Charge air system & turbocharger assembly

OBJECTIVES

- Concept of Power development.
- Requirement of Supercharging.
- Charge Air System.
- Working of Turbochargers.
- Various Charge air cleaning Systems.
- Factors affecting efficient working of Turbochargers.
- Factors affecting BAP.
- Case Study - Fire in loco due to failure of Charge Air System.

DEVELOPING POWER

- Power-
  - Product of mean effective pressure and rpm.
  - IHP=PLAN
- Power will be increased.
  - Pressure kept constant and rpm is increased.
  - RPM kept constant and pressure is increased.

FACTORS AFFECTING POWER

- Humidity-
  - Molecular weight of water vapor is less than oxygen.
  - Water vapors replace oxygen molecules.
  - Moist air is less dense than dry air.
  - Less dense air means less oxygen.
- Temperature-
  - Affects air density which affects performance: T↑, d↓, P↓

REQUIREMENT OF AIR SUPER CHARGING SYSTEM

- Diesel engine
    - Uses chemical energy to generate Heat energy.
  - Converts into Mechanical energy.
      - Burns fuel inside the combustion chamber.
      - Naturally aspirated engines have high SFC.
      - For efficient burning more oxygen is required.
      - For this SUPER CHARGING is required.

SUPERCHARGING

- Introduction of air into engine cylinder
  - At a density greater than ambient.
  - Produces more power than a naturally aspirated engine.
    - For the same bore and stroke dimension.
- Causes better scavenging.

ADVANTAGES OF SUPER CHARGING

- A supercharged engine of given bore and stroke dimensions can produce 50% or more power than a naturally aspirated engine.
- The power to weight ratio in such case is much more favourable.
- Charging of air during the suction stroke causes better scavenging in the cylinders.

  This ensures carbon free cylinders and valves and better health for the engine also.
- Higher heat developed in a supercharged engine due to burning of more fuel calls for better cooling of the components.The cool air charged into the cylinder have better internal cooling of piston, cylinder head and valves and save them from failure due to thermal stresses.
- Better ignition due to higher temperature developed by higher compression in the cylinder.
- Better fuel efficiency due to complete combustion of fuel by ensuring availability of matching quantity of air or oxygen.

METHODS OF SUPERCHARGING

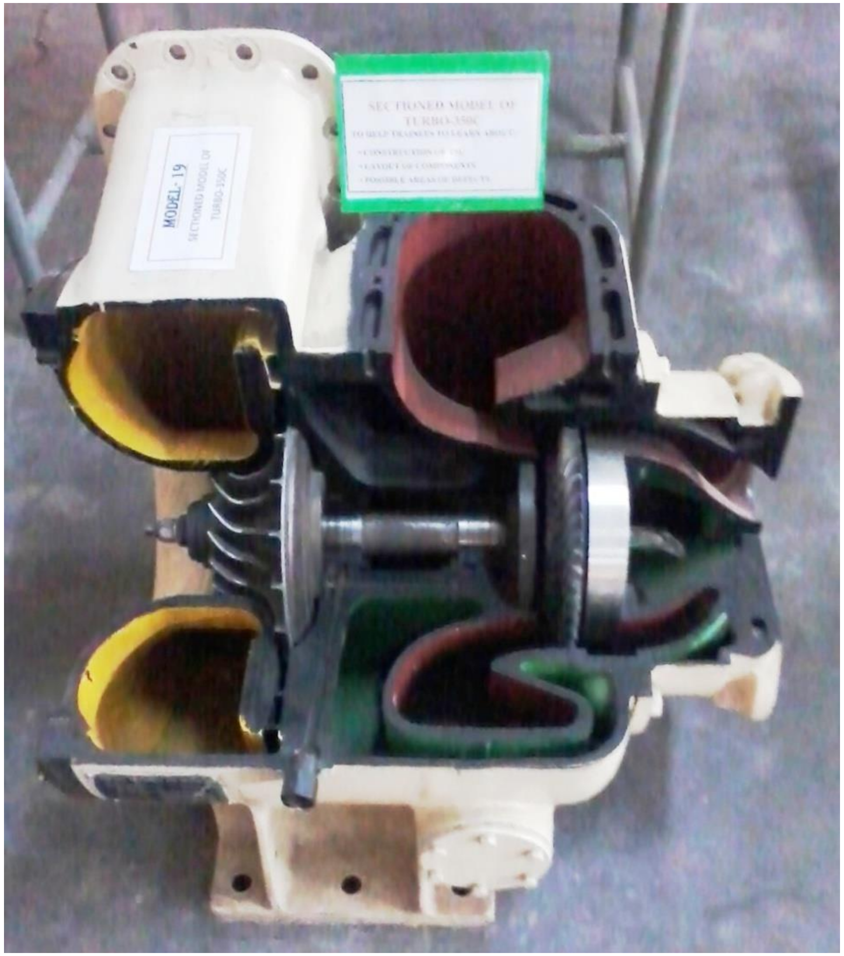
- Separately driven air compressor,
  - Used on four wheel drive military vehicles.
  - Have high SFC.
- Blowers driven by exhaust gas.
  - Uses the energy of other-wise waste Exhaust gas.
  - Very efficient & economical method.
  - Blowers run by the exhaust gas driven turbine.

