide Vane	1st Stage	2nd Stage	3rd Stage	4th Stage



+49	+26	+19	+12	+5

ACTUATOR AT 0mm or 0%
START = EXTENDED

SGT 400 VGV's (running position)

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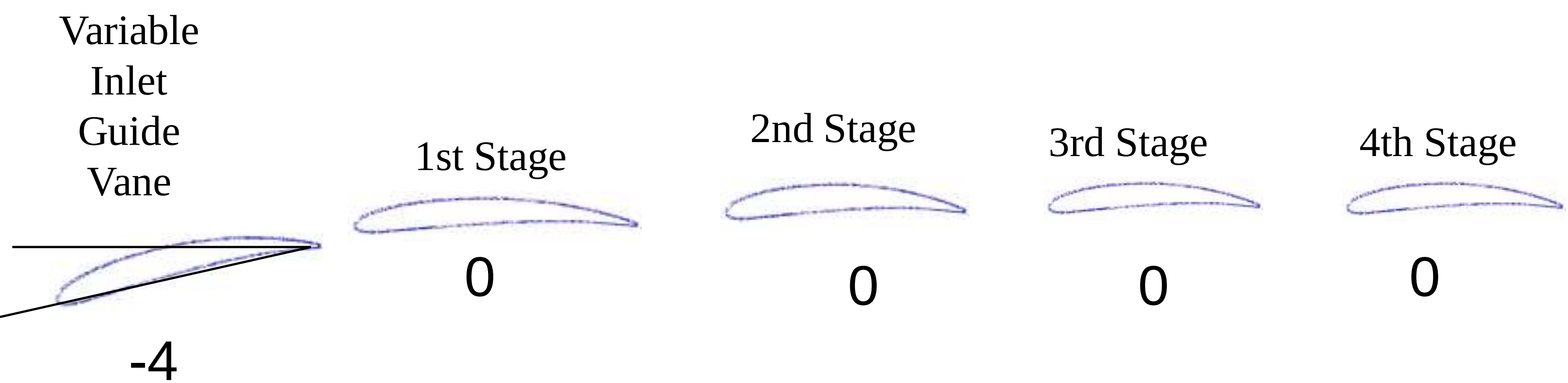
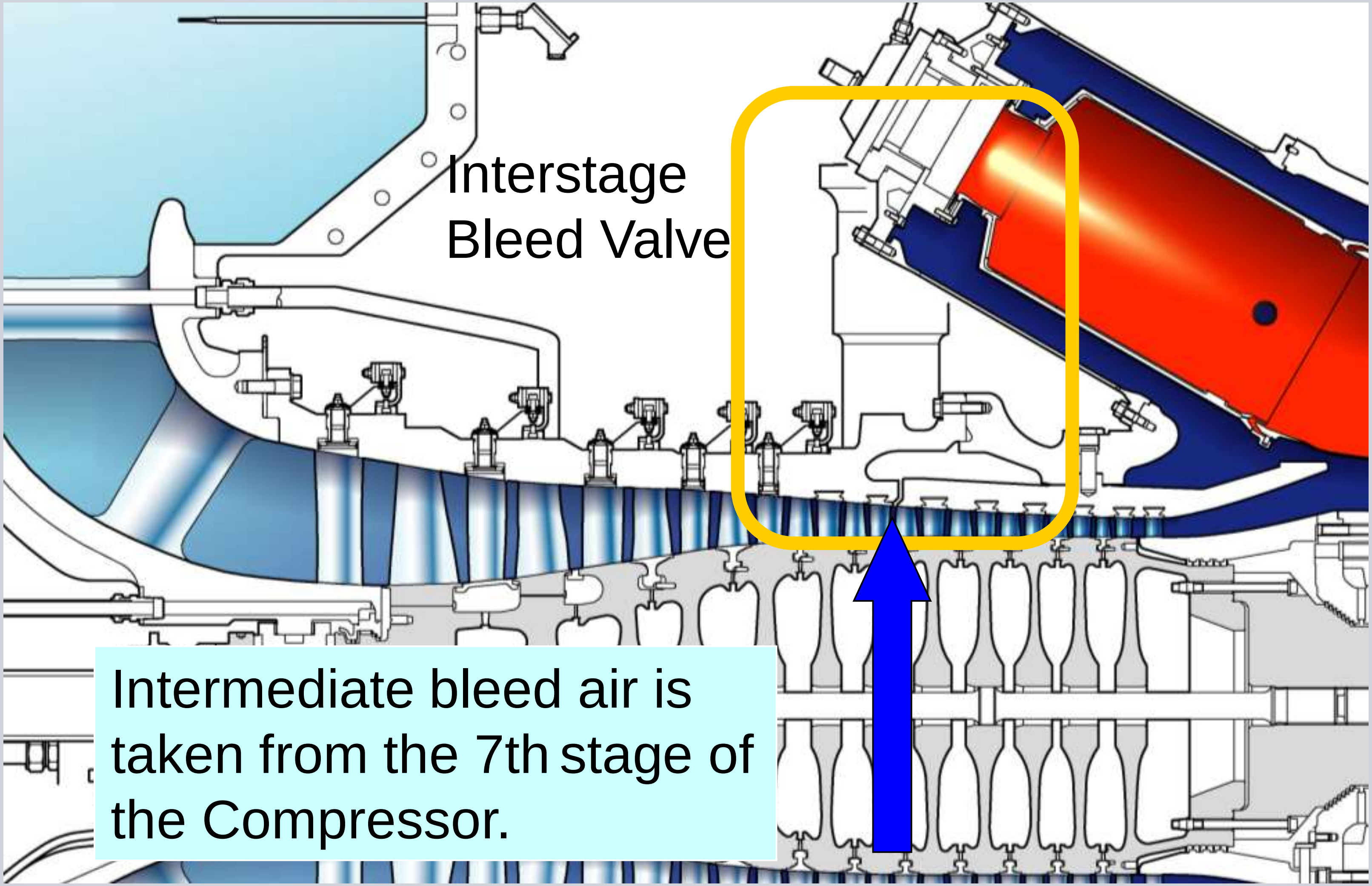
RUNNING ABOVE 1.5 Mw OR ABOVE 10444 rpm

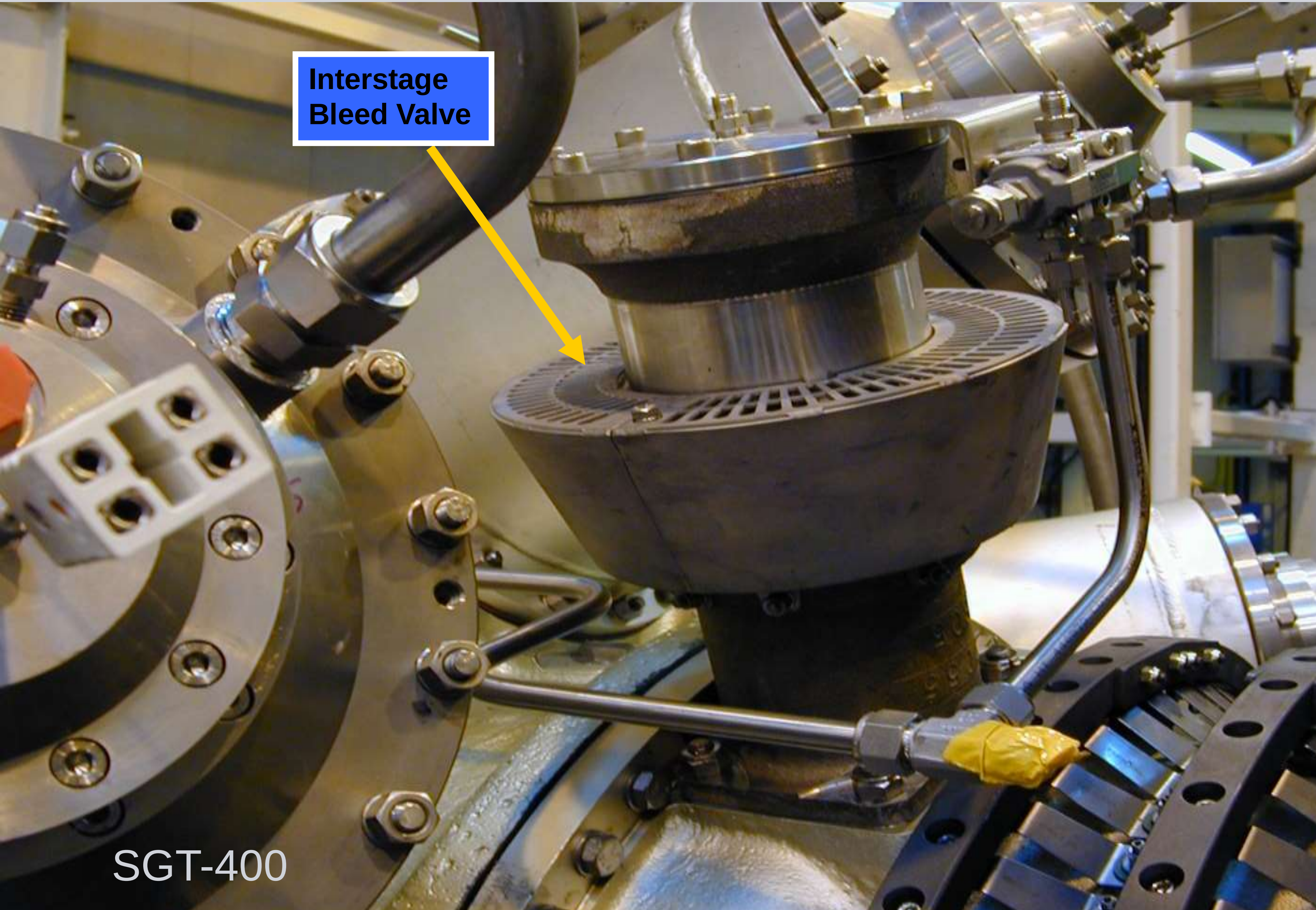


ACTUATOR AT 48mm or 100%
RUN = RETRACTED

SGT 400 Interstage Bleed Valve Arrangement

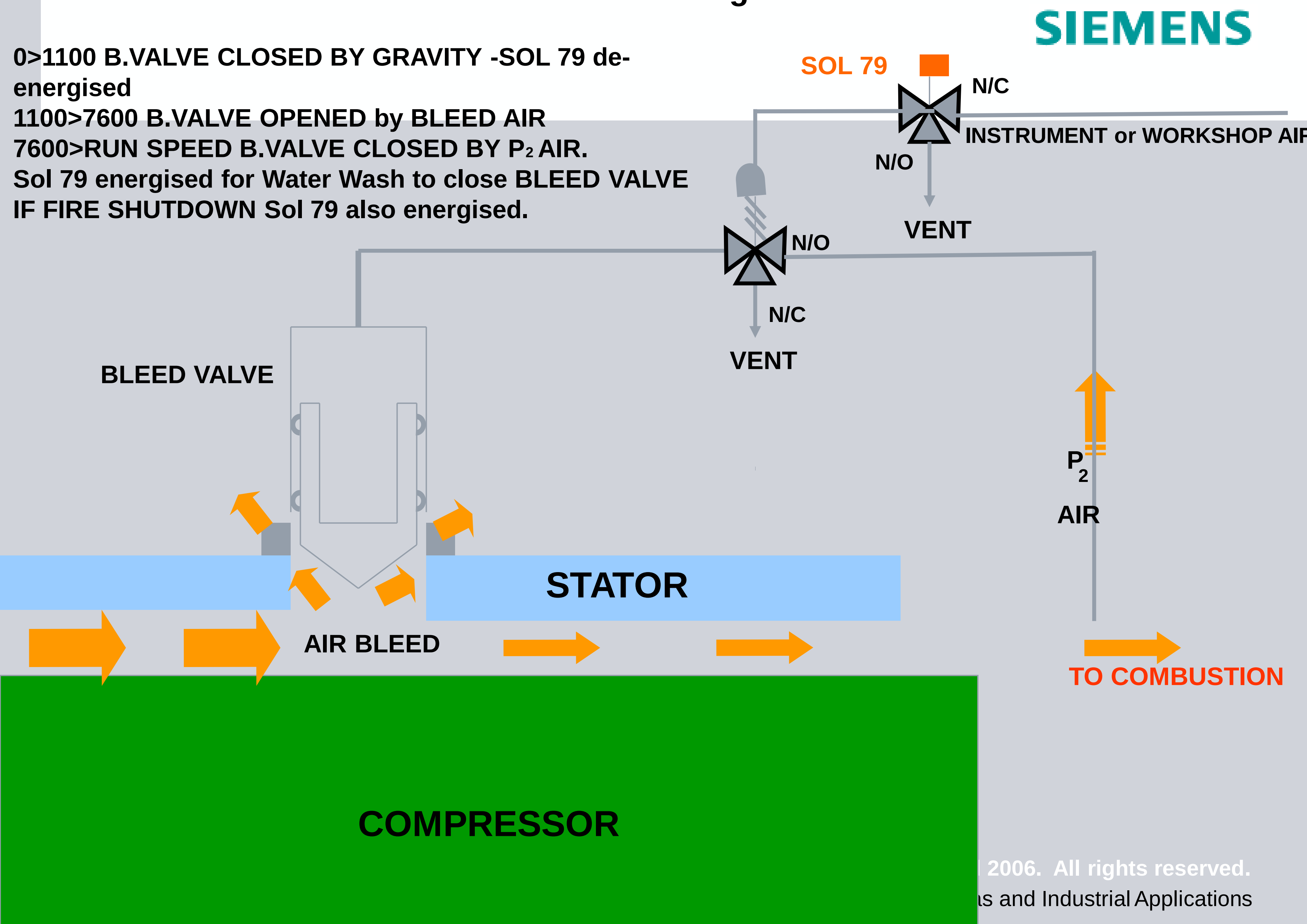


Gas Turbine components.



SGT 300 and 400 Bleed Valve arrangement.

0>1100 B.VALVE CLOSED BY GRAVITY -SOL 79 de-energised
1100>7600 B.VALVE OPENED by BLEED AIR
7600>RUN SPEED B.VALVE CLOSED BY P_2 AIR.
Sol 79 energised for Water Wash to close BLEED VALVE
IF FIRE SHUTDOWN Sol 79 also energised.

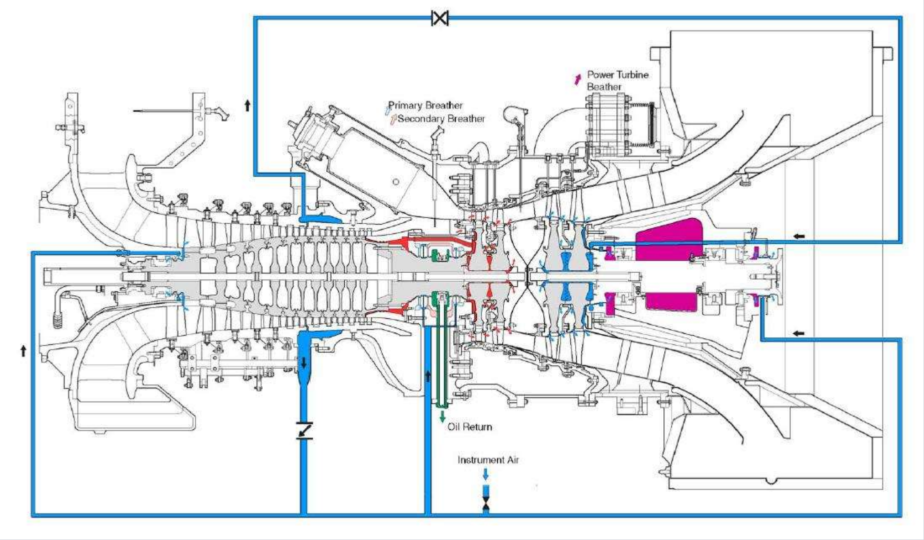


Cooling & Sealing Air.

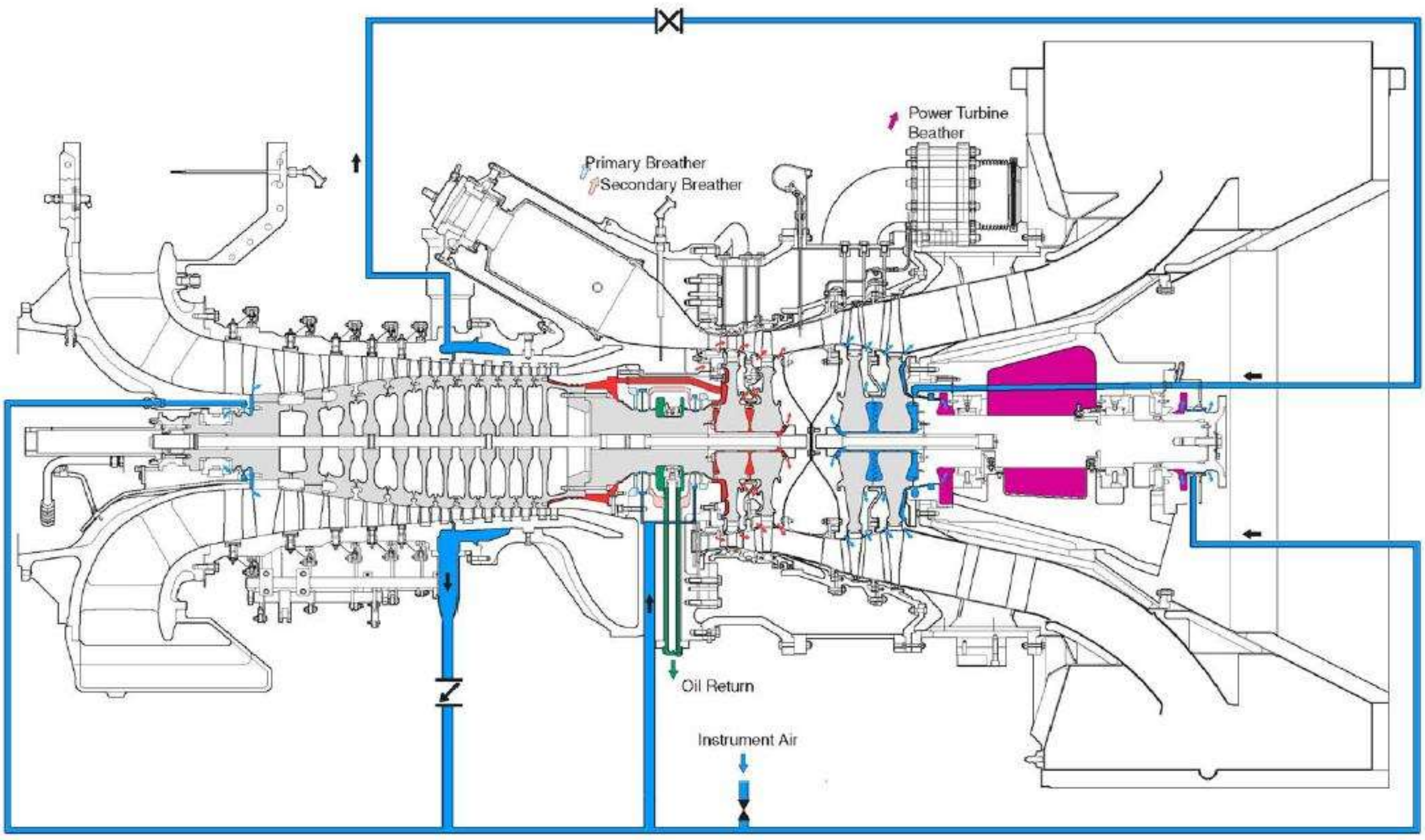
Cooling & Sealing Air.

Please take a look at the
Cooling & Sealing Air system
diagrams in your course folder.

These should be located at the front of the Drawings section.



Cooling & Sealing Air.



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Cooling and Sealing Air.

Air is used contain the Lub Oil within the bearing areas and also to cool the hot components whilst the Turbine is in operation.

Medium Pressure Buffer Air:- This comes from the seventh stage of the compressor and is distributed to the Bearings via configured pipework.

It is used to seal the oil within the No1 Bearing.

