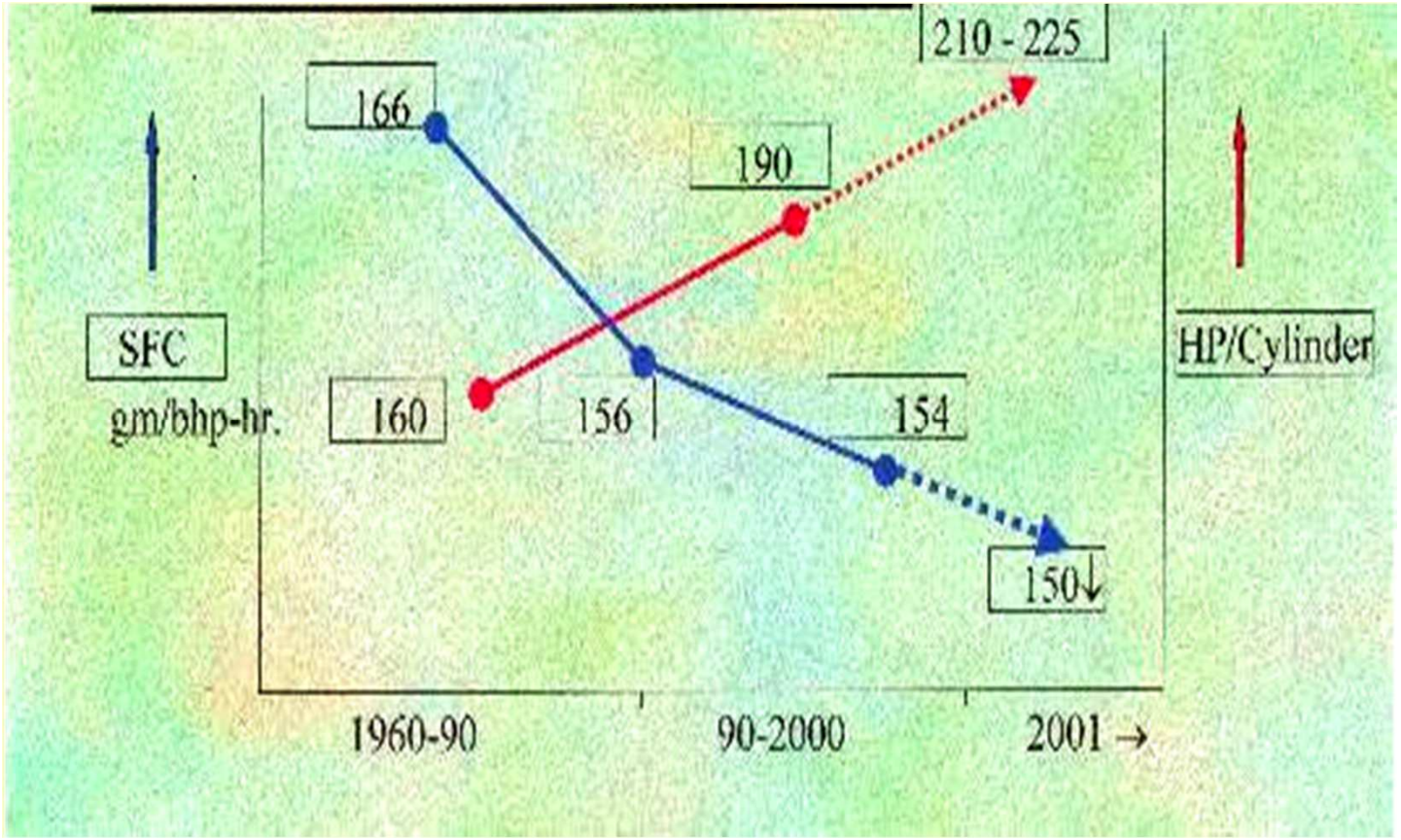
MODIFICATIONS OF DIESEL LOCO (ALCO)

Introduction

- **DSL Loco & TOT-** 1962 (ALCO)
  - Production at DLW started in 1963-64
- **1990s Onward** - Modification started with directed objectives

- **Prime objectives-** Improvement of reliability
  - Reduction of SFC
  - Reduction of maintenance cost & downtime
  - Power upgradation