COMPONENTS OF CHARGE AIR SYSTEM

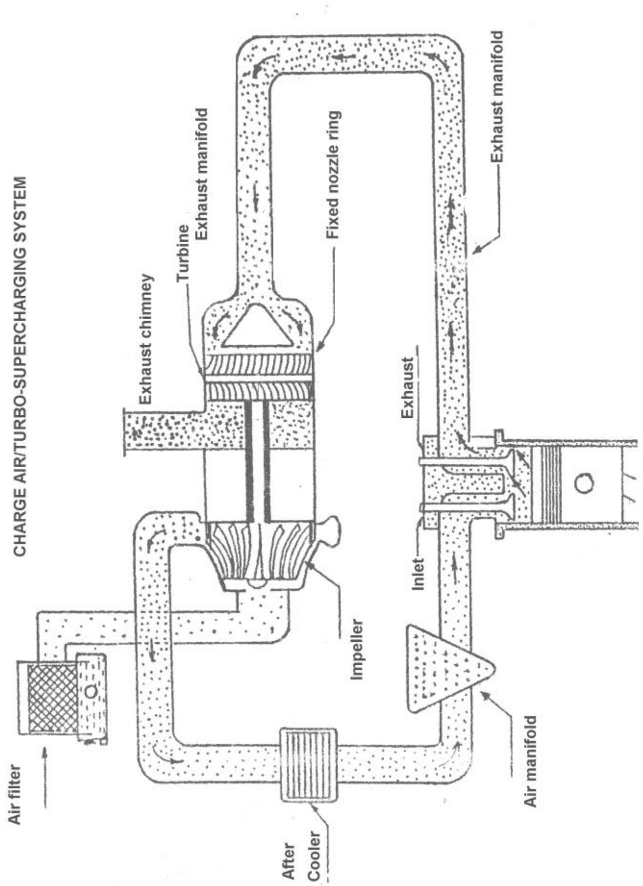
- Air intake filter
- Turbo Charger Assembly
  - ALCO 720
  - ABB
  - GE
- After cooler
- Air manifold
- Exhaust manifold

Main components of turbocharger

- **Gas Inlet Casing**: It is made of CH20 stainless steel which is highly heat resistant. The function of this casing is to take hot gases from the exhaust manifold & pass them through the nozzle ring.
- **Turbine Casing**: It is made of alloy CI or fabricated. It is fitted in between inlet & intermediate casing. This casing is water cooled.