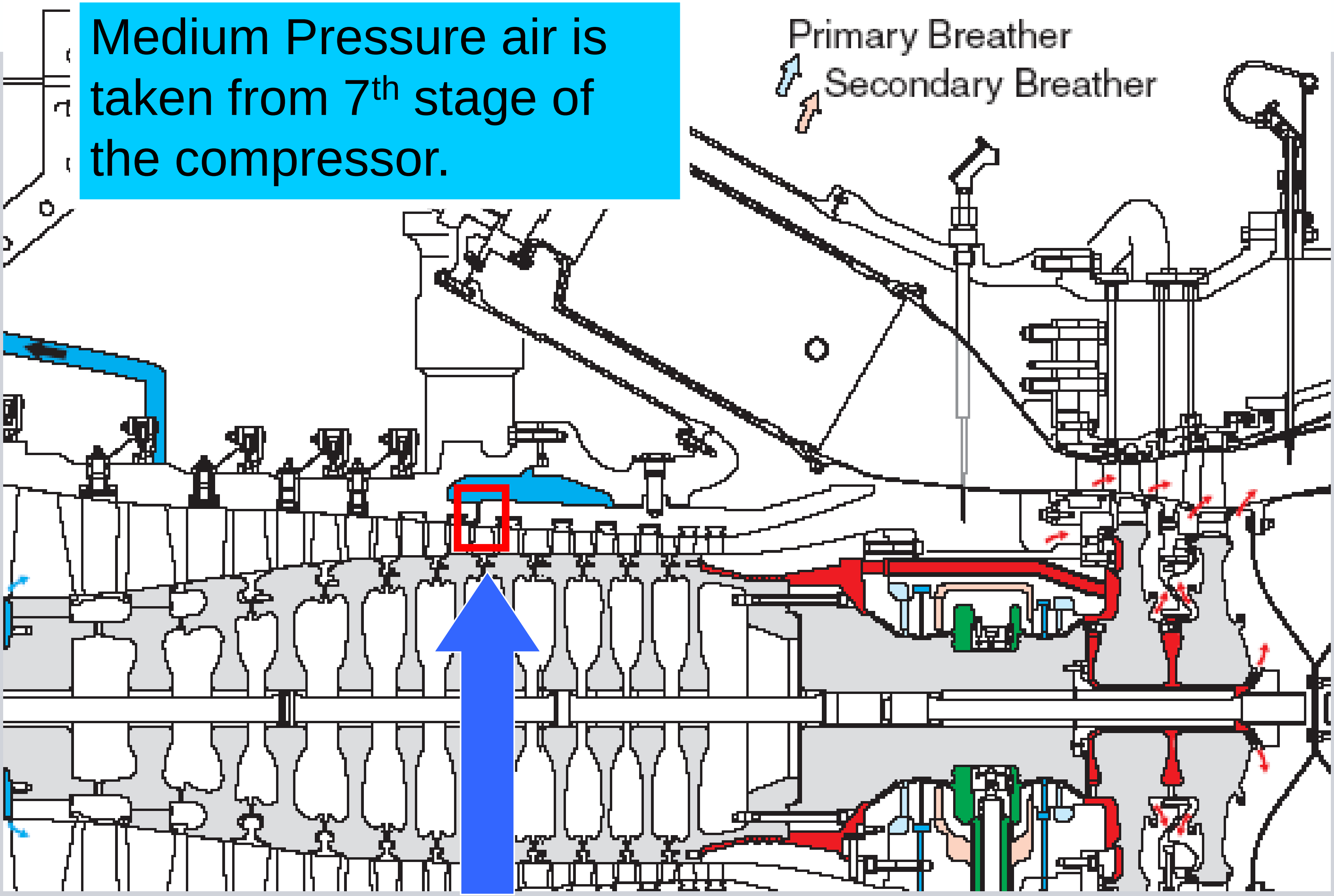
It also serves as a buffer to maintain the lubricant inside the No2 CT Hot end Bearing.

This air also seals the PT Bearings and cools the PT Discs.

Cooling & Sealing Air.

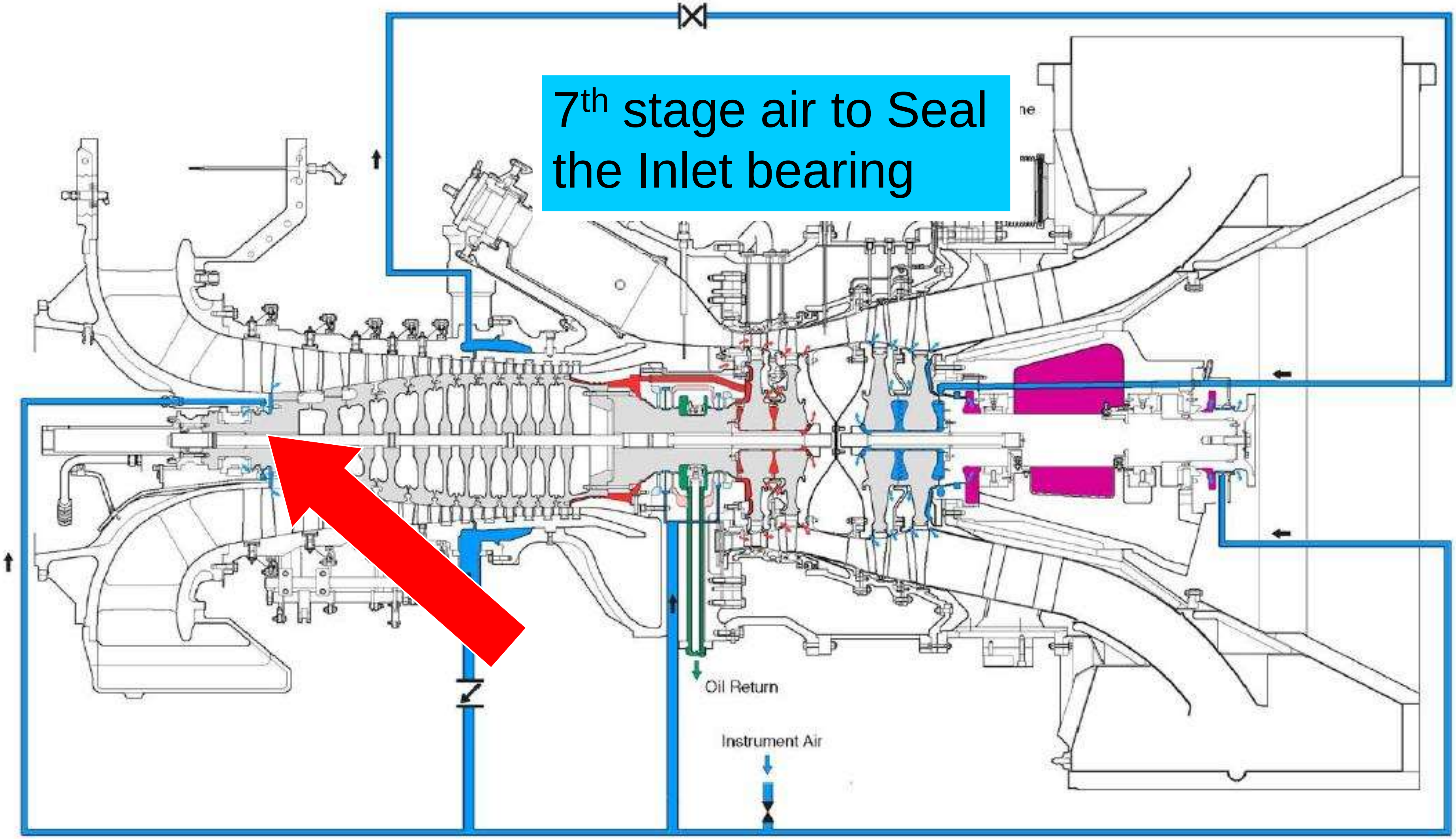
SIEMENS

Medium Pressure air is taken from 7th stage of the compressor.



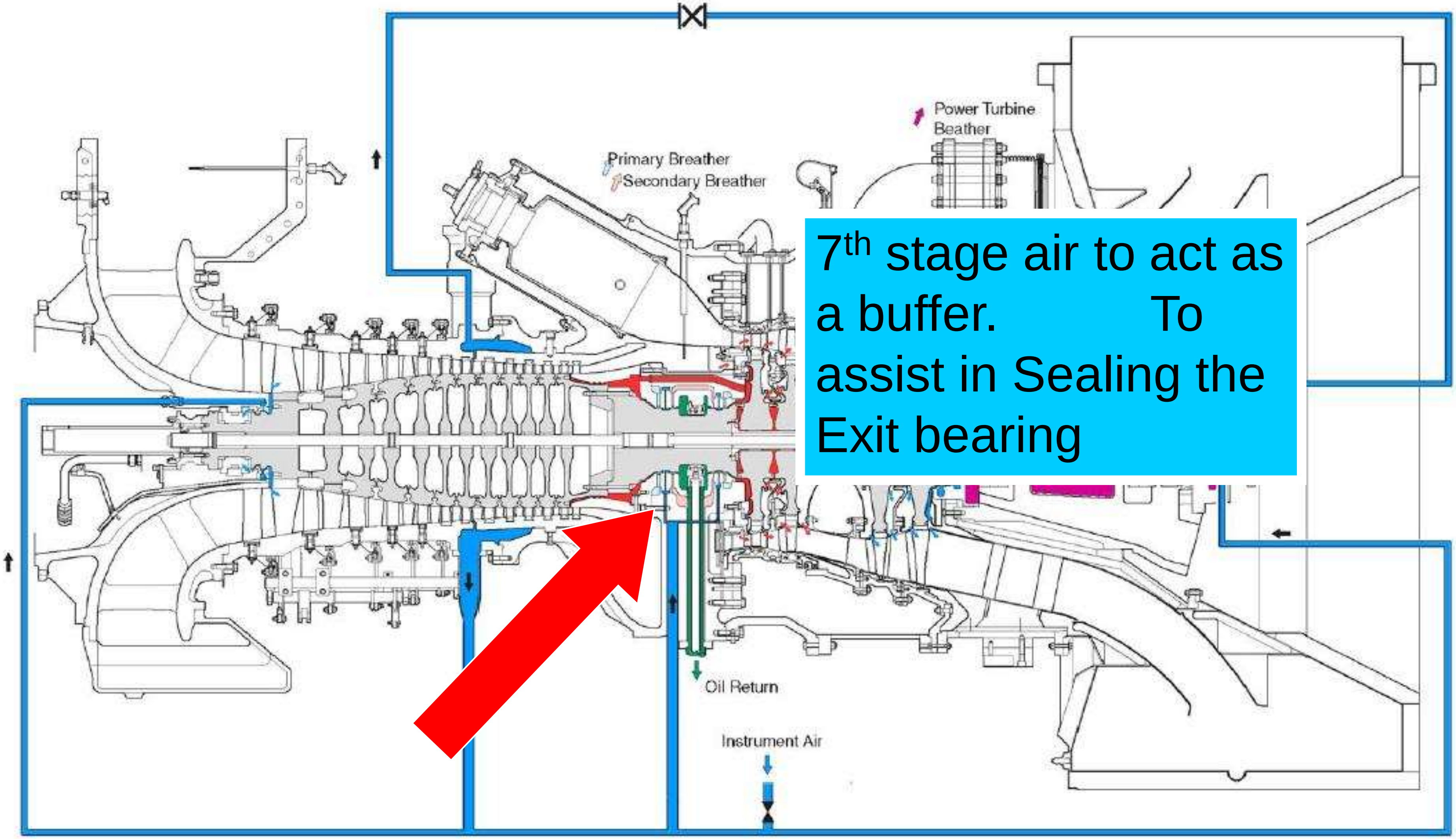
Cooling & Sealing Air.

SIEMENS



Cooling & Sealing Air.

SIEMENS

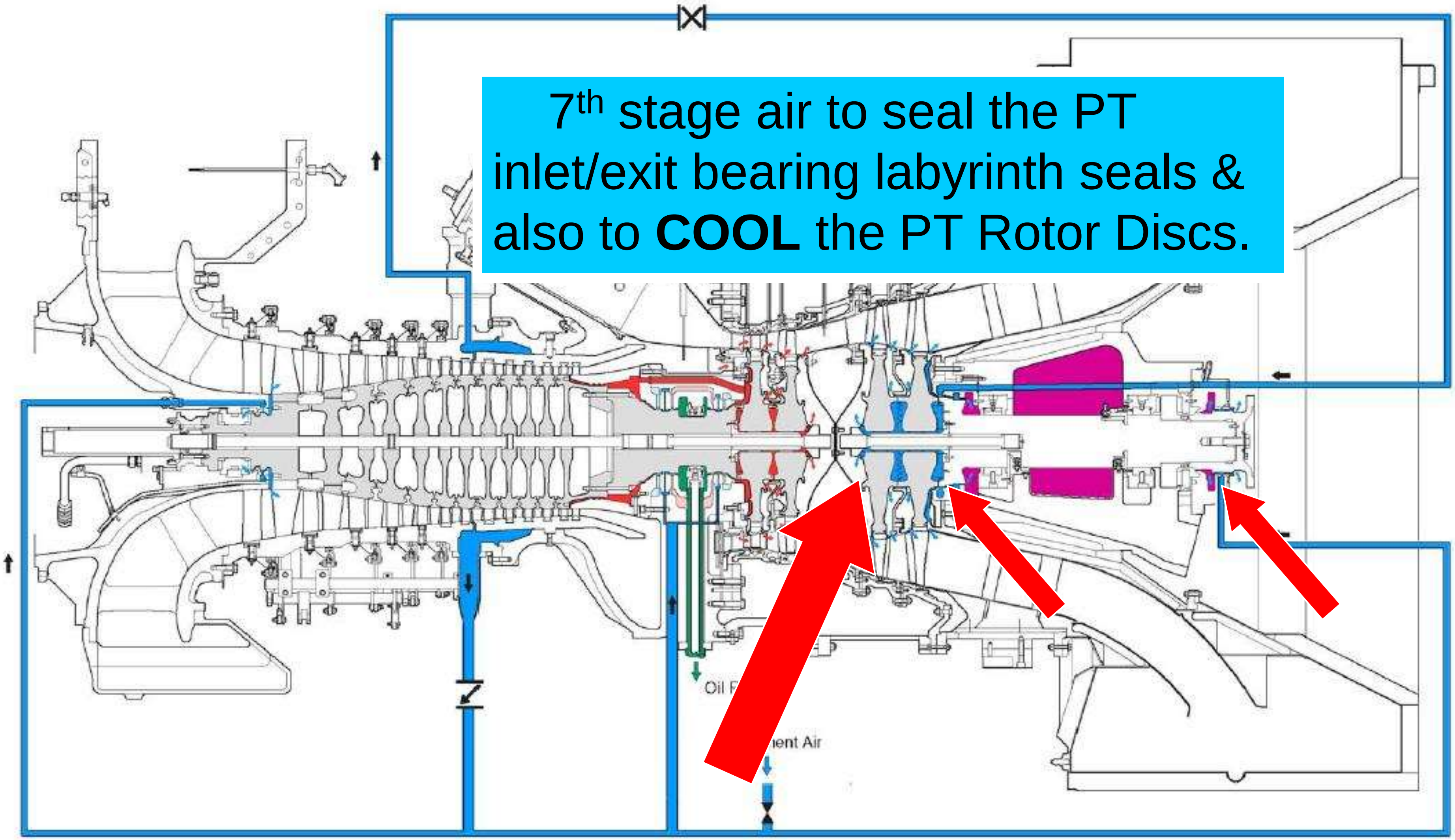


7th stage air to act as a buffer. To assist in Sealing the Exit bearing

Cooling & Sealing Air.

SIEMENS

7th stage air to seal the PT inlet/exit bearing labyrinth seals & also to **COOL** the PT Rotor Discs.



Cooling and Sealing Air.

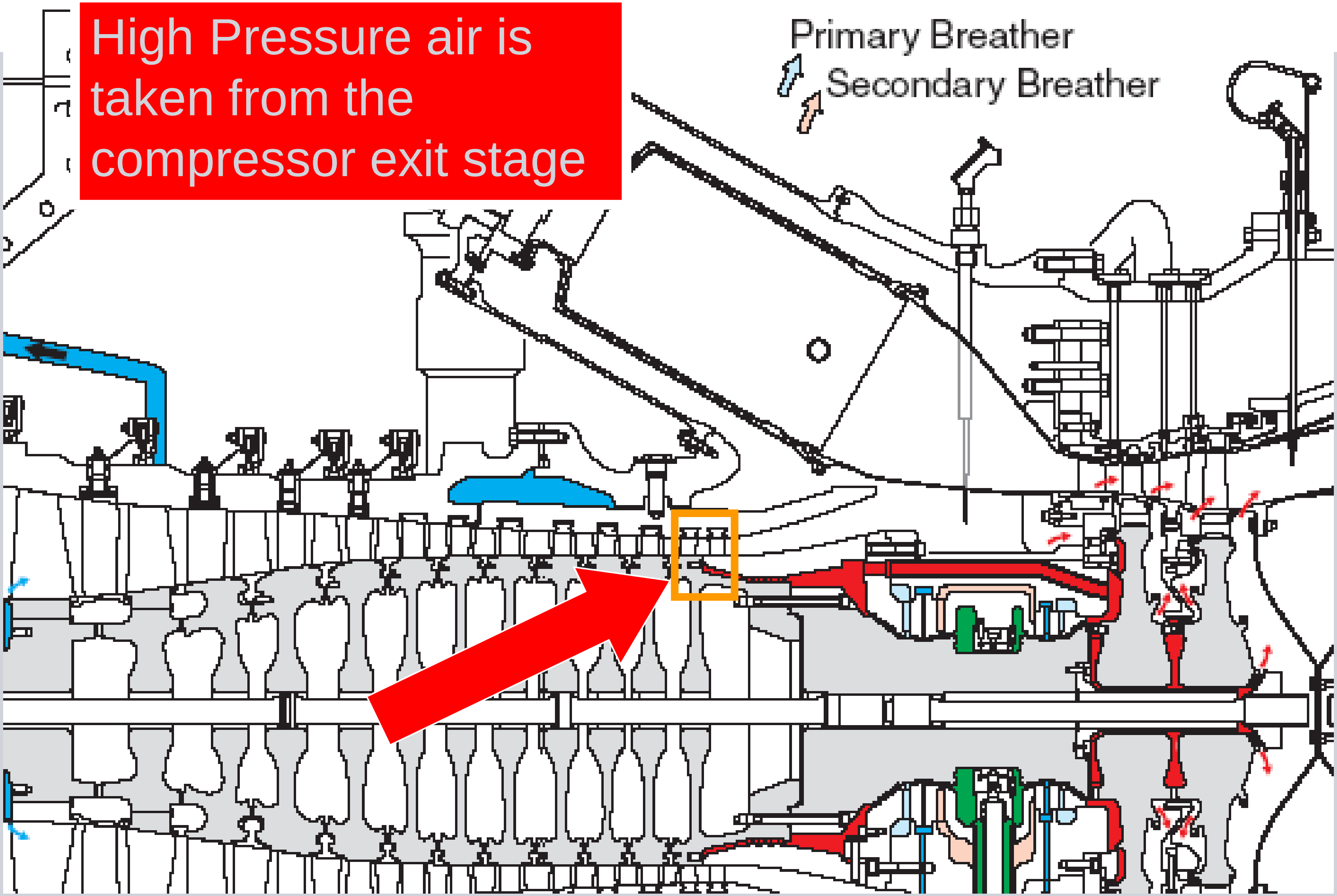
Air is used contain the Lub Oil within the bearing areas and also to cool the hot components whilst the Turbine is in operation.

Medium Pressure Buffer Air:- This comes from the seventh stage of the compressor and is distributed to the Bearings via configured pipework. It is used to seal the oil within the No1 Bearing. It also serves as a buffer to maintain the lubricant inside the No2 CT Hot end Bearing. This air also seals the PT Bearings and cools the PT Discs.

High Pressure Air:- Comes from the eleventh stage of the compressor and is used for sealing the CT Rotor and is also used for cooling the Turbine Discs.