REDUCED SFC & INCREASED HP



STAGE WISE MODIFICATION

- Improving efficiency of 2600 HP engine with the application of FE kit
- Upgradation of engine to 3100 HP, 3300 HP, 3600HP
- Loco upgradation
- with **higher HP engine** and
- **micro processor control engine** and traction system. (WDM3A, WDG3A, WDP 3A, WDM3D.)

higher HP engine

- 1. High efficiency T.S.C
- 2. STIFFER UNIT CAM SHAFT
- 3. PISTON AND PISTON RINGS
- 4. 251 PLUS CYL. HEAD
- 5. VALVES
- 6. DOUBLE HELIX FUEL INJECTION PUMP
- 7. FUEL INJECTION TUBE
- 8. PLATE TYPE L.OIL COOLER
- 9. Improved After Cooler Design
- 10. MECHANICALLY BONDED RADIATOR

contd...

higher HP engine

11. MULTIGRADE OIL
12. LONG LIFE FILTER
13. CENTRFUGAL OIL CLEANER
14.ROLLER SUSPENSION BRG.
15.MICROCONTROLLER BASED GOVERNOR
16. AIR DRYER
17. PANEL MOUNTED BRAKE SYSTEM

higher HP engine

- **Improved components**
- **1. High efficiency T.S.C**

Objective -Performance improvement
-Lesser maintenance
-Improved SFC
-Higher HP

COMPARISON OF DIFF 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 by RDSO	ALCO 720A	Napier-NA295 ABB-VTC-304	GE 7S1716	HS5800NGT ABB TPL-61RR
Turbo Overall Effeciency	50%	62%	64%	70%
Rated power 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	3-6 Years
Salient Features	Bearing Interference fit. Thrust on Hot Side	Bearing Sliding Fit. Floating bush. Thrust on cold side	Bearing Sliding Fit. Thrust on both Sides.	Bearing Sliding Fit. Thrust on both Sides. No Water cooling.

HIGH EFFICIENCY TSC (SINGLE DISCHARGE)