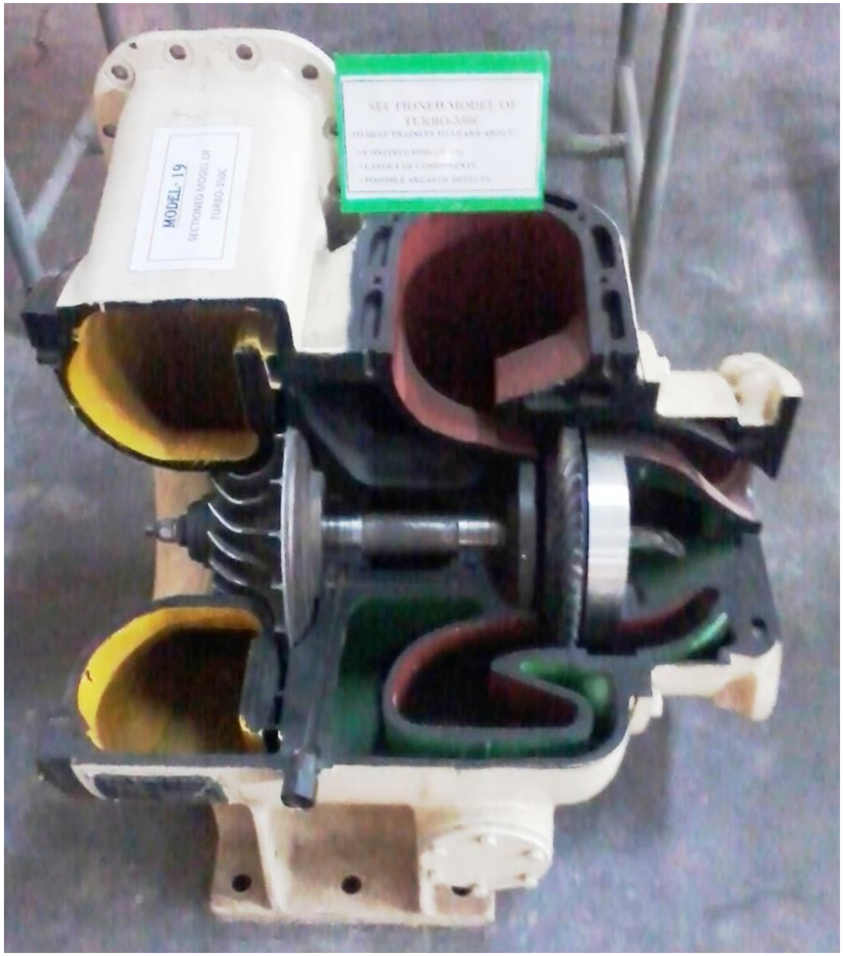


Charged Air System



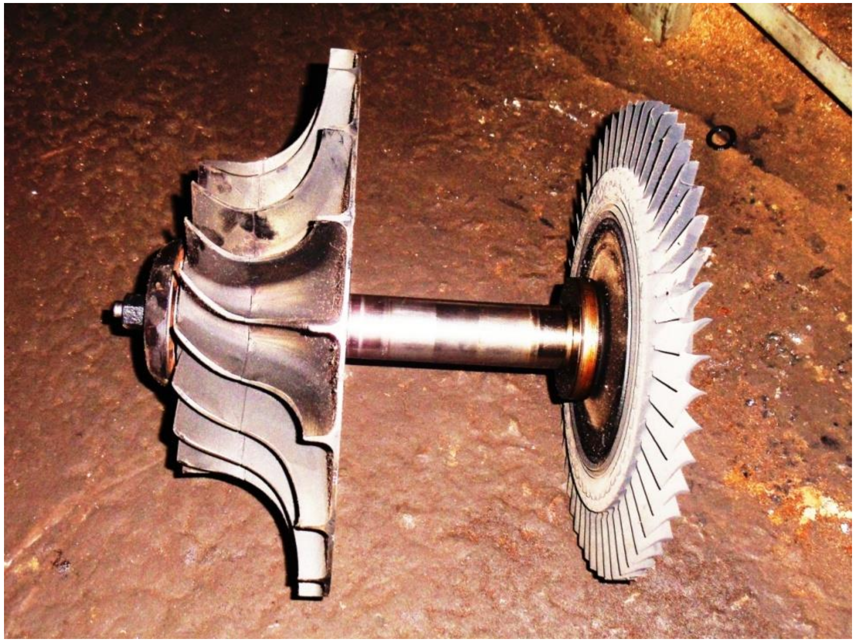
Main components of turbocharger

- **Intermediate Casing**: It is made of alloy CI or fabricated like turbine casing. It is placed between turbine casing & bllower housing. This casing is also water cooled. It separates exhaust & air side.
- **Blower Housing Assembly**: Air enters through the blower inlet axially & is discharged radially to the vane diffuser.