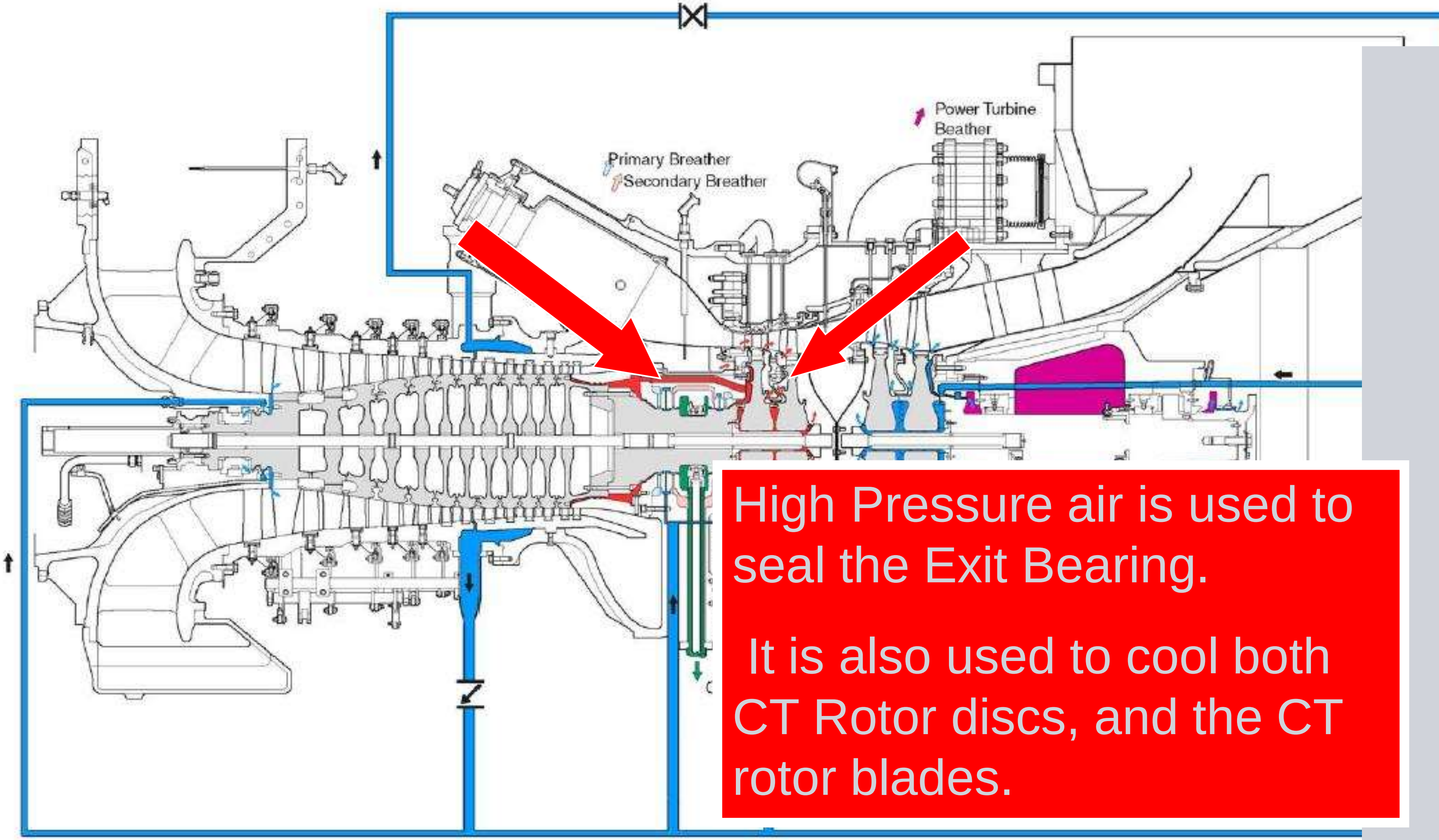
Cooling & Sealing Air.

SIEMENS



Cooling & Sealing Air.

SIEMENS

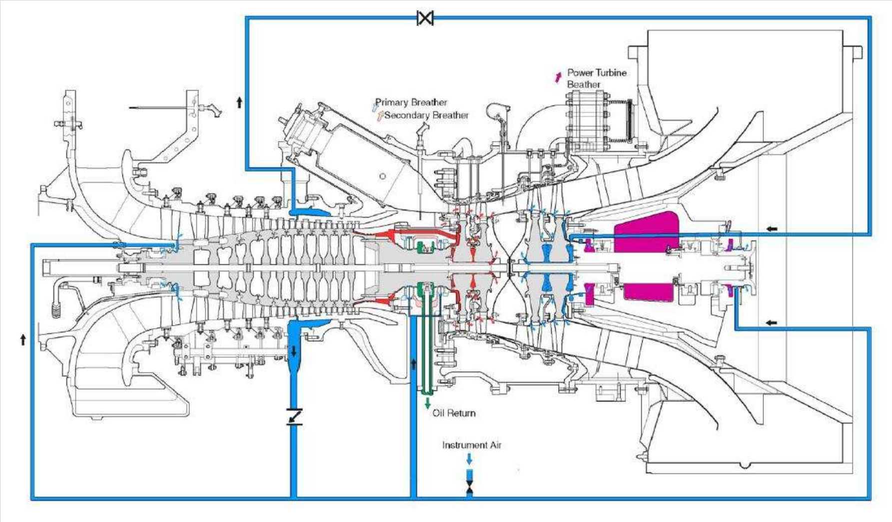


High Pressure air is used to seal the Exit Bearing.

It is also used to cool both CT Rotor discs, and the CT rotor blades.

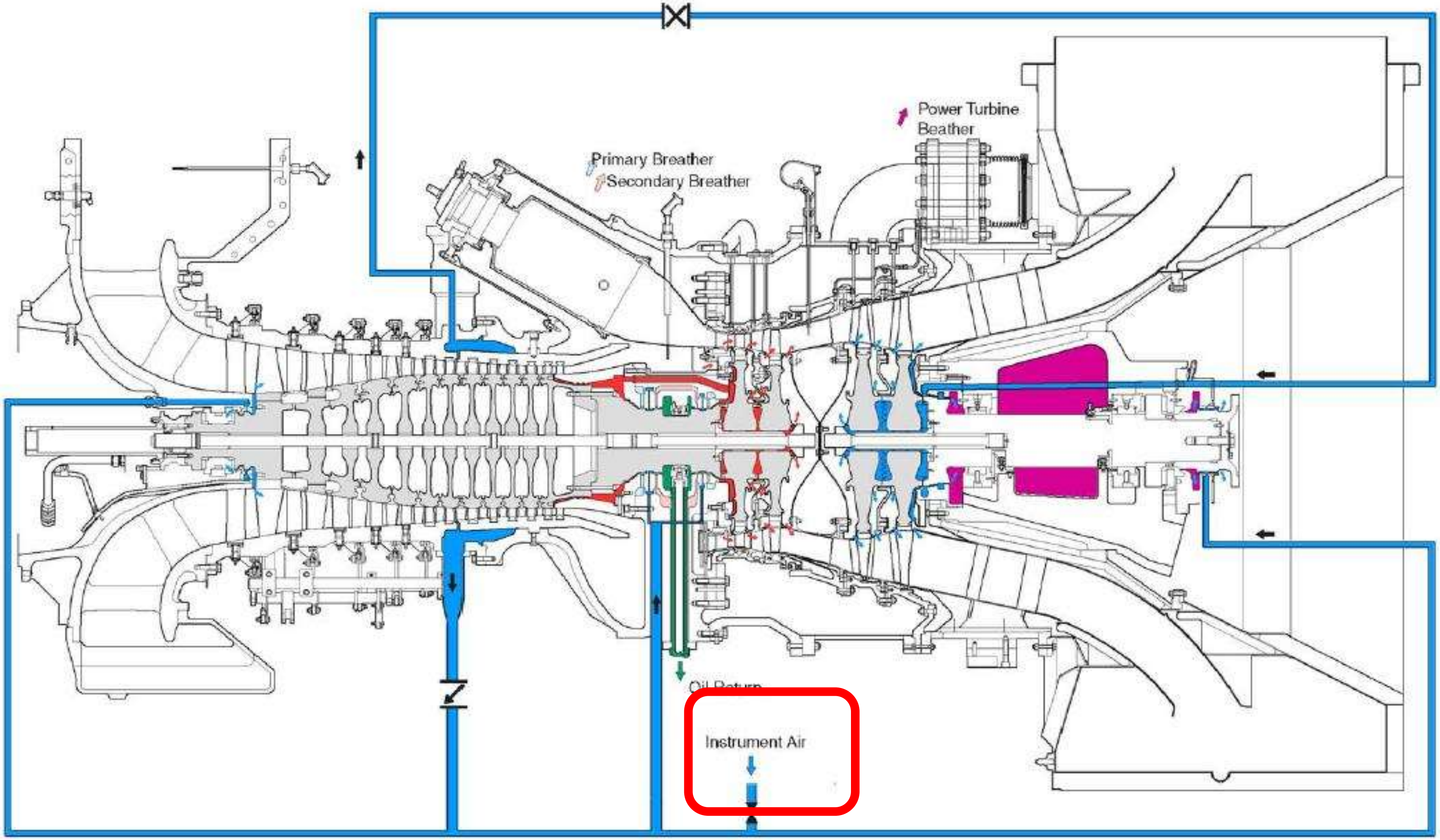
Cooling and Sealing Air.

Instrument/Workshop Air :- This is also provided through filters to an on-skid manifold. This serves as the medium pressure Buffer Air when the Turbine is stationary and during the Start and Stop sequences. i.e. When medium pressure Compressor Air is unavailable. *(highlighted next slide)*



Cooling & Sealing Air.

SIEMENS

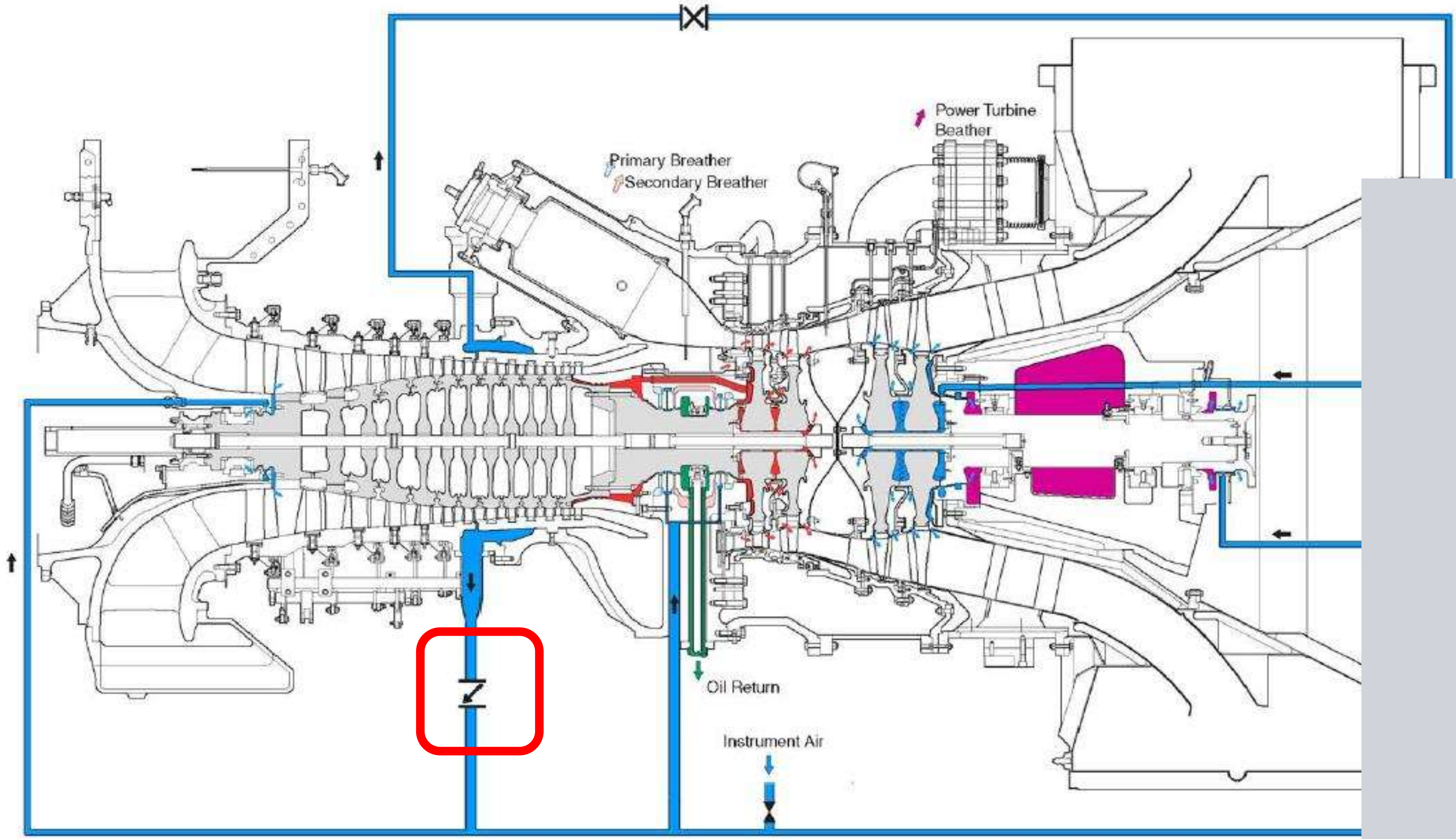


Cooling and Sealing Air.

<u>Instrument/Workshop Air</u> :- This is also provided through filters to an on-skid manifold. This serves as the medium pressure Buffer Air when the Turbine is stationary and during the Start and Stop sequences. i.e. When medium pressure Compressor Air is unavailable. Instrument Air is also used when the AC Pump is required and the Turbine is not running. A **<u>non return valve</u>** is fitted in the 7th stage discharge line to prevent air escaping into the Compressor when instrument air is being supplied.

Cooling & Sealing Air.

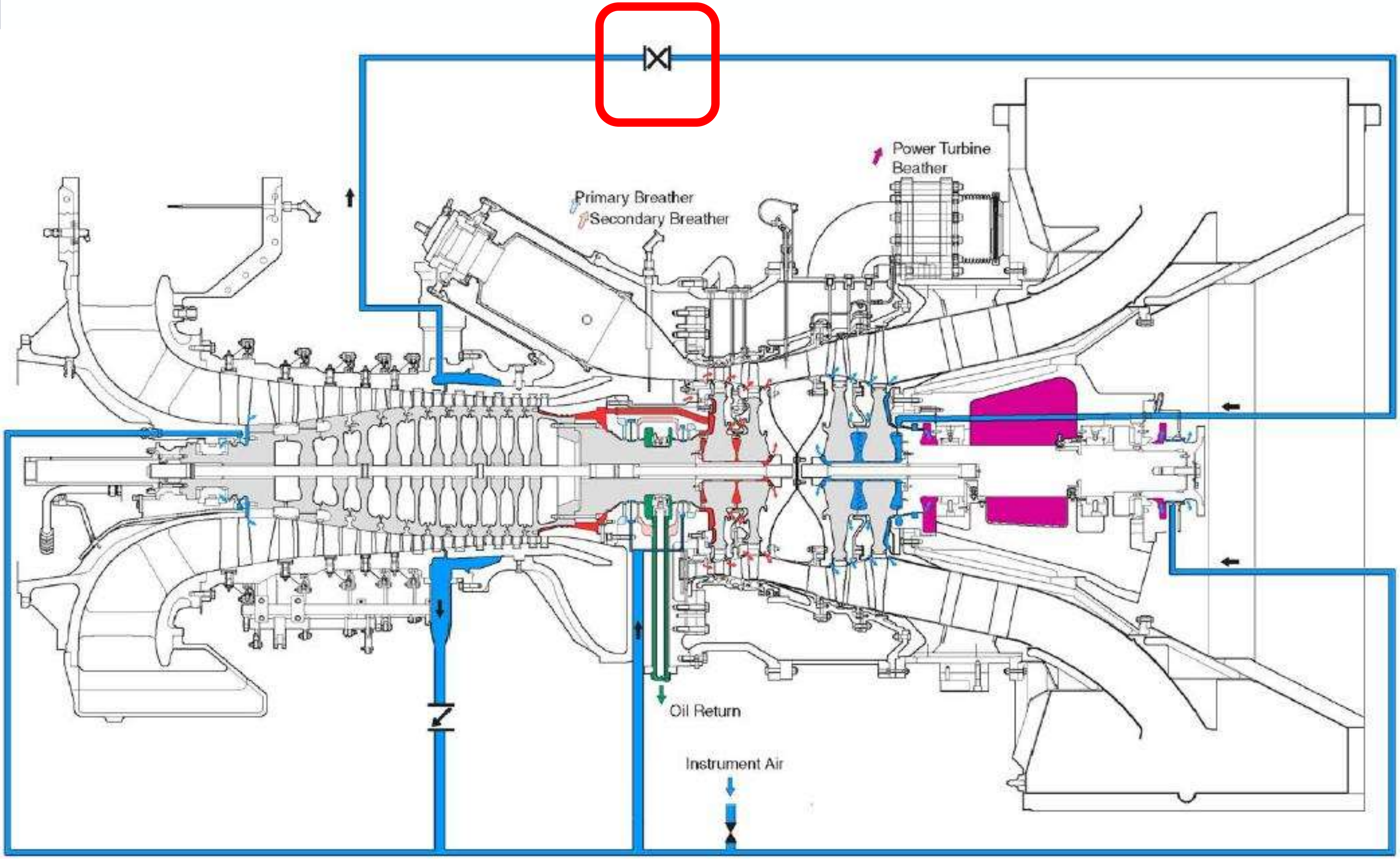
SIEMENS



Instrument/Workshop Air :-
Water Wash – This will be covered later, however the manual valve for water wash is highlighted as follows:-

Cooling & Sealing Air.

SIEMENS



Cooling & Sealing Air.

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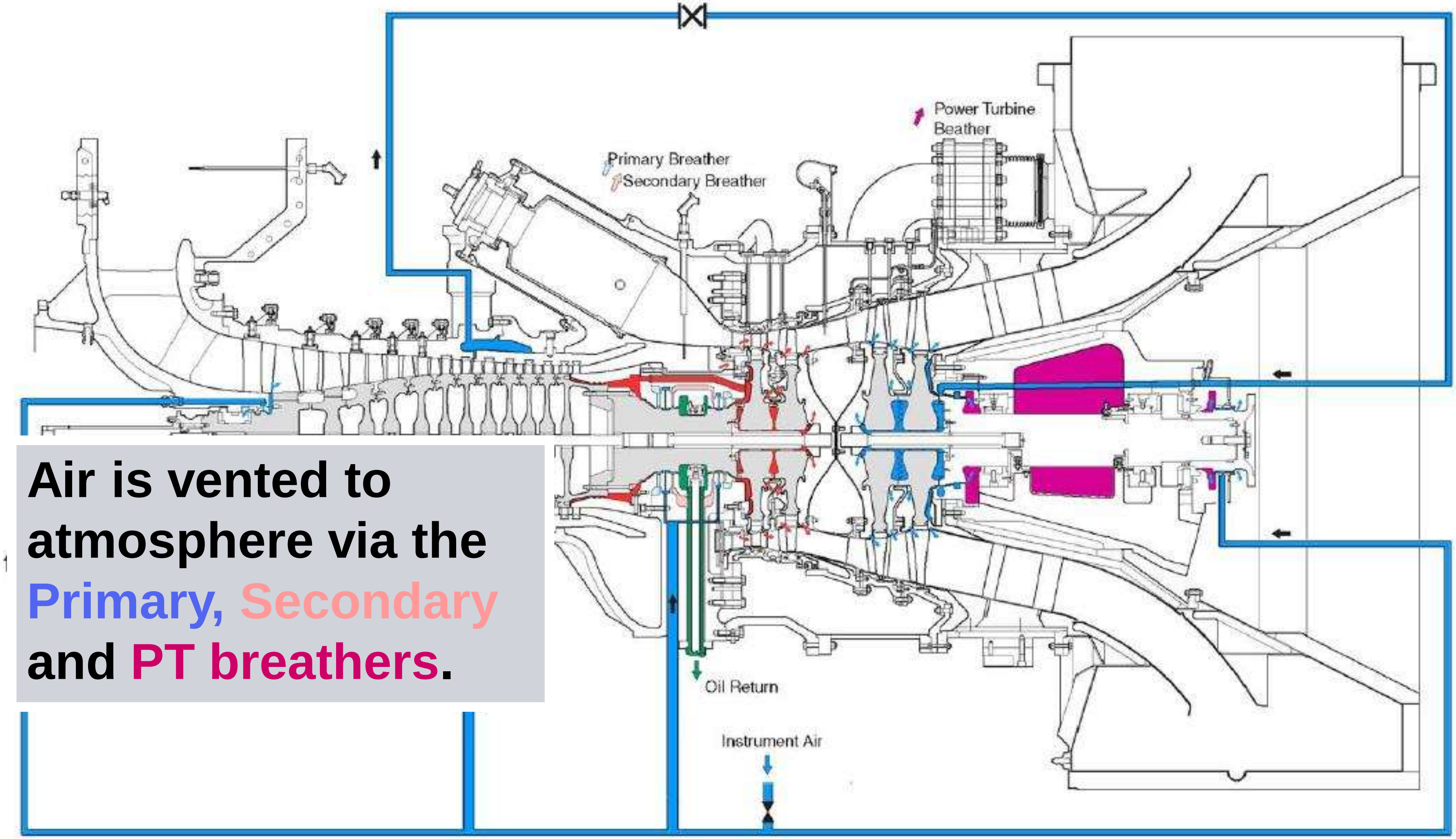


Air is vented to atmosphere via the Primary, Secondary and PT breathers.