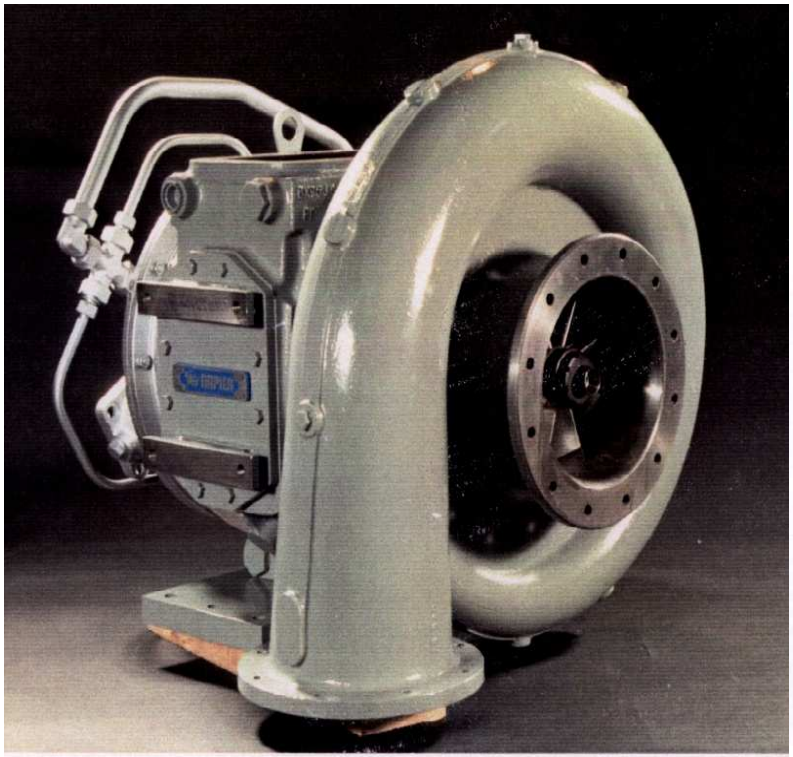
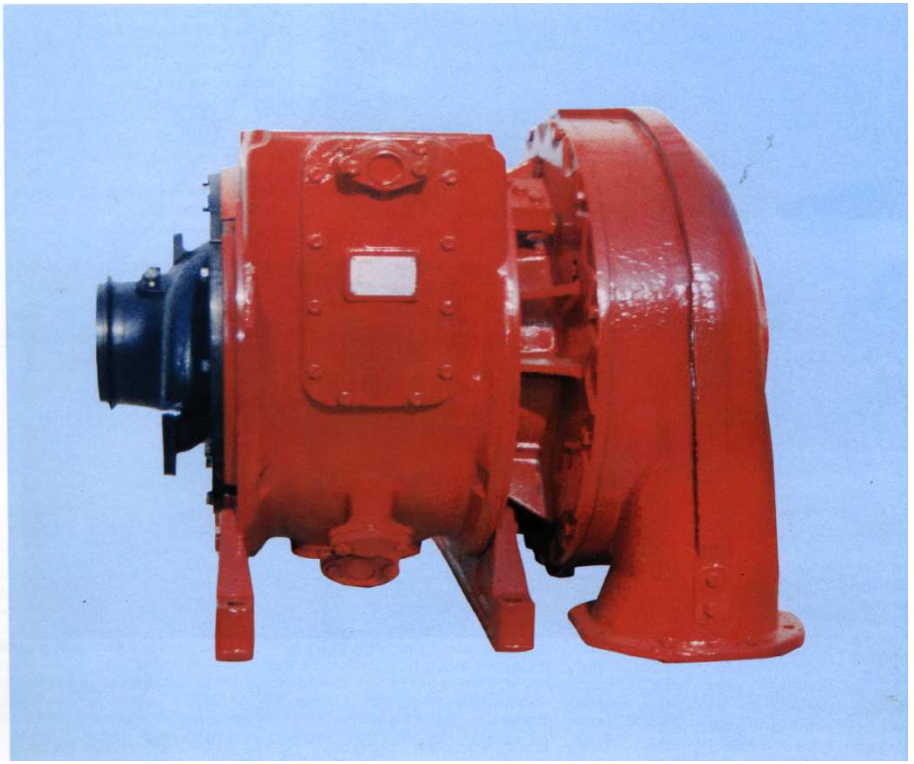