Main components of turbocharger

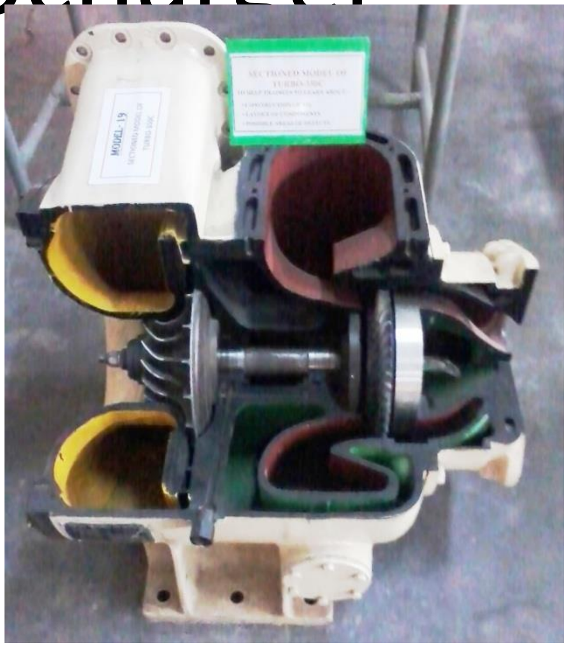
- **Rotor Assembly:** It contains rotor shaft, rotor blade, impeller, inducer etc. It is dynamically balanced component as it has a very high rotational speed.



Main components of turbocharger

- **Diffuser:**
  - It is fixed on the main casing at the back side of impeller assembly.
  - Velocity of air is diffused to increase its pressure.
  - Should be checked for worn out partitions.

Working of turbocharger



- Exhaust gas from all the cylinders accumulates in the common exhaust manifold.
- Turbo-charger is fitted at its end.
- The gas under pressure enters the turbo-charger and passes through the fixed nozzle ring.

Working of turbocharger

- Then exhaust gases are directed on the turbine blades at increased pressure and at the most suitable angle to achieve rotary motion of the turbine.
- After rotating the turbine, the exhaust gas goes out to the atmosphere through the exhaust chimney.

Working of turbocharger

- The turbine has a centrifugal blower mounted at the other end of the same shaft.
- The rotation of the turbine drives the blower at the same speed.

Working of turbocharger

- The blower connected to the atmosphere through a set of filters sucks air from atmosphere and delivers at higher velocity.
- Air then passes through the diffuser inside the turbo-supercharger where the velocity is diffused to increase the pressure of air.

Working of turbocharger

- Due to compression heat develops & the density of air decreases.
- The air is then passed through an after cooler having two separate passages where cooling water is passed through one passage.

Working of turbocharger

- The heat in the air is thus transferred to the cooling water and air regains its lost density.
- From the after cooler air goes to a common inlet manifold connected to each cylinder head.

TURBO RUN – DOWN TEST

- To check the performance of turbocharger.
- Procedure
  - The engine is run at 8th notch
  - Keep there for some time.
  - Bring throttle to 4th notch.
  - Ensuring water temperature around 65°C.
  - Shut down through over speed trip mechanism.

TURBO RUN DOWN TEST

- Wait till the rotation of the crank shaft stops.
- Record the time taken by turbine to stop.
- Should be within 90 sec to 180 sec.
- If time is less than 90 sec,
  - Some problem with the bearings.
  - Seizure tendency.
- If time is more than 180 sec,
  - Turbine is moving freely.
  - Check blower assembly..