The Combustion System.

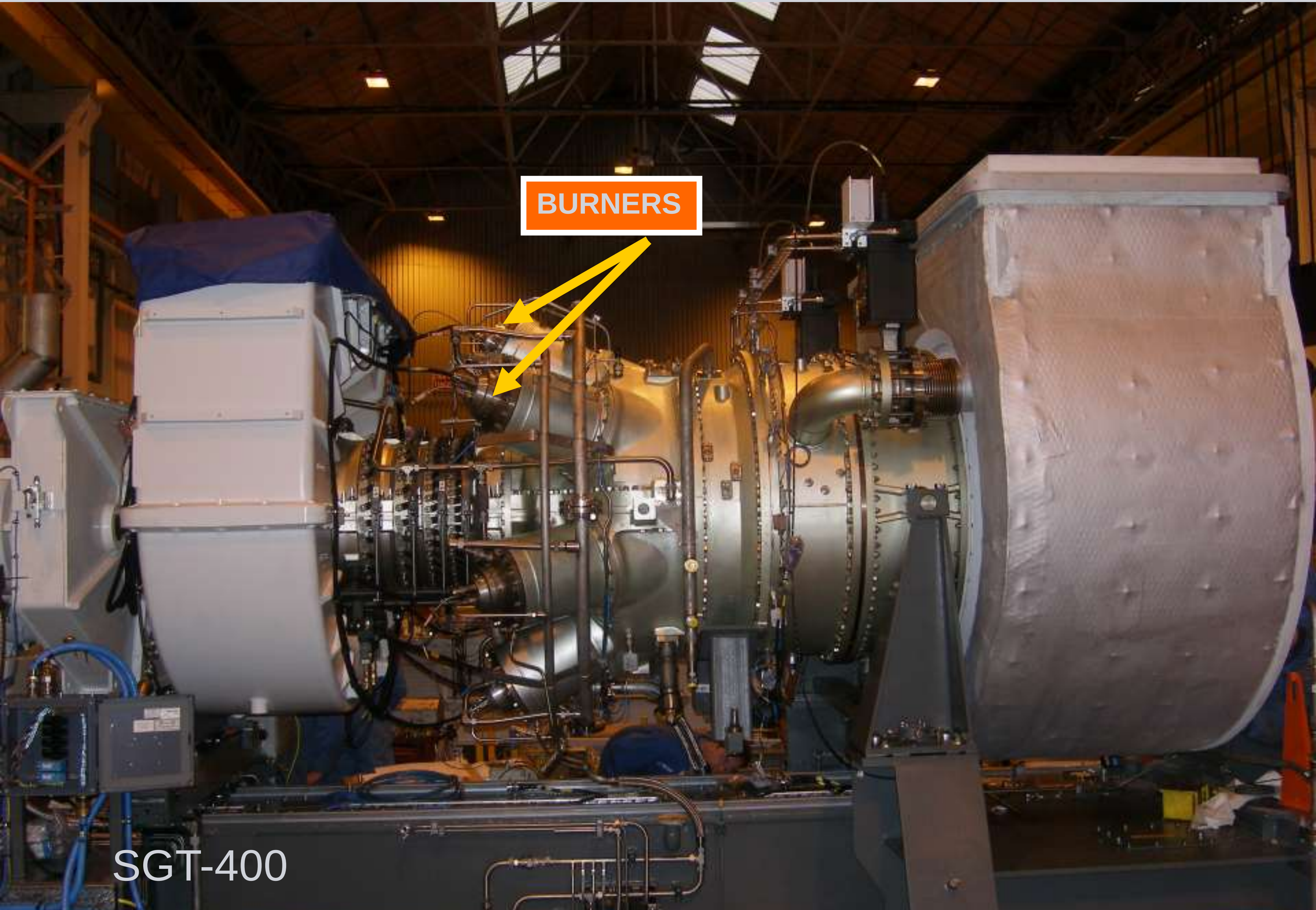
The Combustion system

There are two types of combustion system in use.
DLE
Non DLE
The DLE system will be looked at in detail later in this course, however in brief it has been designed to reduce emissions without the need for water injection.
Hence **Dry Low Emissions** – DLE.

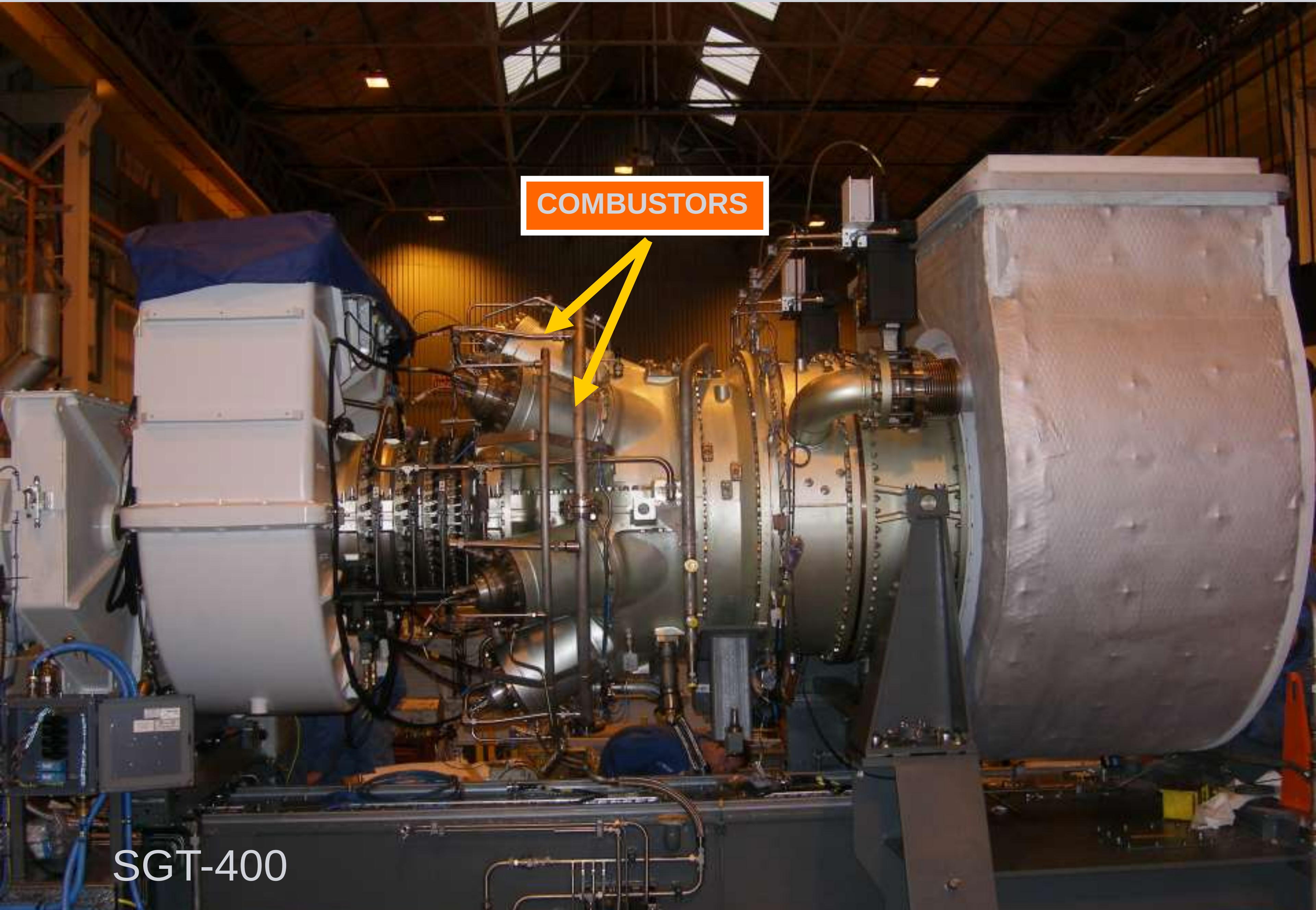
The older system, Non DLE is sometimes referred to as standard combustion. This can be somewhat misleading as we now fit DLE as standard!

NOTE: SGT400 is DLE ONLY

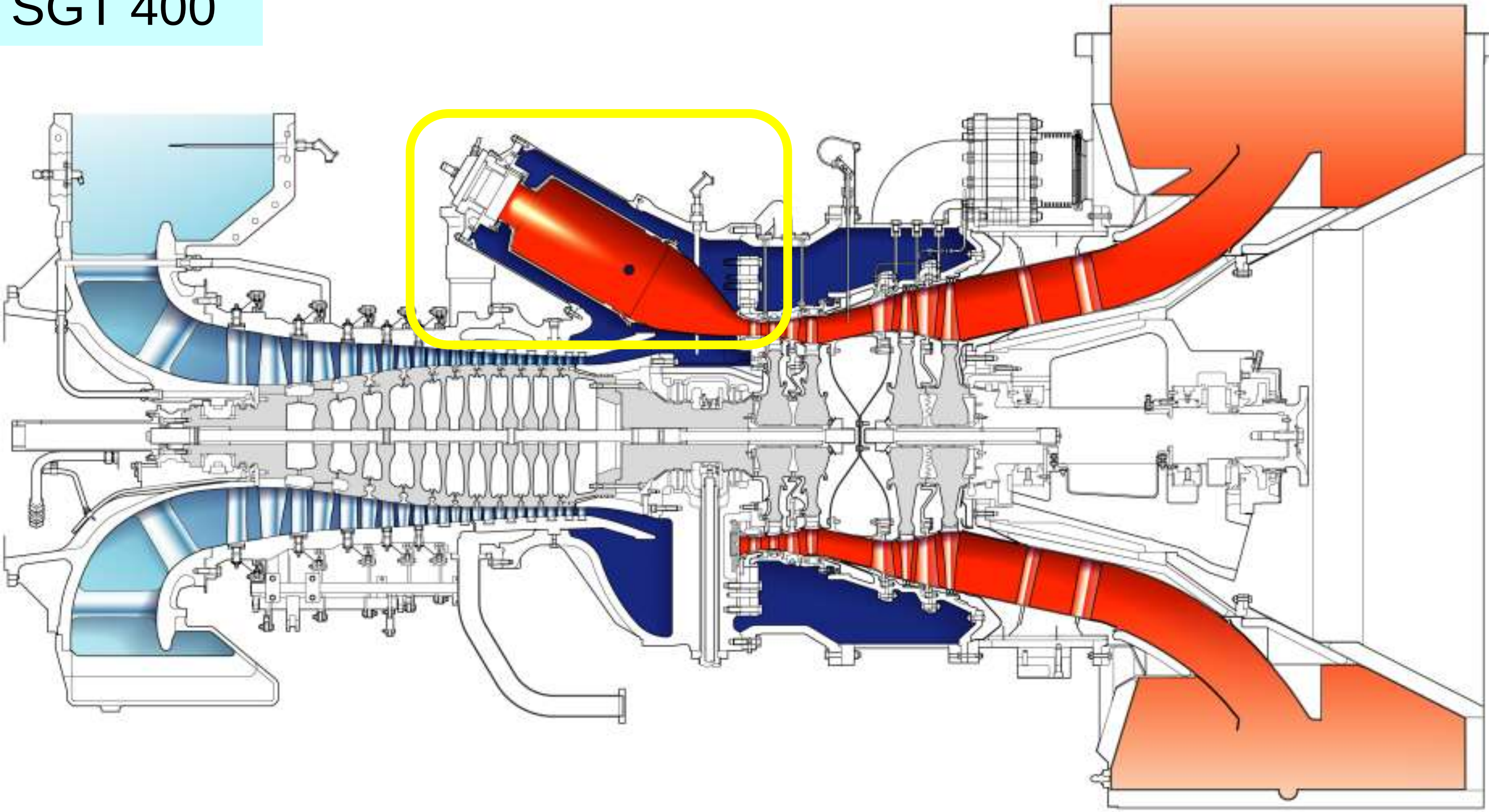
DLE Combustion system



DLE Combustion system



SGT 400



The combustion system on the SGT400 is DLE only.

SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

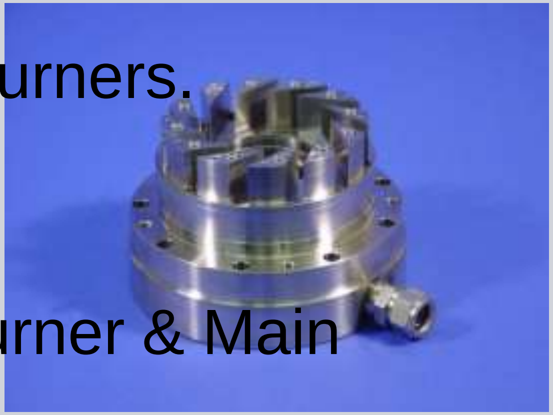
Can annular combustion system.

Dual Fuel DLE
Combustion System

Can Annular Combustion System

SIEMENS

Fuel Burners



The fuel is injected into the engine via the burners.
This maybe Gas or Liquid fuel.

DLE Burners
Made up of two main components – Pilot burner & Main burner

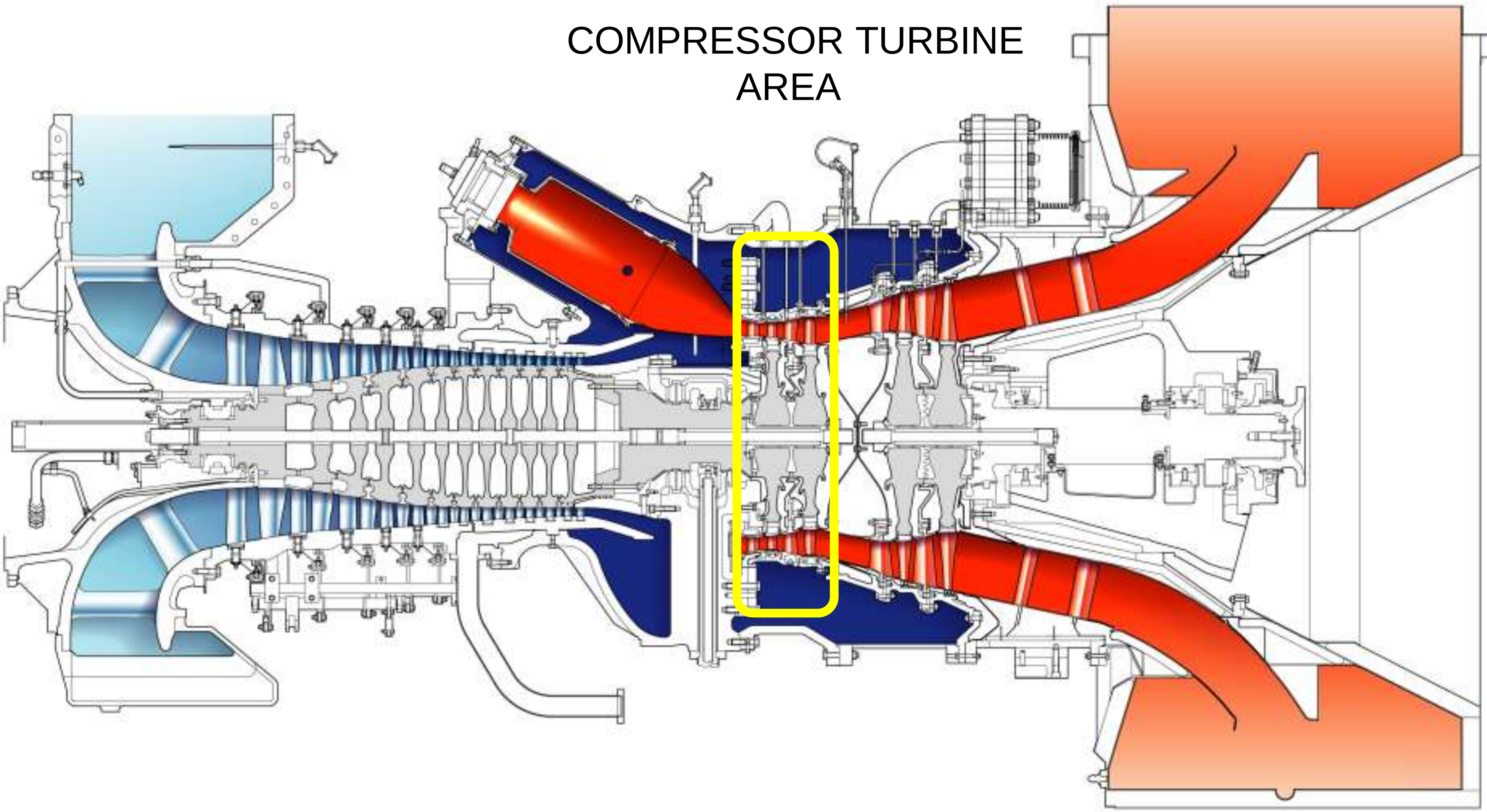
Non DLE
Made up of One burner unit only. (MPI)
These come in various configurations & types.
They inject Standard Gas fuel, Liquid fuel
Dual fuel, water and steam etc.