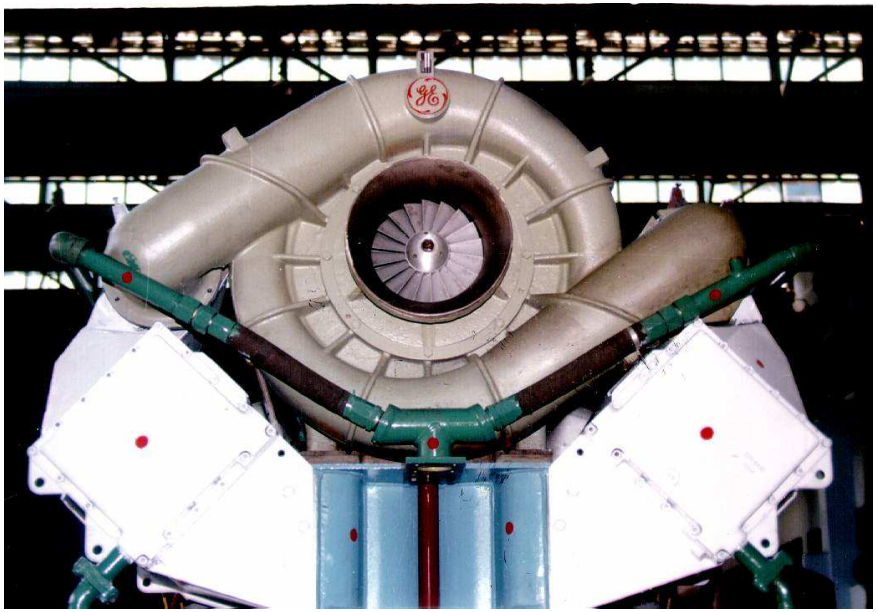
ABB VTC304



Napier NA295/296

TWIN DISCHARGE TURBOCHARGER

ABB VTC-304 TD



GE 7S 1716

NEW GENERATION TURBOCHARGERS

ABB TPR61

HS5800 NGT

2. STIFFER UNIT CAM SHAFT

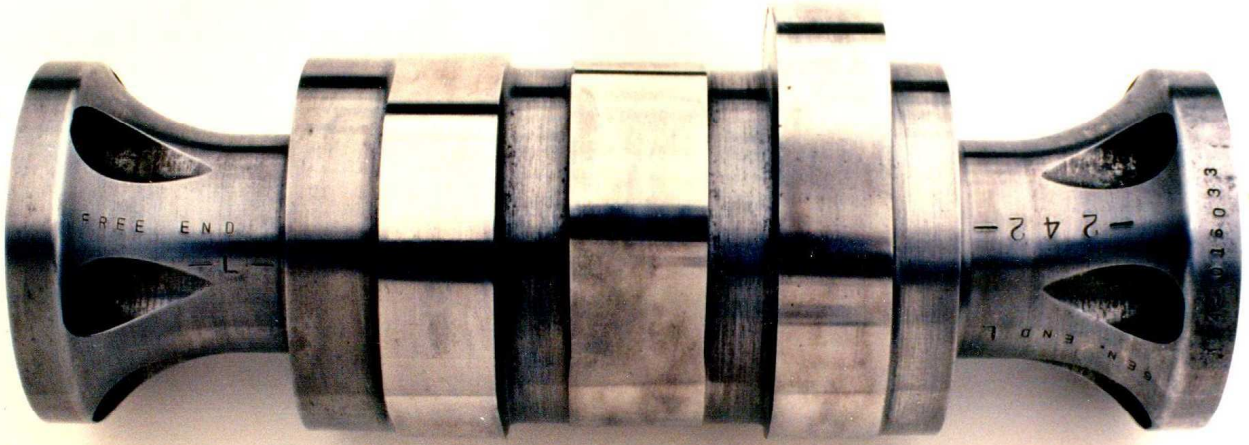
- **Evolution** – Conventional → Unit cam shaft
  → Stiffer Unit camshaft
  - More reliable, Longer life
  - Easy replaceability
  - Required for high HP Loco

Status – DCW has been fitting in all Rebuilt Loco
- Larger dia. introduced in all DLW manufactured loco since Nov 2001

COMPARISON OF CAM SHAFTS

Base Circle Dia In mm	Existing Cam Shaft	Unit Cam Shaft (Conventional & FE)	Unit Cam Shaft Stiffer (GE)
Fuel	82.75	82.75	**112.116**
Air/Exhaust	80.12	80.12	**118.32**
No. of Sections	8	**2**	**2**

UNIT CAM SHAFT



Unit cam shaft

Conventional

3.PISTON AND PISTON RINGS

- Earlier: Al-alloy
- Now: Steel Cap
  - 4-bolt / 6-bolt design
  - Single bolt (GE PISTON)

TOP FASTENING EXPOSED TO FIRE FACE

Six bolt design

IMPROVED DESIGN BOTTOM FASTENING

IPL FOUR BOLT DESIGN

GE/EML SINGLE BOLT DESIGN

GE SUPERBOWL PISTON

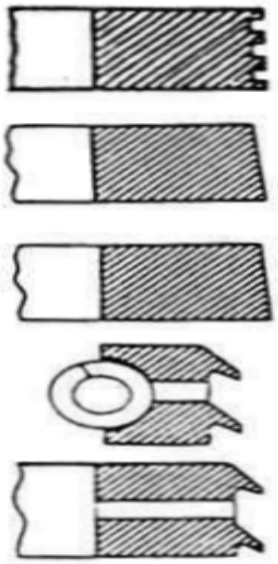
-STEEL CAP

-SINGLE BOLT

-11.75 C R

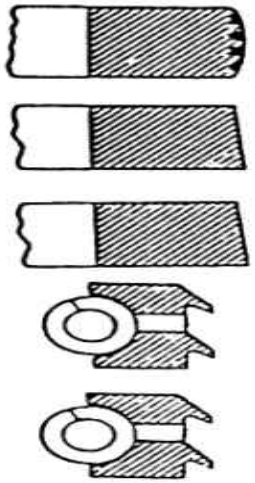
Improved Piston Ring Design

CONVENTIONAL



Square, taper, taper, oil conformable and oil scraper configuration

FE RING



Barrel taper, taper, oil scraper and oil conformable configuration.