COMPARISON OF DIFFERENT MODELS OF TSC

Time Period	**1960-90**	**1990-95**	**1995-2000**	**2001**
Technology wise classification of Turbo Charger	Conventional	High Efficiency	Twin Discharge	New Generation
Turbo models used	ALCO 720A	Napier-NA295/ ABB-VTC-304/ HS 5800NGT	GE 7S1716	ABB TPR-61/ GE7S1716
SFC gm/BHP.Hr	168	156	154	151
Exhaust Gas Temperature	600 Degree C	580	500	500
Frequency of Maintenance	6 Months	2-3 Years	6 Years	6 Years

HIGH EFFICIENCY TSC (SINGLE DISCHARGE)

GE TSC

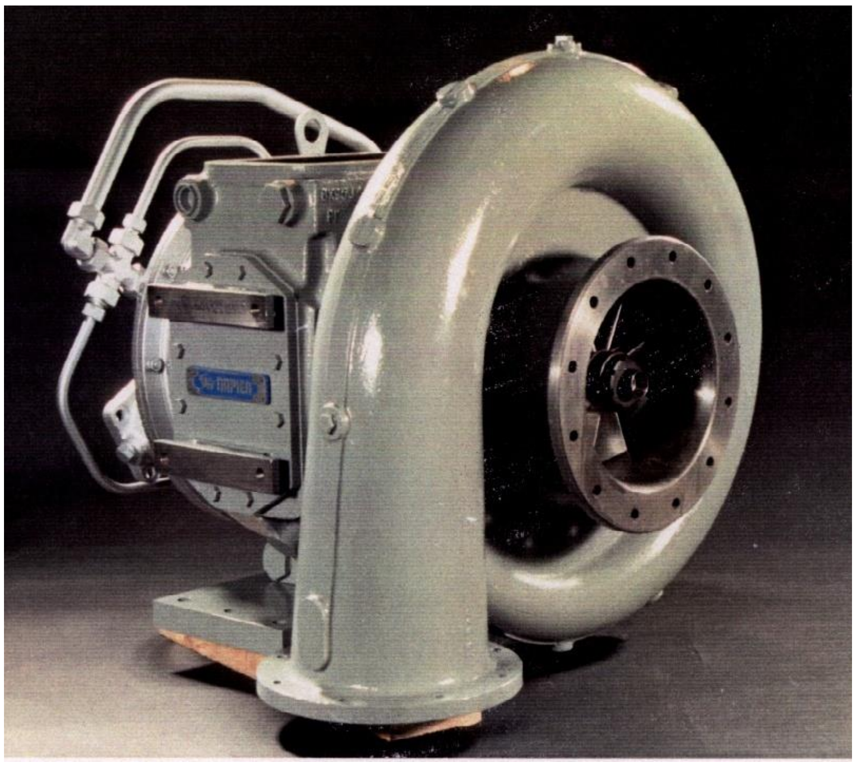
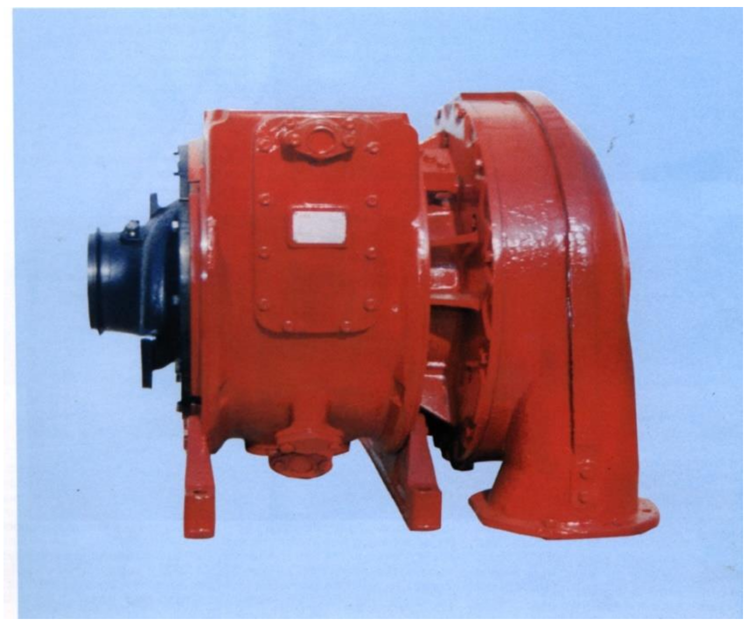