We will cover this in more detail later within the course

Typical DLE Combustion system

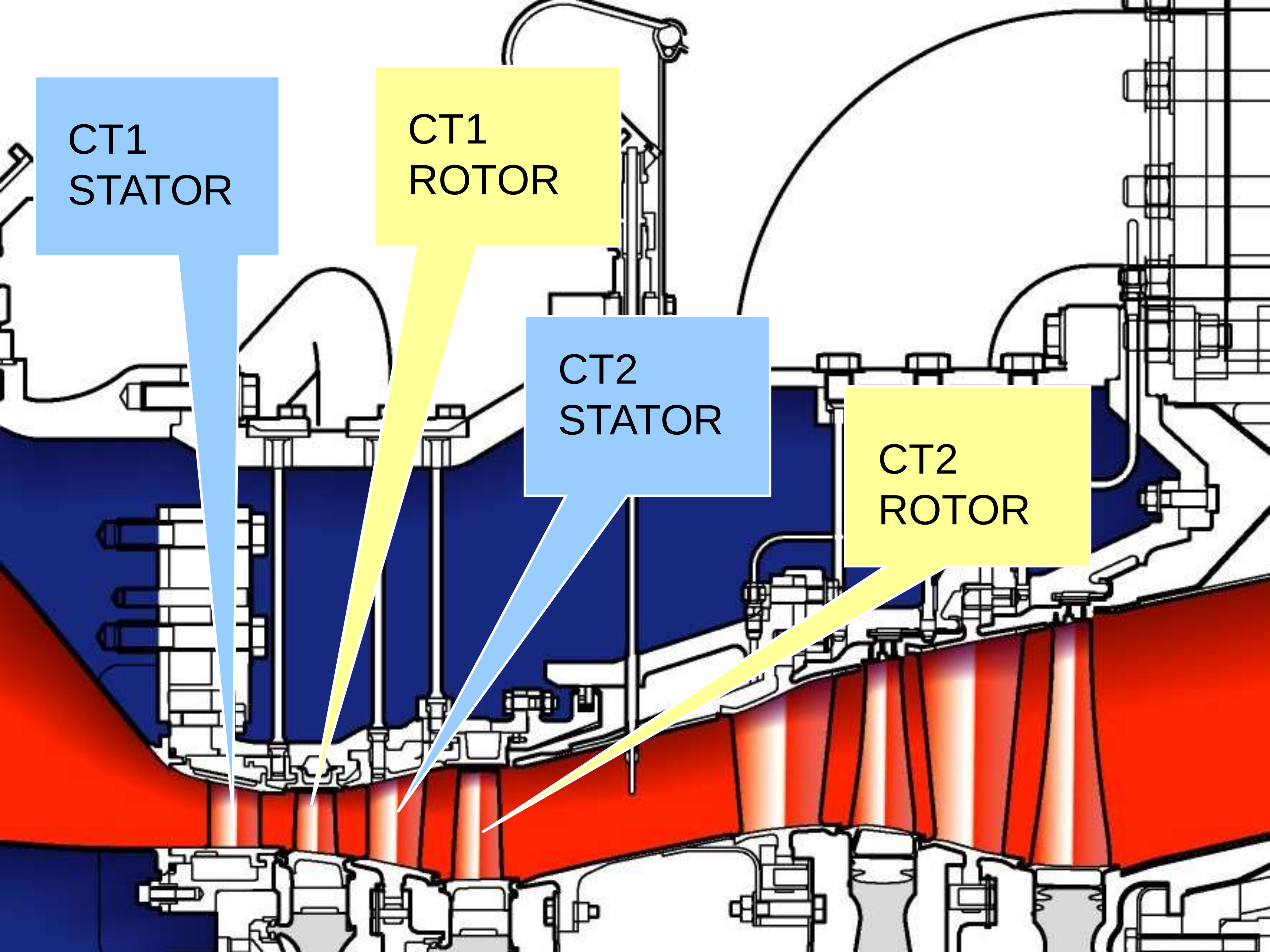
The Compressor Turbine section or 'Hot End'!

COMPRESSOR TURBINE
AREA



SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

MW - CO


CT1
STATOR
CT1
ROTOR
CT2
STATOR
CT2
ROTOR

Compressor Turbine section

TERMINOLOGY
There can be a little confusion over terminology & description of the component blades.

Compressor Rotor…………… Compressor Turbine…………..

Stator Blades……………. Rotor Blades…………..

On SGT100 & 300 we refer to the "Hot end" section as HP & LP blades. Not CT1 & CT2 !

High Pressure & Low Pressure

On SGT200 & 400 we refer to the above section as CT1 & CT2
Compressor Turbine 1 & Compressor Turbine 2

Therefore CT1 = HP & CT2 = LP !

Compressor Turbine section

SGT400

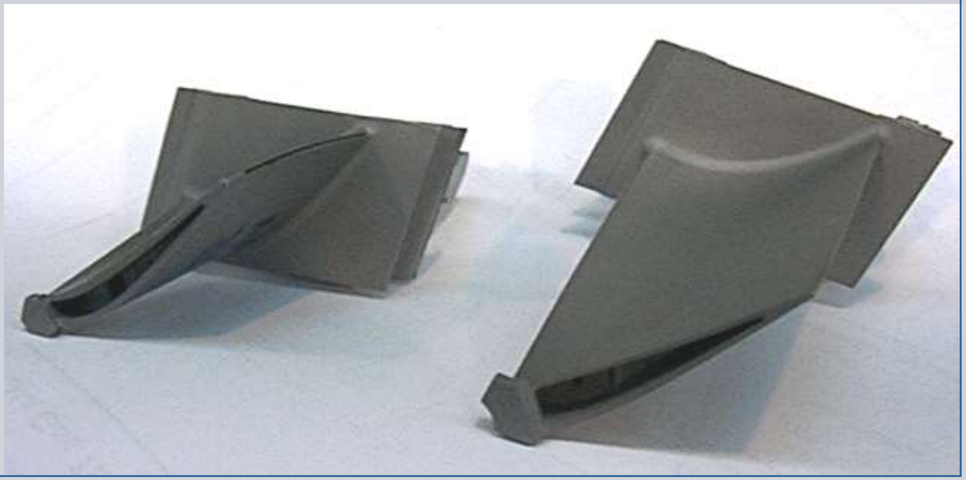
CT1 Rotor blade

Both CT1 & CT2 rotor blades are internally cooled.

Compressor Turbine section

Compressor Turbine
Stage 1Nozzle

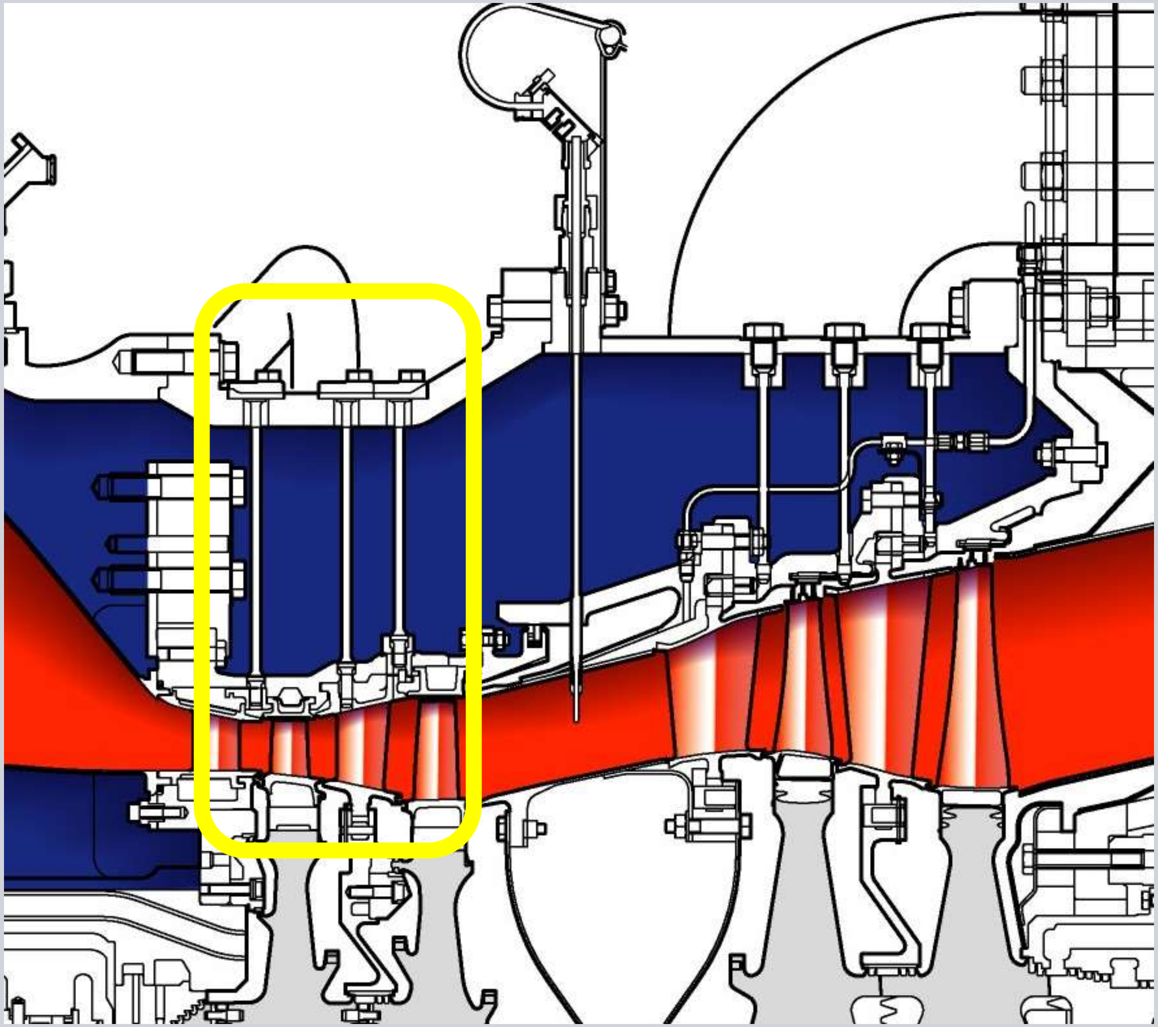
Compressor Turbine
Stage 1
and
Stage 2 Blades



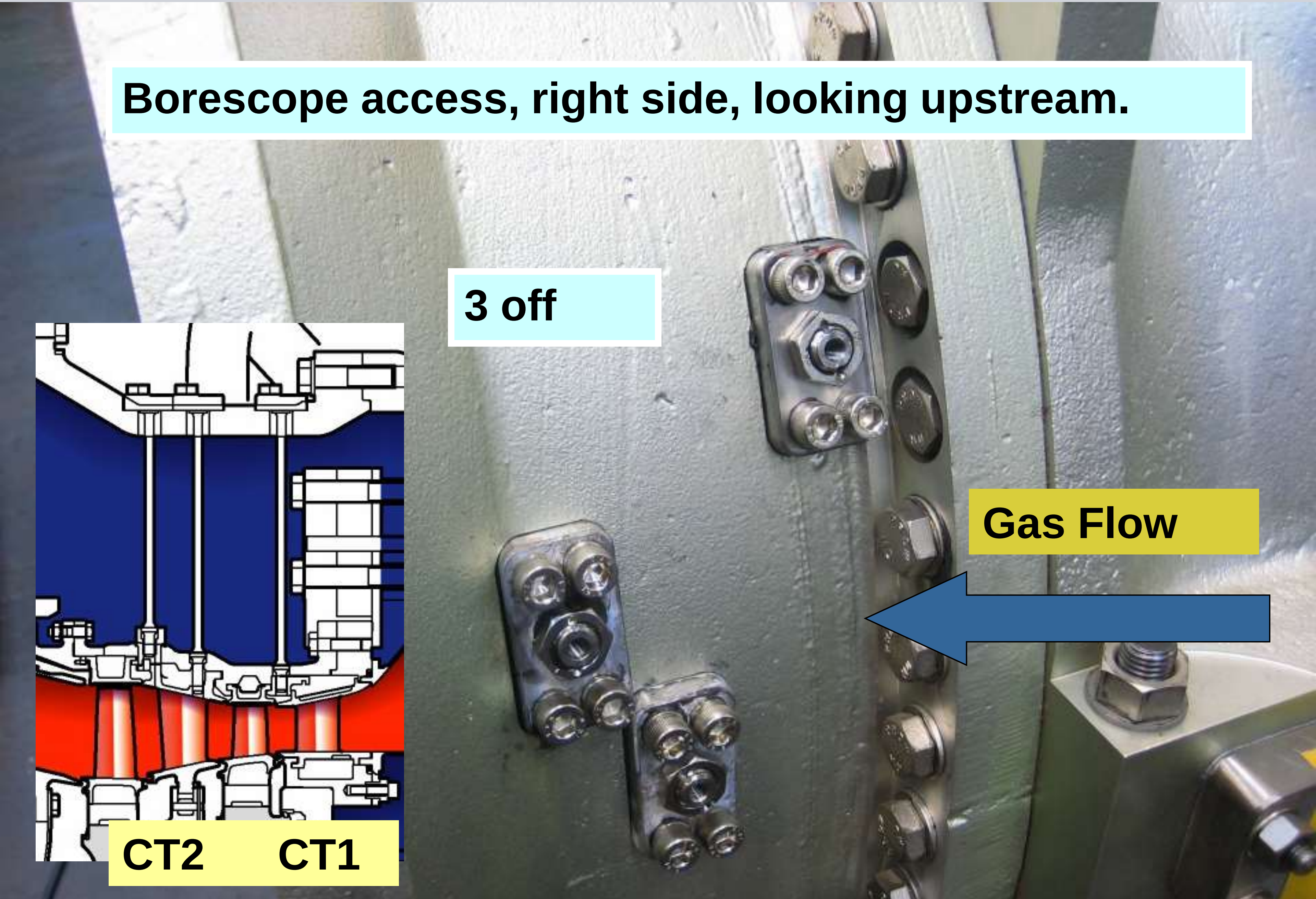
Compressor Turbine CT2 Rotor

Compressor Turbine section

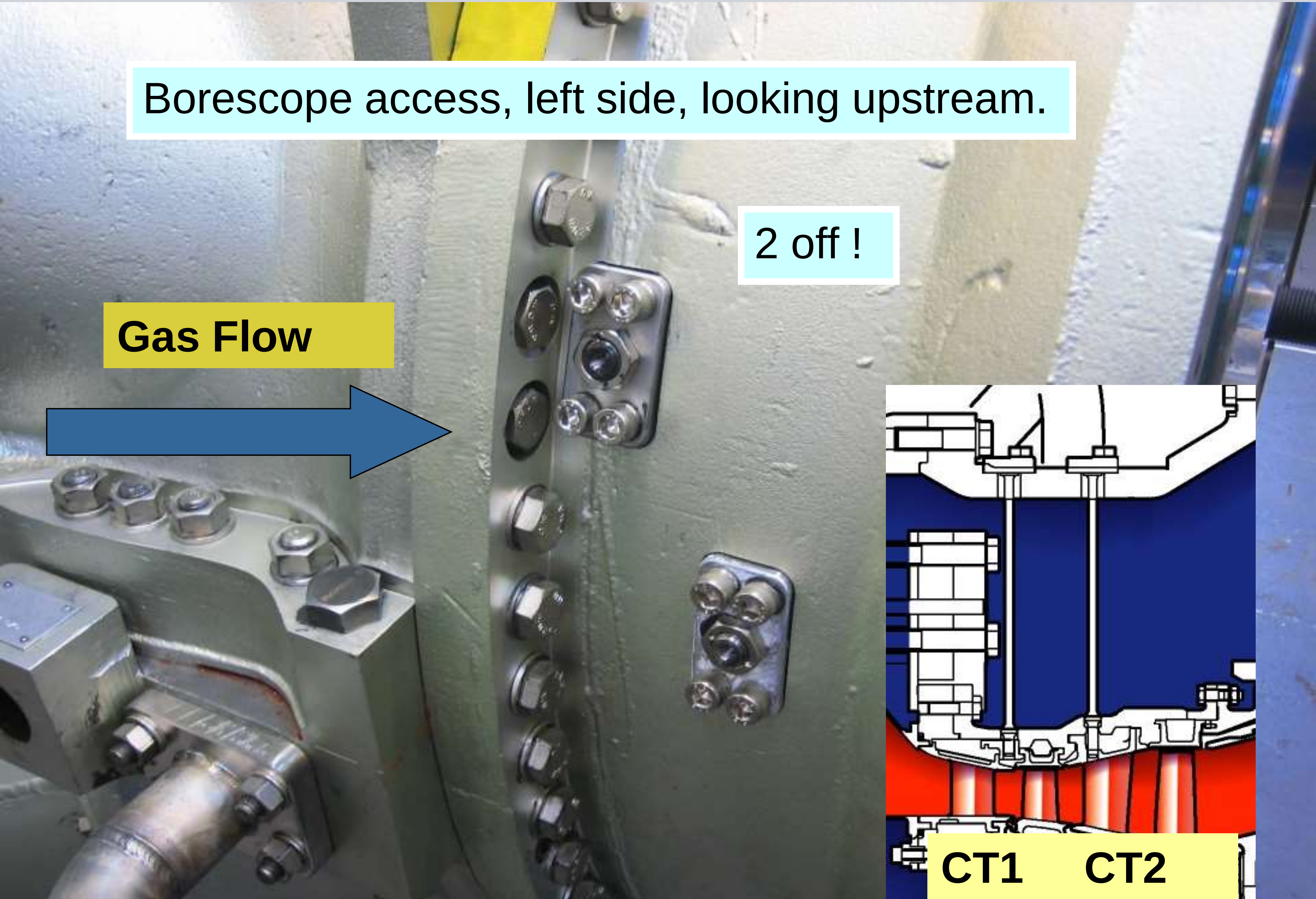
Removable plugs are fitted for inspection



Borescope plugs on CT casing SGT400



Borescope plugs on CT casing SGT400



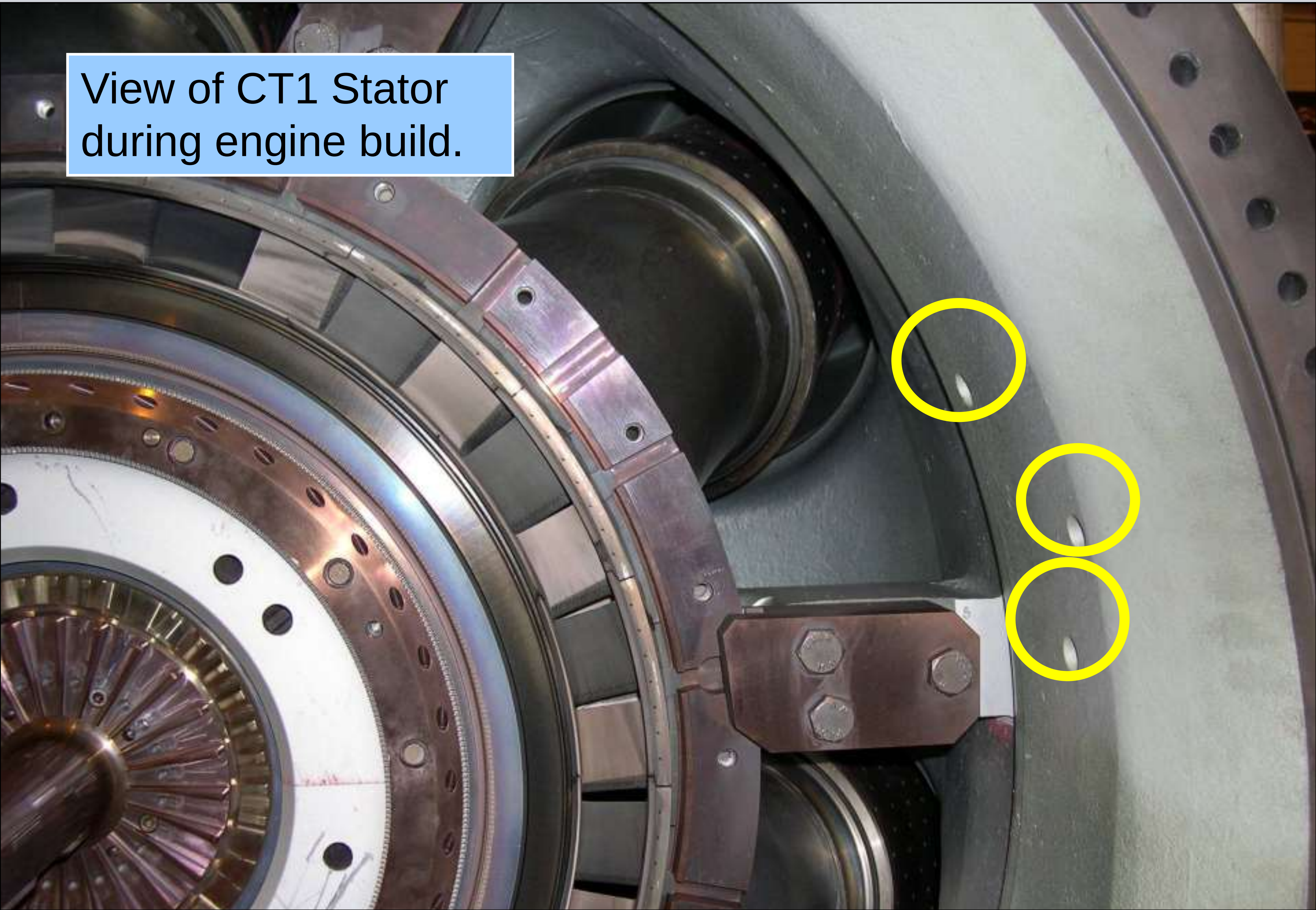
Example Borescope plugs

SGT-400 Typical CT Borescope access plugs

SGT-400

PT access.