PROPOSED

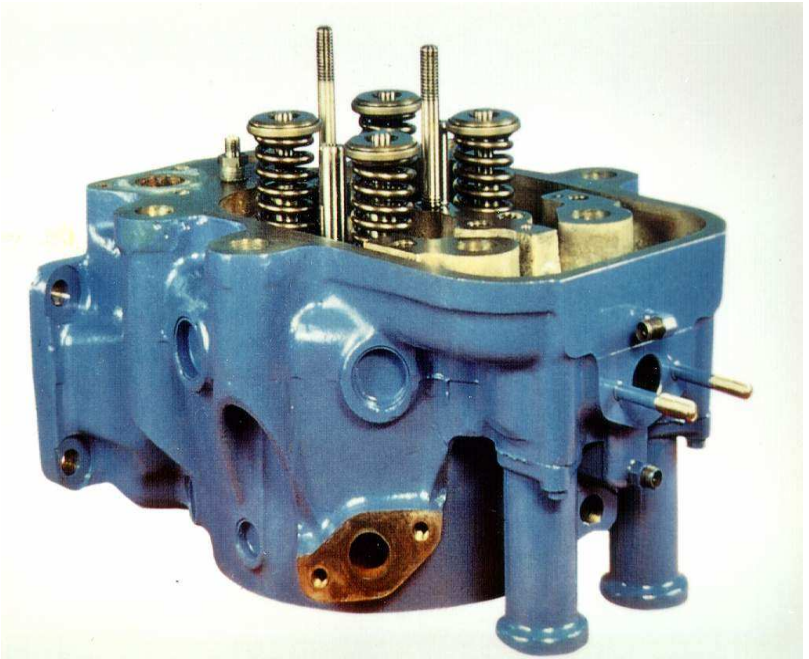
1. Plasma filled top ring
2. 2nd Taper ring
3. 3rd Taper ring
4. 4&5 Oil conformable ring

Fuel efficient piston rings Advantages

- **Reduced piston / ring and liner wear**
- **Reduced lube oil consumption.**
- **Reduced fuel oil consumption.**

4. 251 PLUS CYL. HEAD

To improve heat transfer & to avoid crack in exhaust port area , fire deck area & stud bosses specially for higher HP Engine.



FEATURES OF 25I+ CYL HD

- **Thin wall section of fire deck** for better heat transfer.
- **Middle deck in butterfly fashion** for better water circulation
- **Increased no. of cores (14) to strengthen fire face and increased water holding capacity.**
- **Use of frost plugs in place of threaded plugs.**
- **AL spacer to make good the gap between rubber grommet & cyl. Head.**
- **Lighter by 8 kgs**
- **Retaining ring for valve seat insert eliminated.**

5. VALVES

- Exhaust Valves with INCONEL material
  - Improved reliability and longer life on account of improved mechanical strength at higher temp
- Inlet valves with thicker neck and 30° seat angle
  - More opening area and guided flow for the induced air

VALVES

45° VALVE

30° VALVE

6. DOUBLE HELIX FUEL INJECTION PUMP

•Fuel efficiency even at part load operation, hence better fuel efficiency over operating duty cycle.
•0.8% lower fuel consumption over duty cycle.
•0.47-8.95% better SFC on part load i.e. 5th notch to idle in 3100 HP DLW engine.