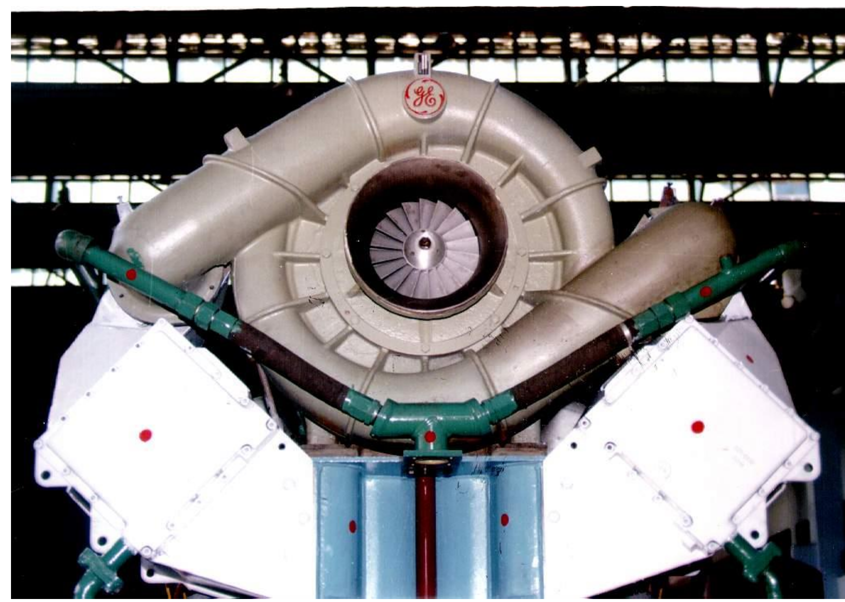
ABB VTC304



NEW GENERATION TURBOCHARGERS

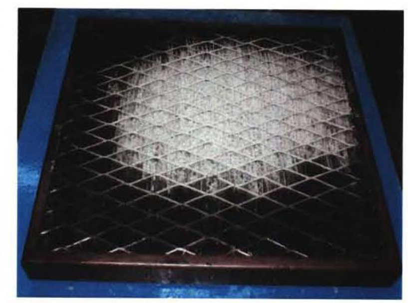
ABB TPR 61

GE 7S 1716



WIRE MESH CARBODY FILTER SYSTEM

- Initially wire mesh type dry or oil soaked filters were used to clean the air being sucked by the turbo inducer by absorbing the dirt, dust etc in the atmospheric air so that the effectiveness as well as service life of after cooler gets increased.
- Smaller dust particles could not be filtered leading to less service life of after cooler and as such frequent choking and attention (quarterly in some areas)



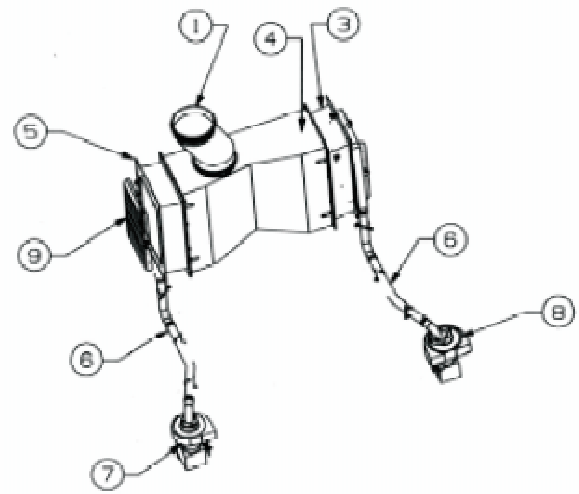
OIL BATH FILTERATION SYSTEM

- These filters were later on replaced by oil bath wire mesh filters where the air was made to pass through oil before entering the turbo inducer leaving all the dirt, dust etc in the oil itself.
- Some part of the oil was sucked by turbo inducer slowly, leading to shortage of oil & premature choking of after cooler.