Borescope plug access highlighted



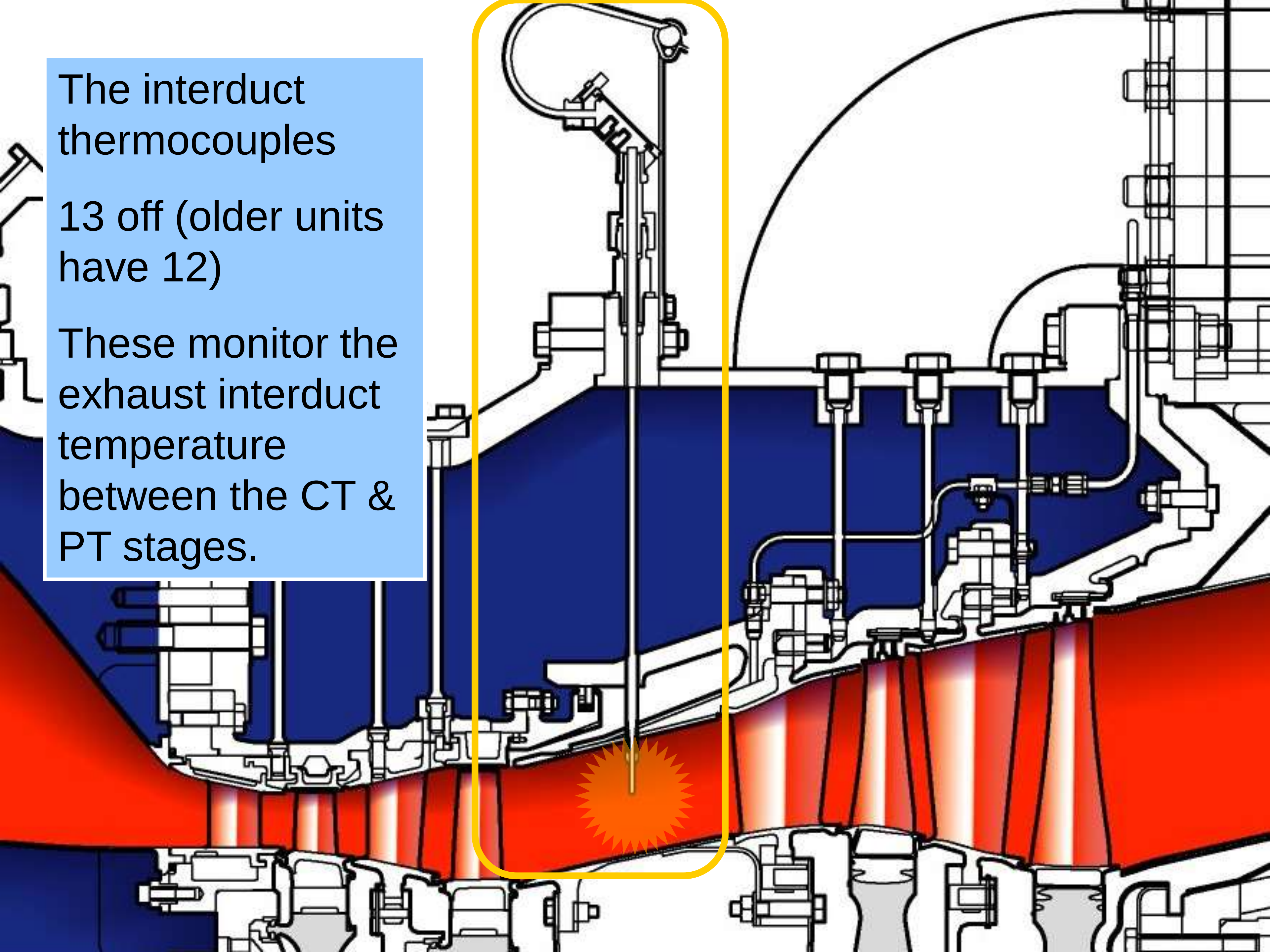
Compressor Turbine CT2 Rotor

SGT400 With Borescope access plugs in view

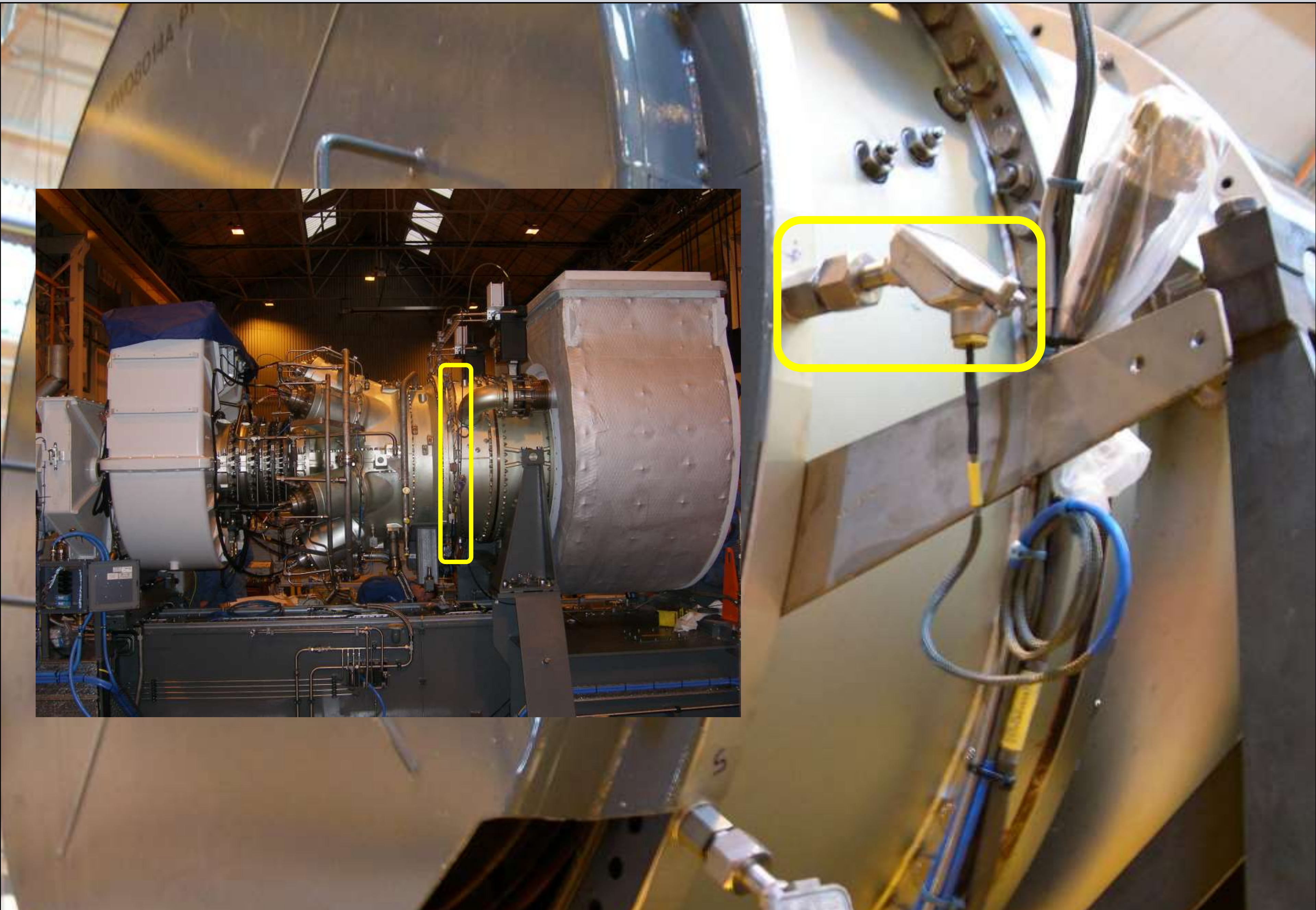
The interduct thermocouples

13 off (older units have 12)

These monitor the exhaust interduct temperature between the CT & PT stages.



PT & location of Thermocouples

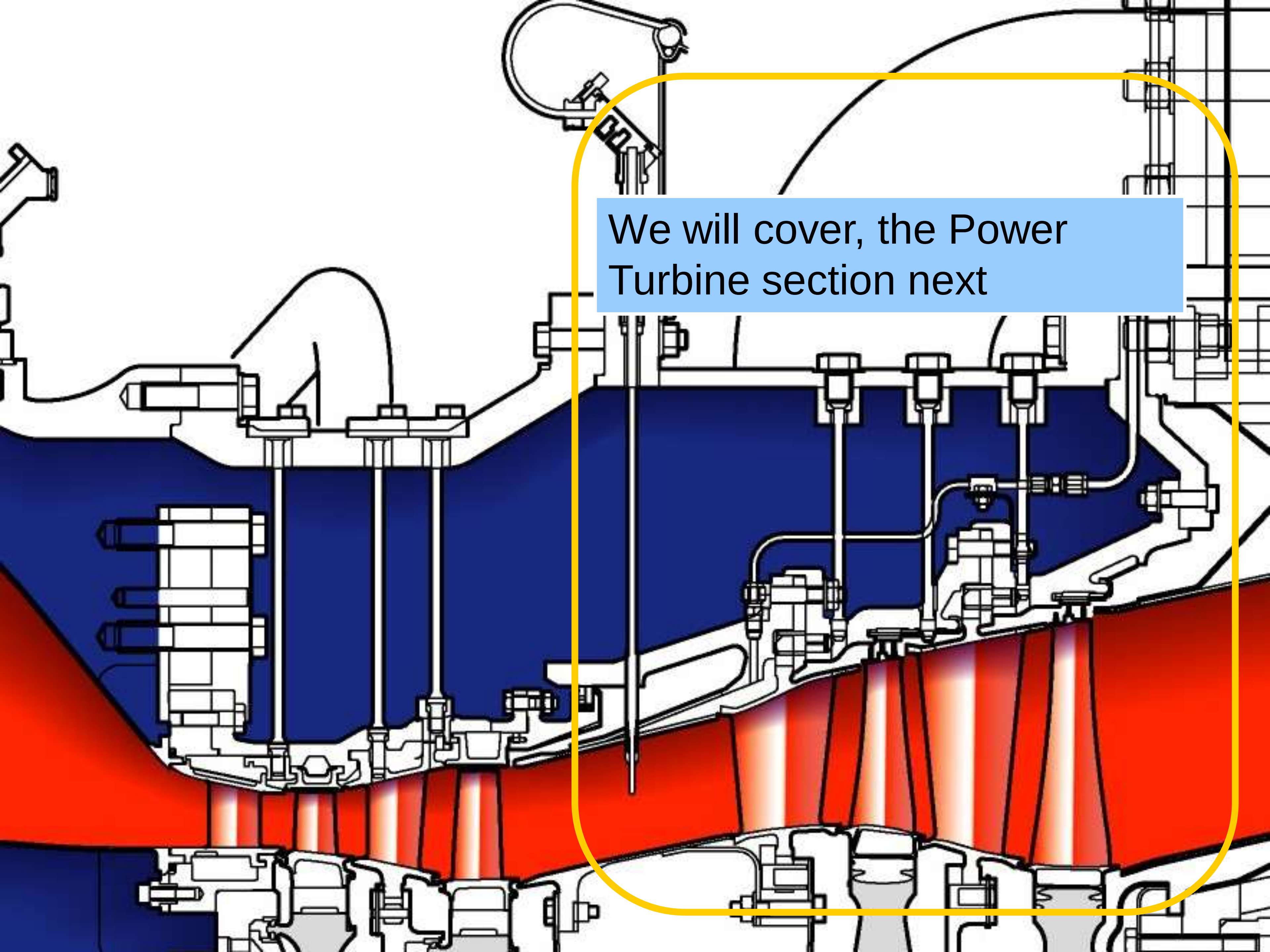


T/Cs can be removed for inspection.

Removing T/C and Adaptor.

Adaptor removed for access

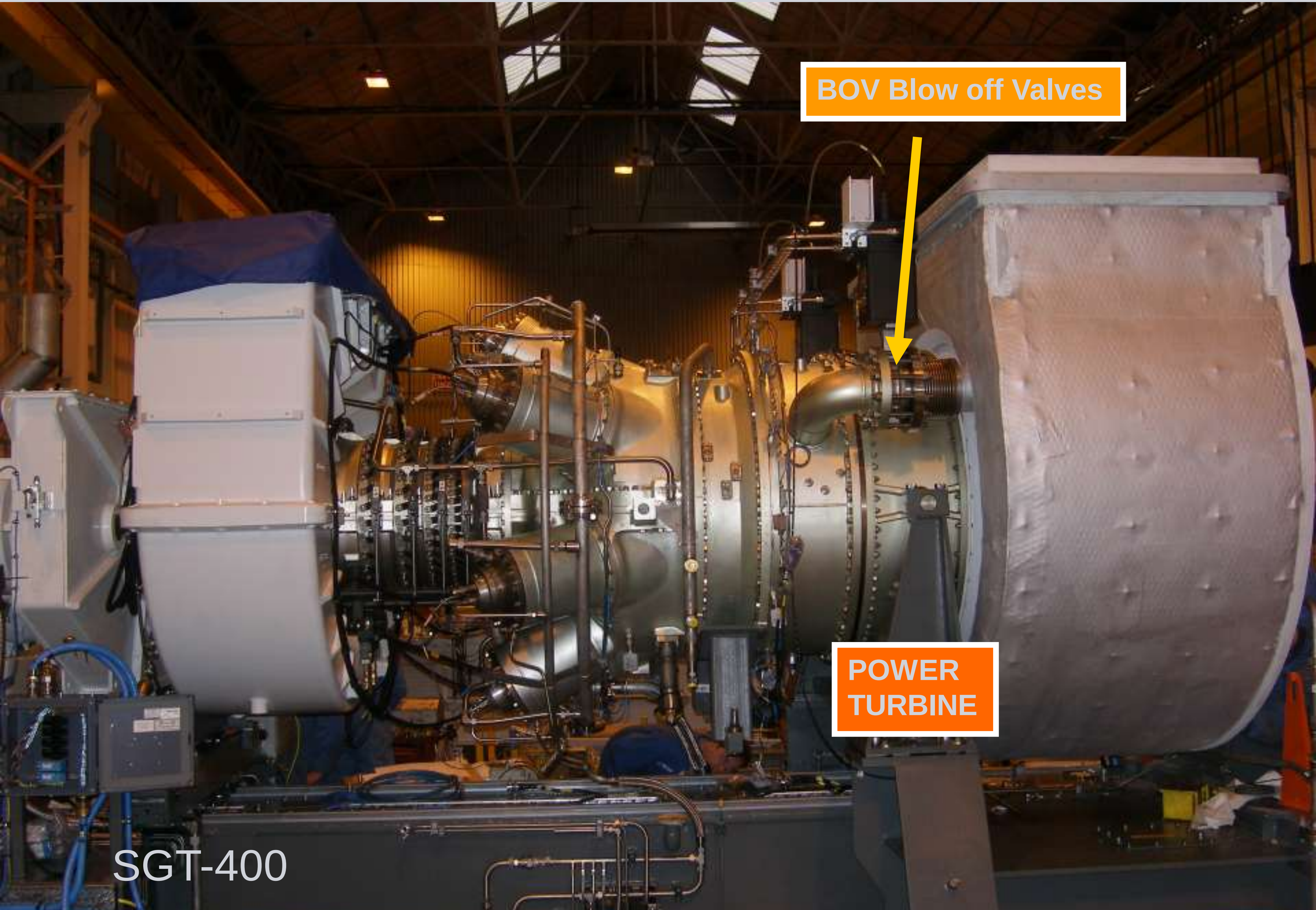
Thermocouple and Adaptor


We will cover, the Power Turbine section next

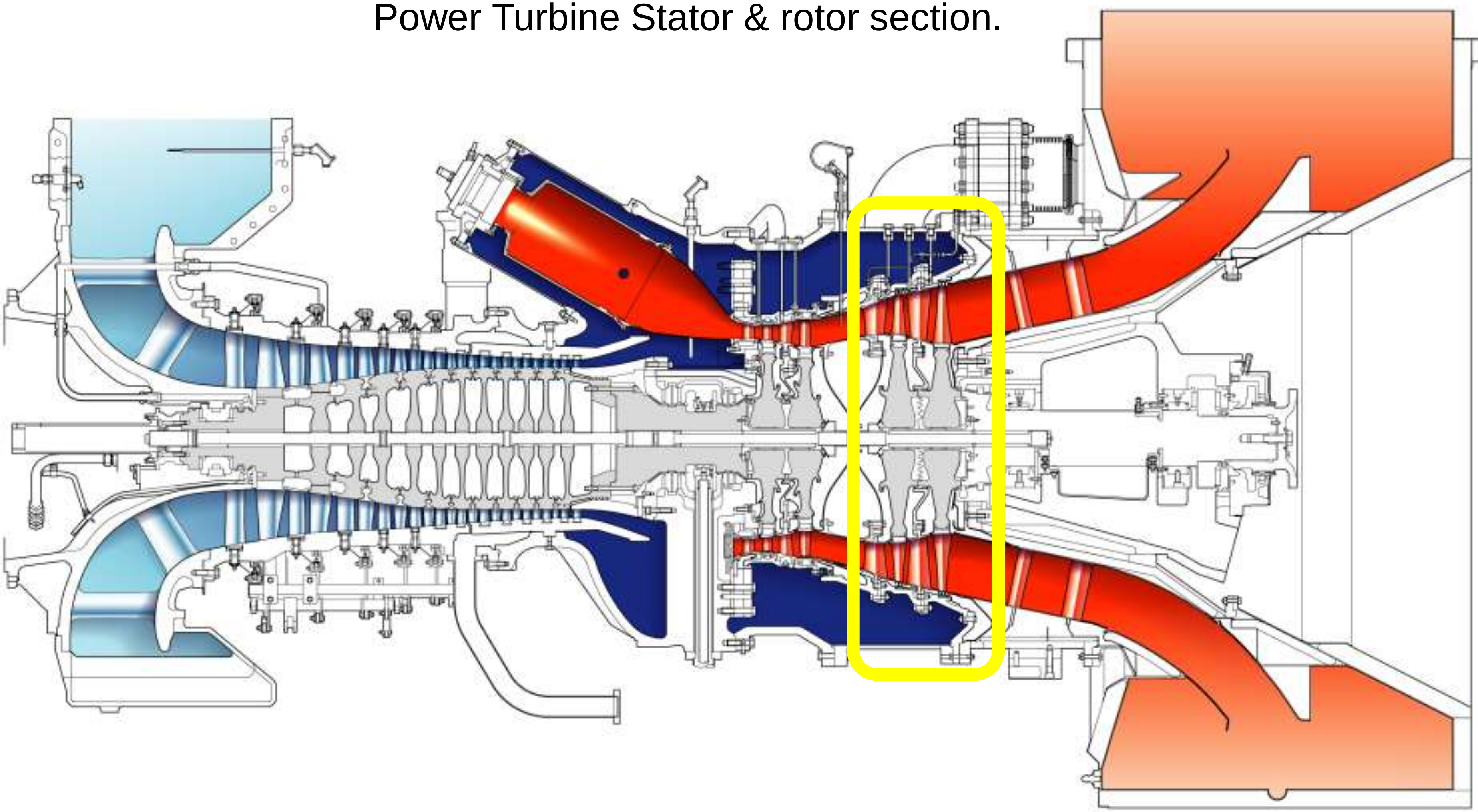
The Power Turbine & BOV's.

SGT 400 POWER TURBINE Unit (Less Exhaust diffuser & BOV units)

Power Turbine & Blow Off Valves

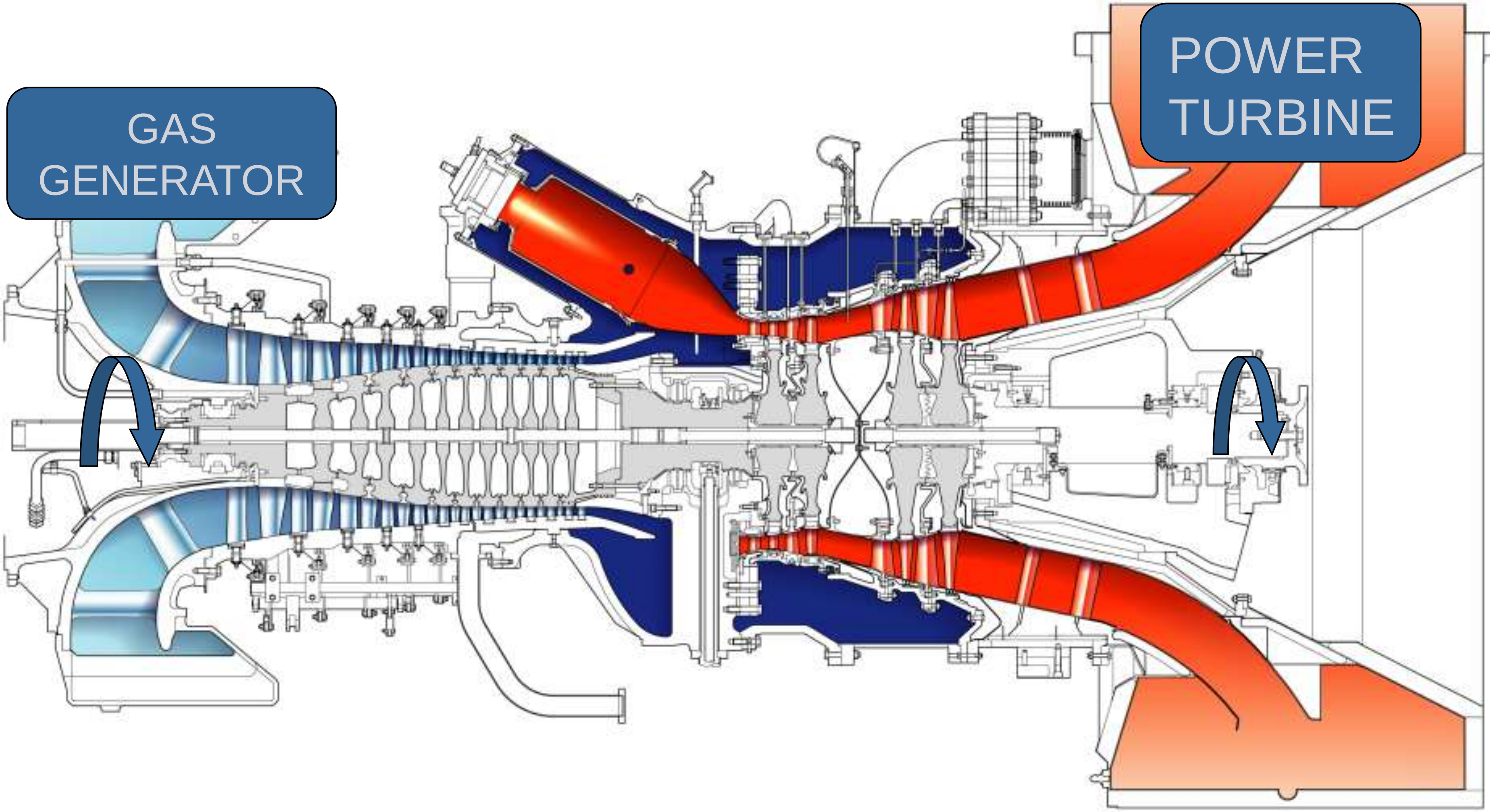


Power Turbine Stator & rotor section.



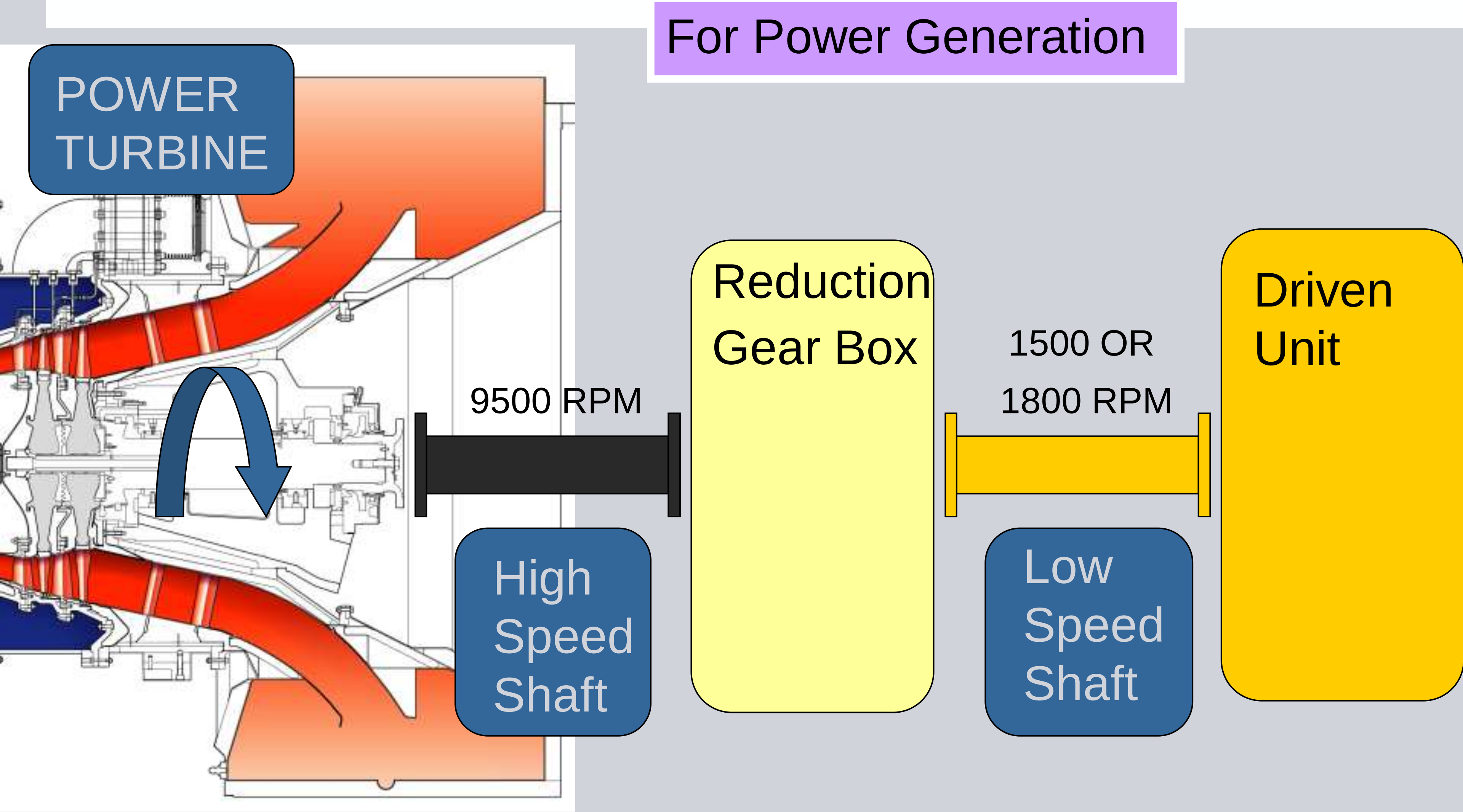
SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

MW - CC



SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

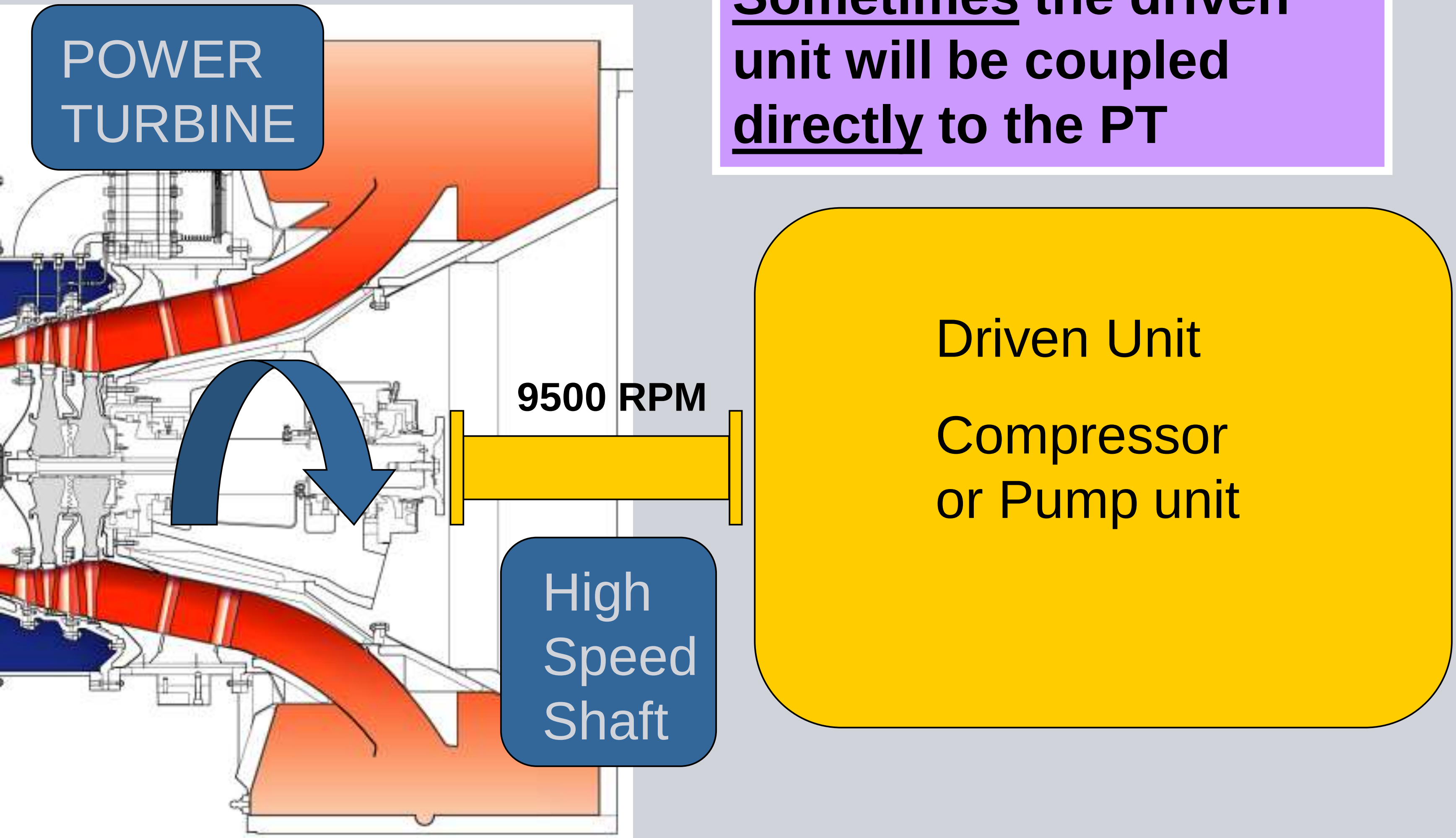
PT output to driven unit.



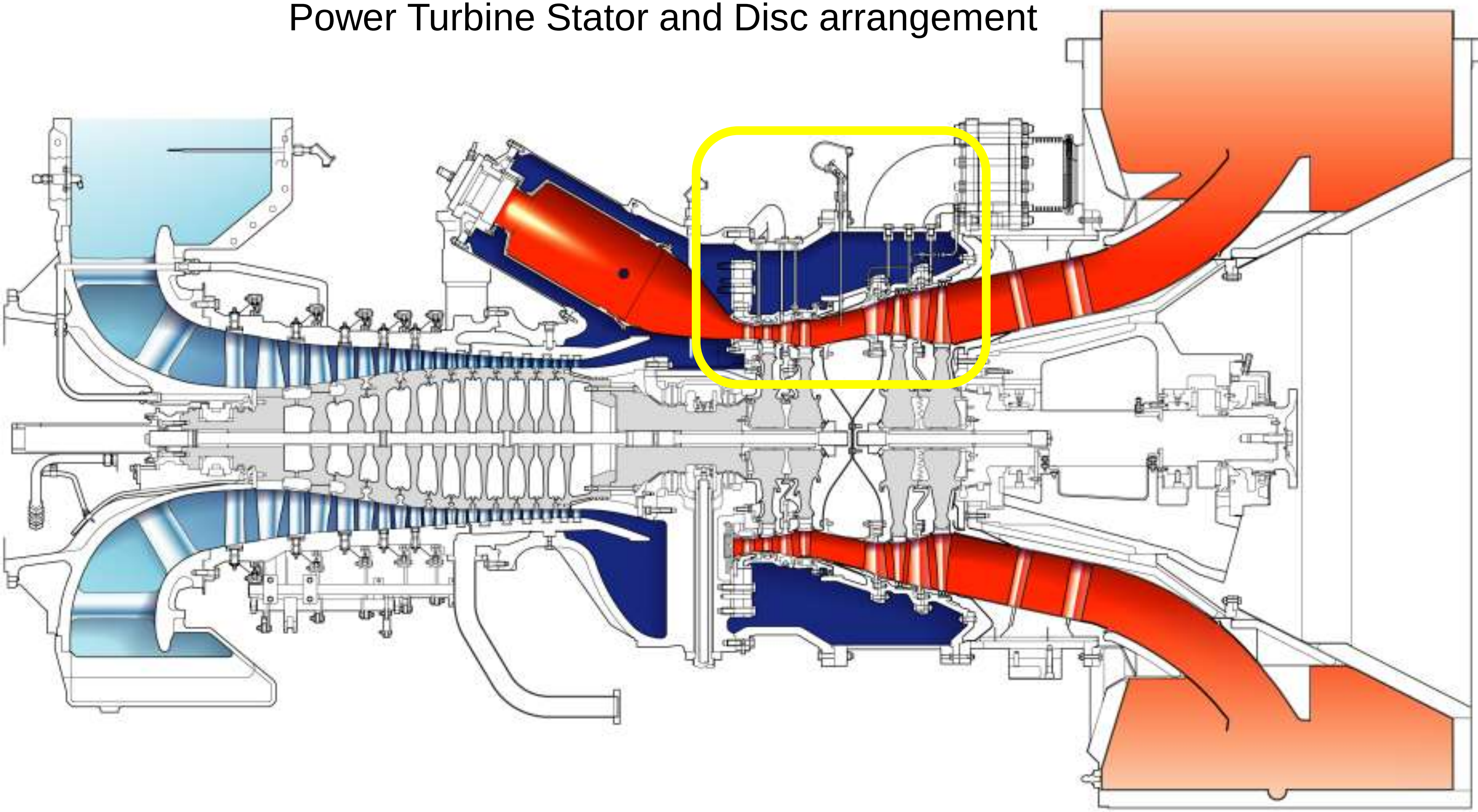
PT output to driven unit.

SIEMENS

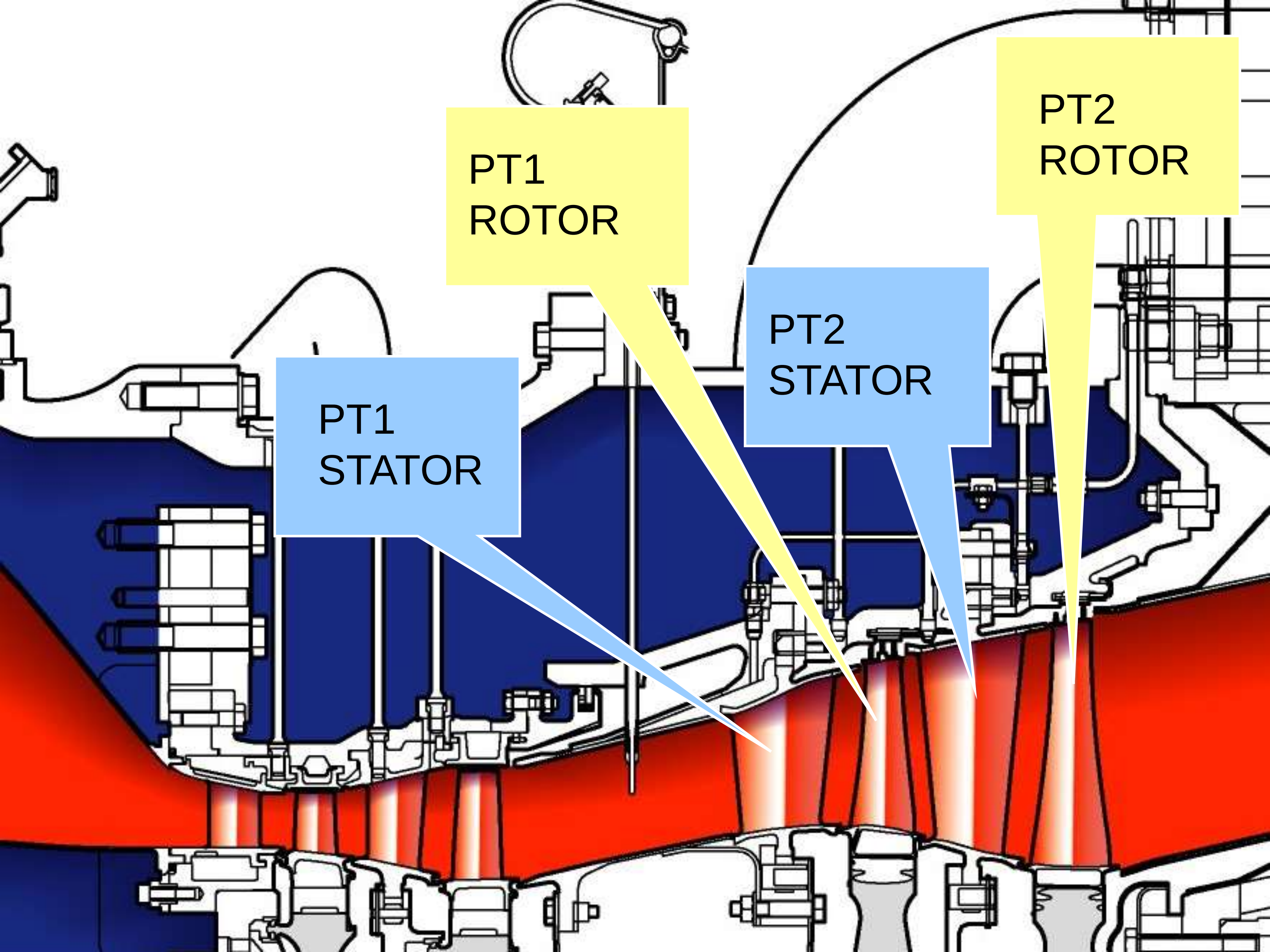
<u>Sometimes</u> the driven unit will be coupled <u>directly</u> to the PT

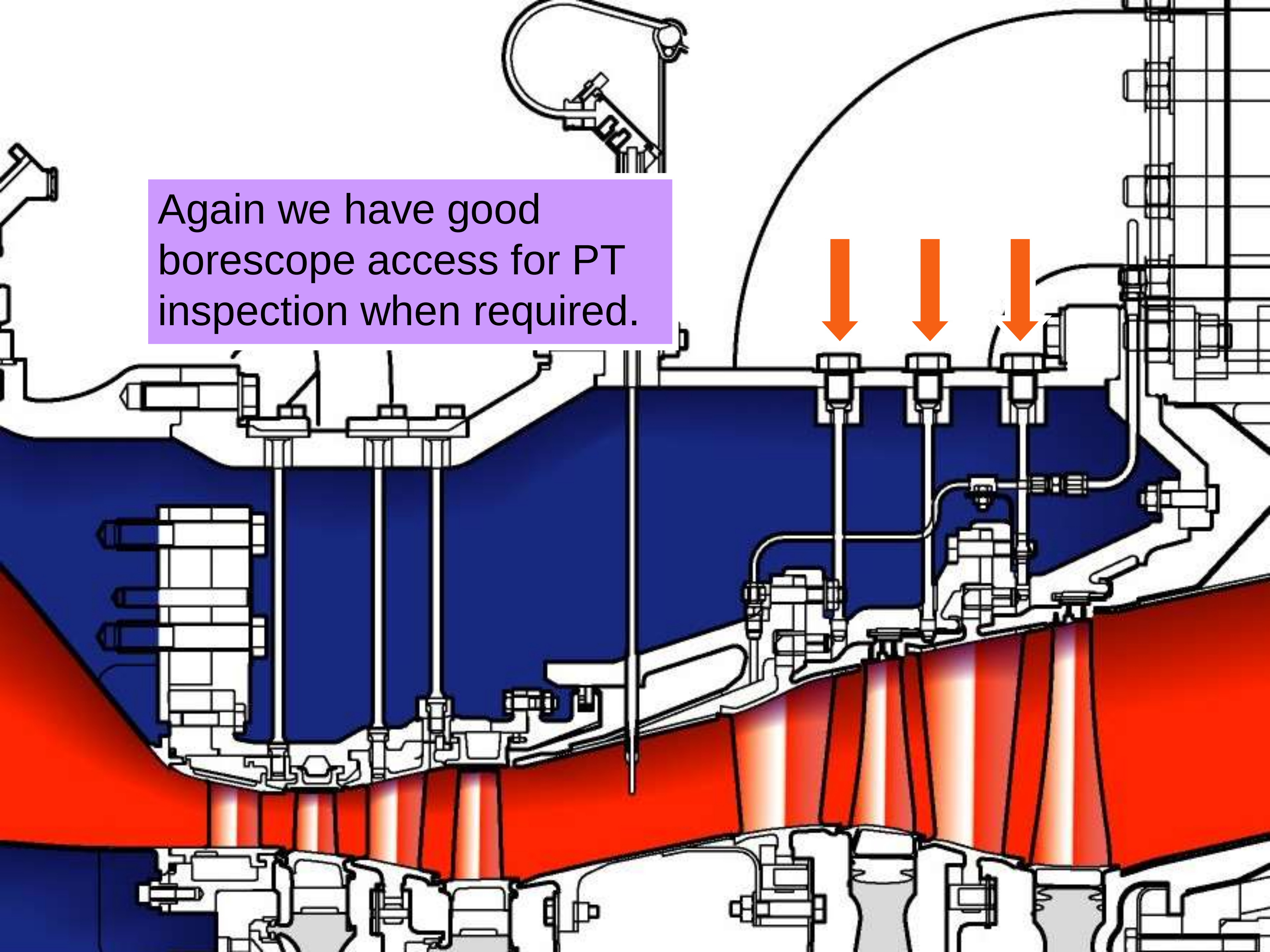


Power Turbine Stator and Disc arrangement



SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)


PT1 ROTOR
PT2 ROTOR
PT2 STATOR
PT1 STATOR



Again we have good borescope access for PT inspection when required.