OIL BATH AIR FILTER

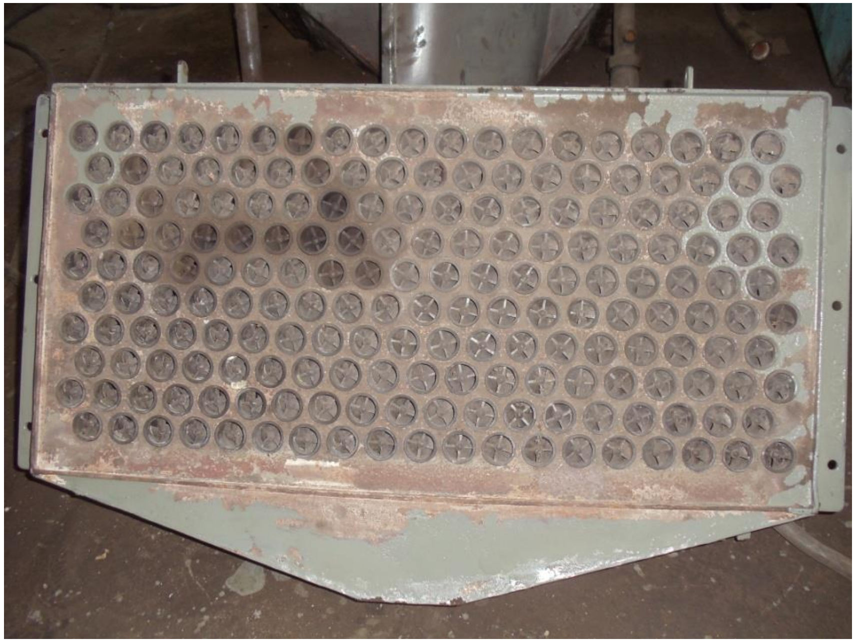
 

LAYOUT OF AIR FILTERATION SYSTEM



1. CONNECTOR
2. FILTER FRAME ASSY.R.H.
3. FILTER TER FRAME ASSY.L.H.
4. GLASS FIBER BAG FILTER
5. FLANGE FOR PRECLEANER
6. DUST COLLECTOR & EXTRATI ON PIPING
7. DUST COLLECTOR BLOWER L.H.
8. DUST COLLECTOR BLOWER R. H.
9. ENGINE PRIMERY FILTER

PRIMARY AIR FILTER



DEEP DESIGN TYPE GLASS WOOL FILTERATION SYSTEM

- Two stage filtration using primary filter(swirling action caused by plastic volutes added by suction power of Exhauster motor to extract solid dust, dirt etc) and secondary Glass wool filter media (Deep design type to filter fine impurities in the sucked air)
- Less service life of secondary filters due to frequent choking requiring frequent attention (in some areas 4 months against 8 months life)

BAG TYPE GLASS WOOL AIR FILTERATION SYSTEM

- Two stage filtration using primary filter(swirling action caused by plastic volutes added by suction power of AC Exhauster motor to extract solid dust, dirt etc) and secondary Glass wool filter media (BAG type to filter fine impurities in the sucked air)
- RDSO has advised (MP.MOD.EN.01.02.07) to change all previous versions with this type at the earliest.

BOOSTER AIR PRESSURE NORMS

- RDSO/LKO's IB No. MP.IB.EN.01.02.01 Rev.01
- 2600 HP loco.
  – 1.1 to 1.5 (conventional ALCO-720 TSC)
  – 1.6 to 1.8 (for High Efficiency TSC)
- RDSO/LKO's L/No. SD.DEV. Turbo dt. 17.02.09
  – 1.6 to 2.07 kg/cm2 for 3100 HP locos
  – 1.8 to 2.0 kg/cm2 for 3300 HP locos.
- Locos having BAP less than the above will fall in low BAP range.

CAUSES OF LOW BOOSTER AIR PRESSURE / LOW HAULING POWER

- Low fuel oil pressure.
- Fuel Injection Pump defective.
- Nozzle defective.
- Improper valve timings / tappet setting.
- Governor malfunctioning.
- Wheel slip occurring.
- Defects in excitation system.
- Rpm not responding.

CAUSES OF LOW BOOSTER AIR PRESSURE / LOW HAULING POWER

- Tsc defective.
- Defective after cooler.
- Booster air leakage from air elbow joints.
- Exhaust gas leakage from manifold.
- Bellows connector crack.
- Broken / choked booster air connection to governor.

POINTS TO BE REMEMBERED

- Service life of any turbo depends mainly on the duty cycle of engine.
- For ensuring optimum life of any TSC
  - Power generation from be as per laid down parameters of other associated elements.
- RDSO **MPMI-10-rev.02-AUG03 & IB no. Mp.Ib.En.01.02.01 rev 01** lay down the values of associated parameters which must be adhered to during load box testing.