Power Turbine

Single piece Power Turbine Nozzle Ring
(Both stages are single piece)

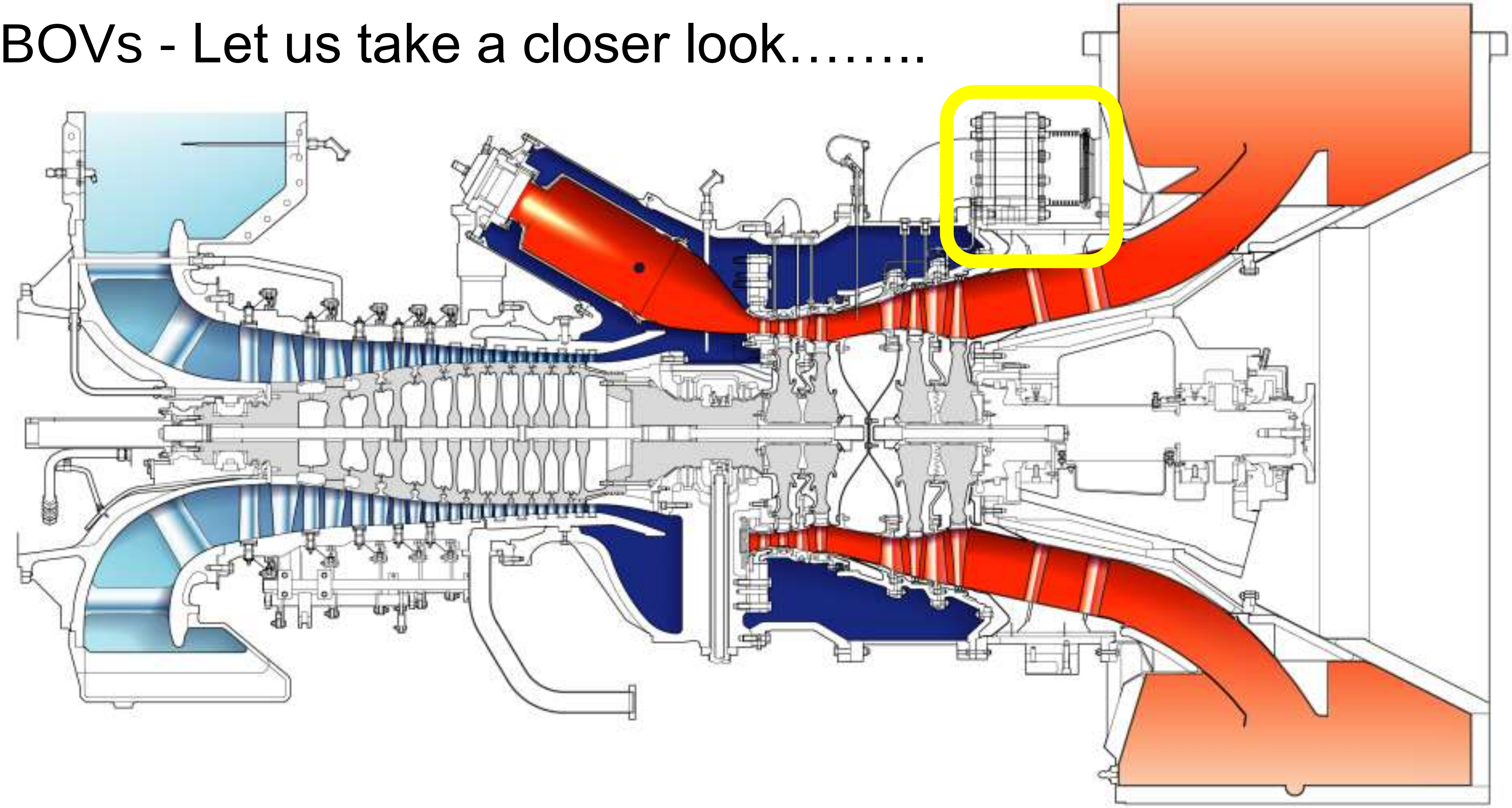
Power Turbine Blade

SGT 400 POWER TURBINE
Borescope Access Points

SGT-400 Power Turbine.

The P2 Air Blow – Off Valves

BOVs - Let us take a closer look……..



SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

The P2 Air Blow – Off Valves

SIEMENS

Generally used on Generator sets only.

There are two BOV’s mounted externally.

One each side of the P T.

The BOV’s are made by MOOG and are **hydraulically operated.**

The Hydraulic system operates at a pressure of **180 BarG** (2646 psi

SIEMENS

P2 Air Blow – Off Valves.

The Blow – Off Valves have three main functions.

They are used to **prevent Power Turbine overspeed** should the electrical load be lost.

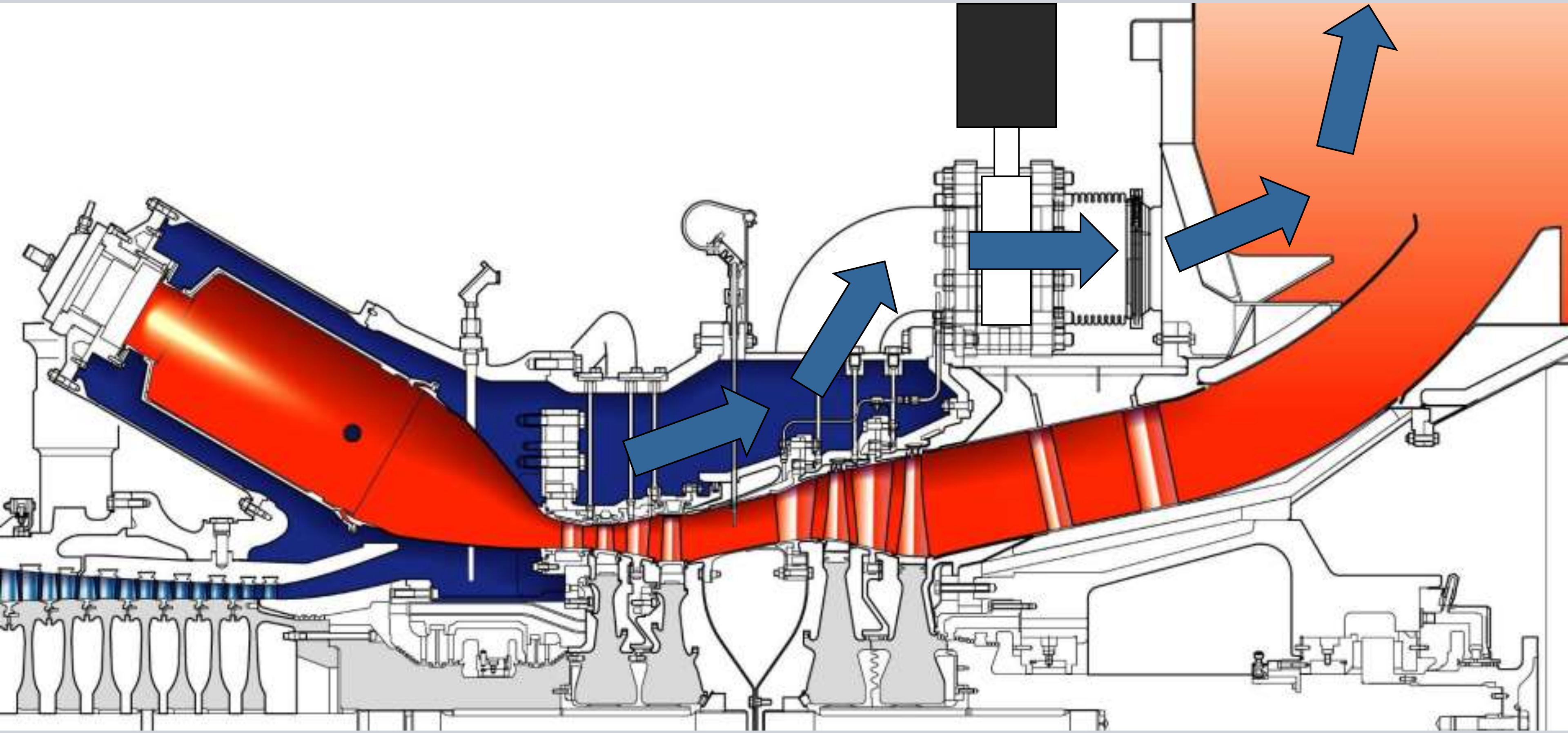
They are also used on some but not all applications to **control Exhaust Emissions** at part load. In this case the BOV's are modulated and the position is controlled by engine temperature.

On Liquid fuel starting they can be used to **control smoke emissions** by remaining open at low loads.

The P2 Air Blow – Off Valves

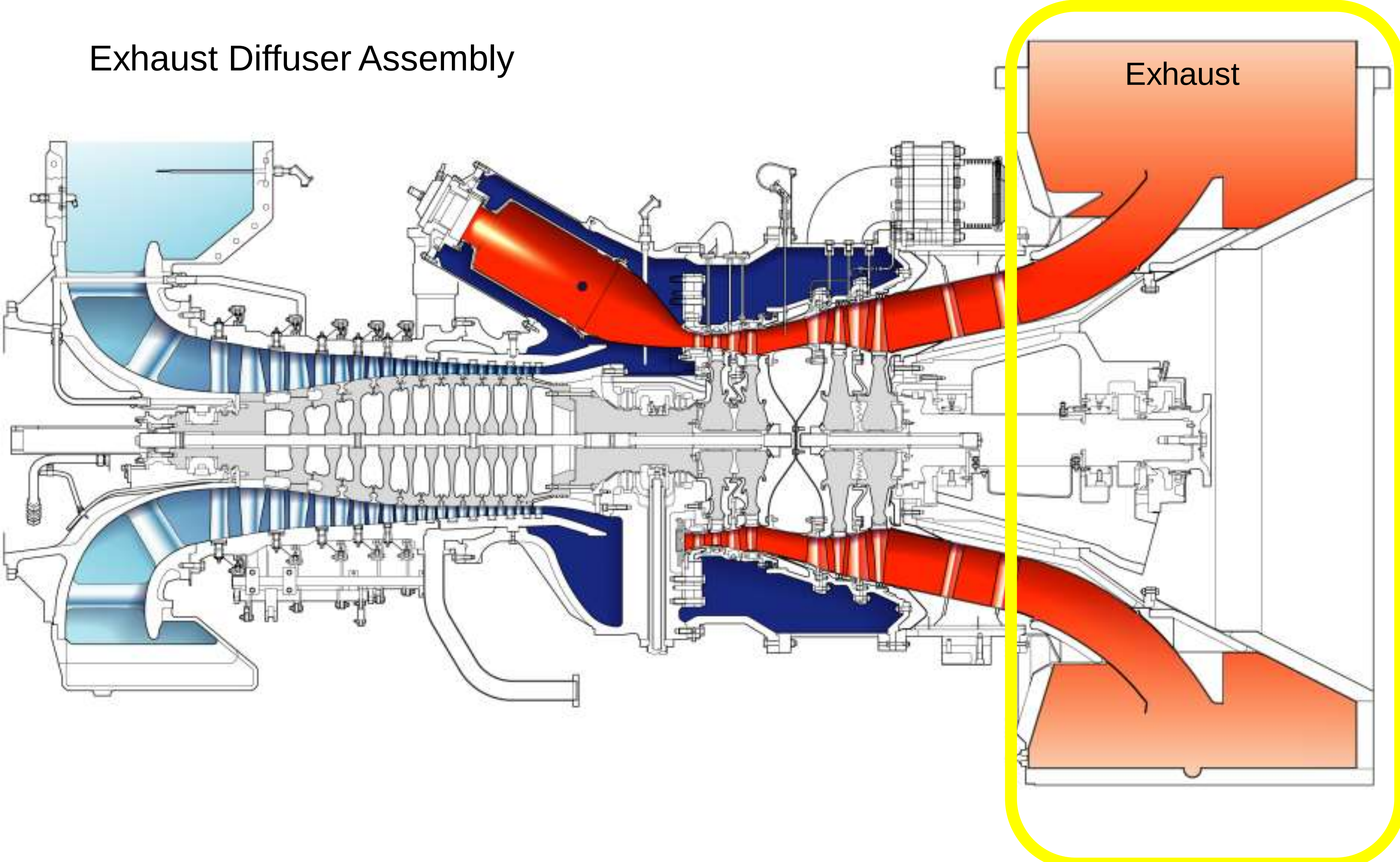
SIEMENS

Both of the BOV’s, vent <u>some</u> of the compressor exit (P2) air, directly into the exhaust diffuser.



The Exhaust System.

Exhaust Diffuser Assembly



SECTIONAL ARRANGEMENT - SGT-400 - TWIN SHAFT (CYCLONE)

Radial Exhaust Diffuser

SIEMENS

Exhaust System

Radial Exhaust Diffuser – The Outlet can be orientated to the left, vertical or to the right. (90° or 60°)

Generally Siemens maintenance responsibility ends at the diffuser flange. The customer "or others" would normally maintain the remaining exhaust ductwork.

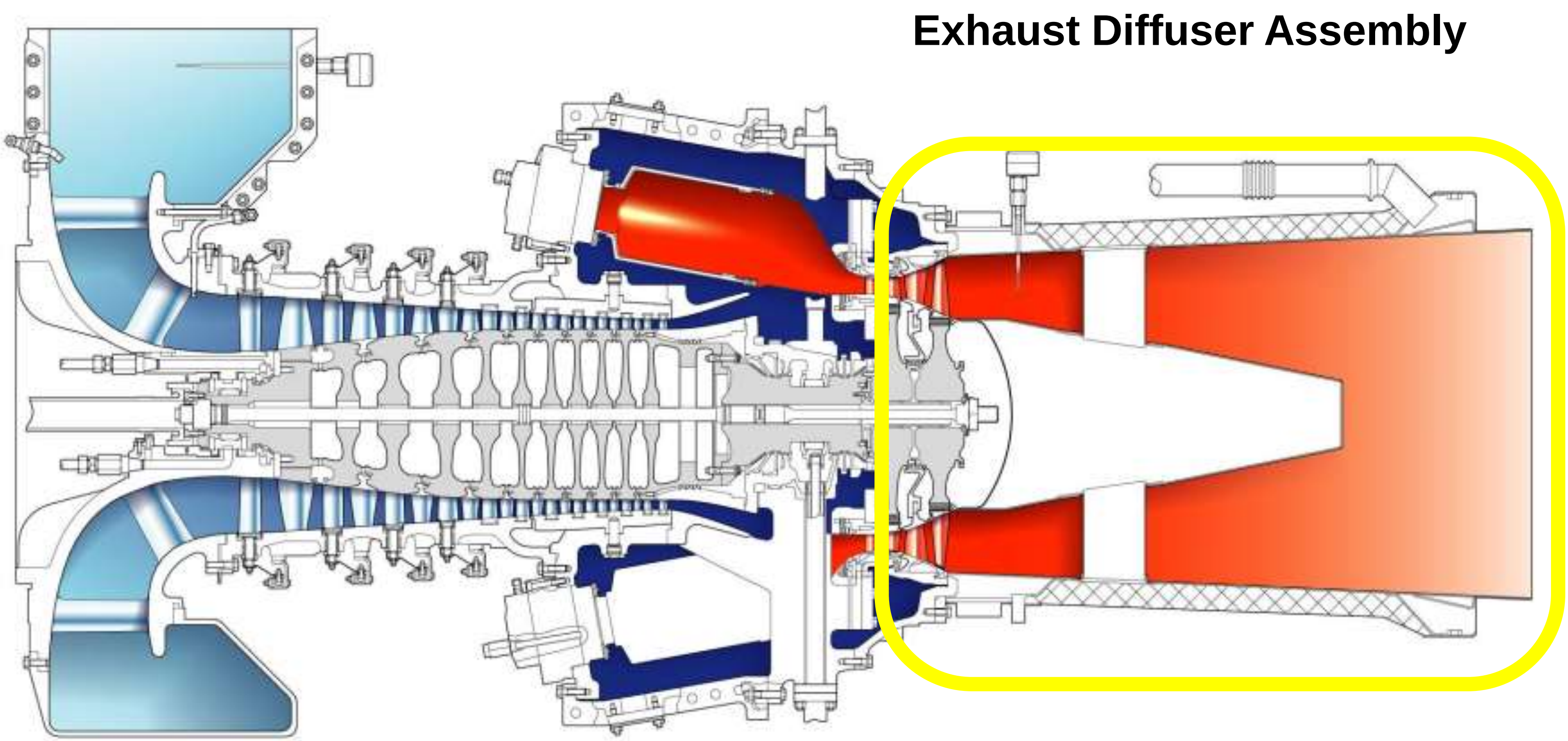
CHP Applications – Where Combined Heat and power is used, the exhaust will pass through a Heat Exchanger/Boiler unit.

Often Dampers are fitted with a bypass exhaust stack. This enables exhaust gas to be directed either through the Boiler or direct to atmosphere.

Because of Heat Expansion there are flexible joints fitted to the Diffuser & parts of the Exhaust stack. Often referred to as "Exhaust Bags".

"Baggy" is Field Staff term for a work colleague or acquaintance!

Axial Exhaust Diffuser



SECTIONAL ARRANGEMENT - SGT-100-1S - SINGLE SHAFT DLE (TYPHOON)

Axial Exhaust Diffuser

This type of diffuser is only used on the SGT100 single shaft & SGT300 units .
Radial types can also be used on the above.
The Older TA type units have a slightly different axial type exhaust diffuser.

ANY QUESTIONS?

End ...

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