POINTS TO BE REMEMBERED

- Ensure that exhaust gas temperature is always maintained within specified limits.
- Air suction filters both primary and secondary are changed at regular intervals depending on local working conditions **(if pressure differential exceeds 470mm/18.5” of water**).
- Dust blower motors are always maintained in working condition.

POINTS TO BE REMEMBERED

- There is **no leakage or discontinuity** in the pipeline connecting primary filter housing and dust blower motors.
- The joint of air suction doom with turbo air inlet flange is made and secured properly making it leak-proof avoiding any possibility of joining material being sucked by the inducer.
- Turbo charger is bye passed from lube oil line at the time of lube oil flushing.

POINTS TO BE REMEMBED

- After cooler cleaning is being done at recommended intervals.
- No leakage of booster air from air inlet elbow joints.
- No exhaust gas leakage from manifold and related joints.
- **Drivers should be discouraged to work locomotives with MCBG booster air pressure switch in bye passed mode for long durations**.

Fuel Rack limits vis-a vis maxm BAP

PRESSURE in Kg/ Cm2	DEFAULT	DECIMALS ALLOWED
0.0	17	1
0.1	19.2	1
0.2	21	1
0.3	22	1
0.4	23	1
0.5	23.9	1
0.6	24.5	1
0.7	25.1	1
0.8	25.7	1
0.9	26.3	1
1.0	26.9	1
1.1	27.6	1
1.2	28.3	1
1.3	29.3	1
1.4	30.5	1
1.5	32	1

EXHAUST GAS PARAMETERS-2600 HP

- As per RDSO/LKO’s IB No. MP-IB-EN-01-02-01-REV-01

SN	Related parameter	Temp ^{O}C	Temp ^{O}F
1	Exhaust gas temperature at turbine inlet (max) a) Alco 720A model b) High efficiency turbos	 620 525	 1148 977
2	Exhaust gas tempat cylinder head a) Maximum i)Alco 720A model ii)High efficiency turbos b) Differential (max)	 550 476 38	 1022 890 100

EXHAUST GAS PARAMETERS-3100 HP

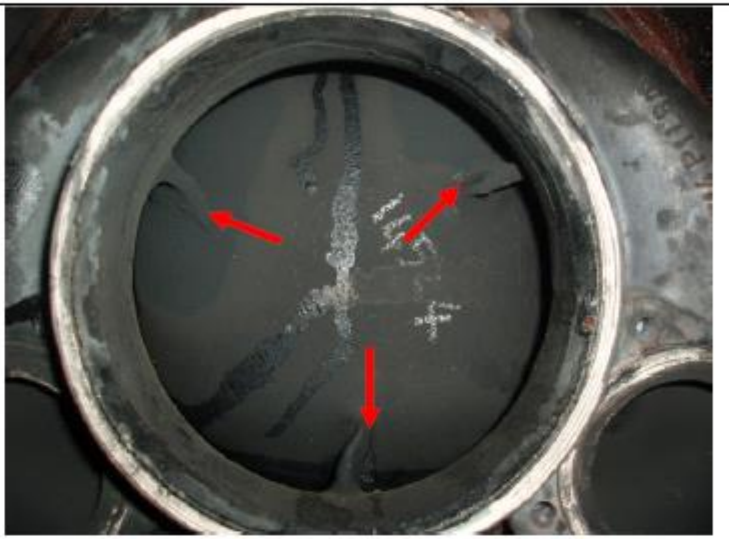
- As per RDSO/LKO's IB No. MP-IB-EN-01-02-01-REV-01

SN	Related parameter	Temp ^{O}C	Temp ^{O}F
1	Exhaust gas temperature at turbine inlet (max)	525	927
2	Exhaust gas temperature at cylinder head a) Maximum b) Differential (max)	 476 38	 890 100

EFFECTS OF HIGH EXHAUST GAS TEMPERATURE

Notch 8 during loadbox test: exhaust gas manifold is red-glowing

Gas inlet casing is also red-glowing → indication for extremly high temperature



THANK YOU.