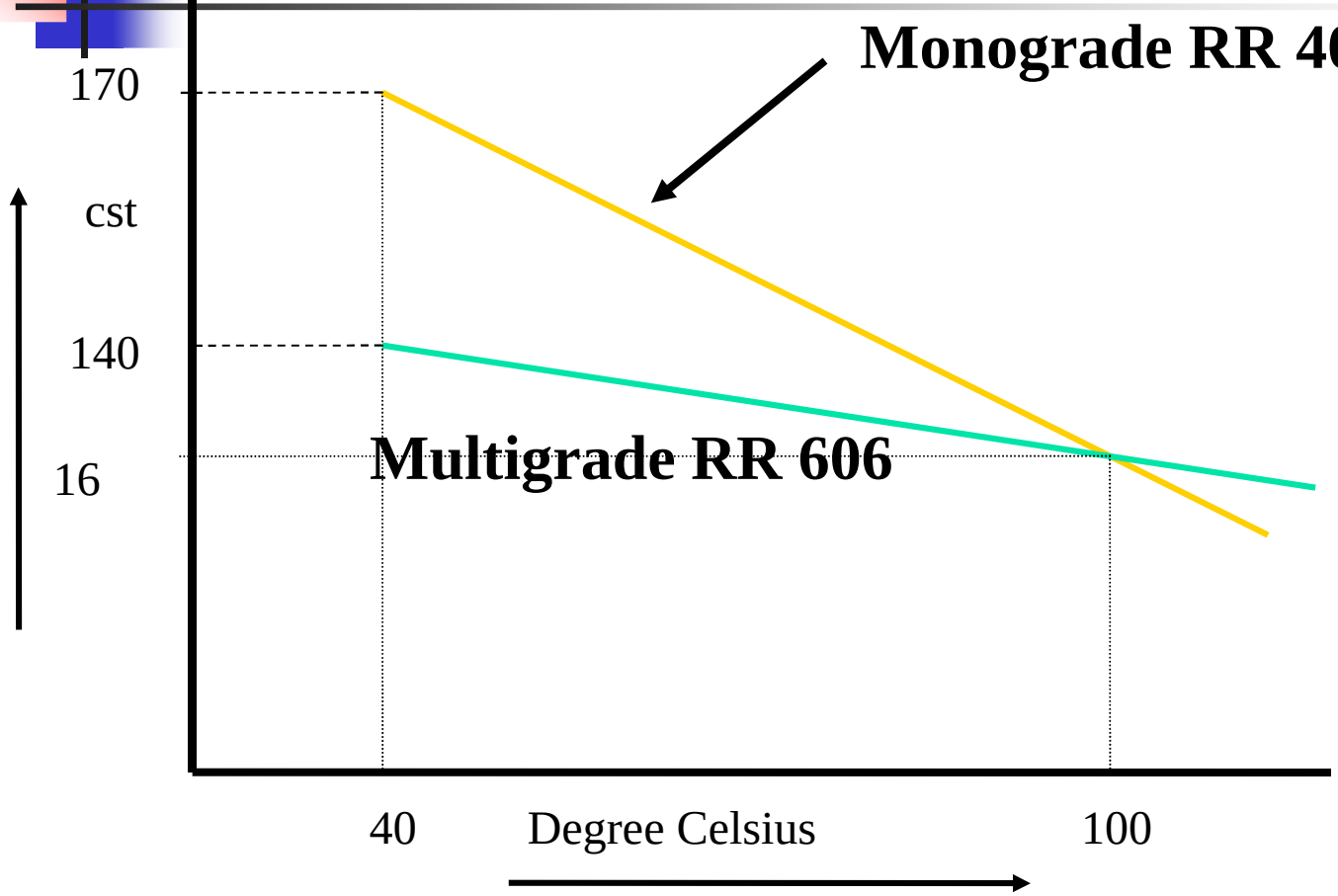
7.FUEL INJECTION TUBE

- **Objective** – High reliability to withstand high pulsating pressure
- **Earlier** – AIS1 4130 material
- **Presently** – ST52.4 NBK material with high quality finish in the bore and sustainability to withstand high compressive (Hoop) stress.

8. MULTIGRADE OIL

	Mono Grade OIL (SAE 40)	**Multi Grade Oil (SAE 20W40)**
Brands	IOC-RR 407	IOC-606M
	HP-HPRR713	HP-HP RR813
	BPC-BPRR940	
Status	In regular use	Recommended and in use in many a shed.
K.Viscosity in CSt	At 37 celcius=205 At 98 Celcius=16 to 16.8	At 40 celcius=138.7 At 100 celcius=15.5
Viscosity Index	90	116
Improvement in SFC	--	2.5%
Decrease in Lube oil cosumption	--	Marginally less
wear	--	lesser
Cleanliness of Valves	--	better

MULTI GRADE OIL(VISCOSITY GRADIENT)



9.PLATE TYPE L.OIL COOLER

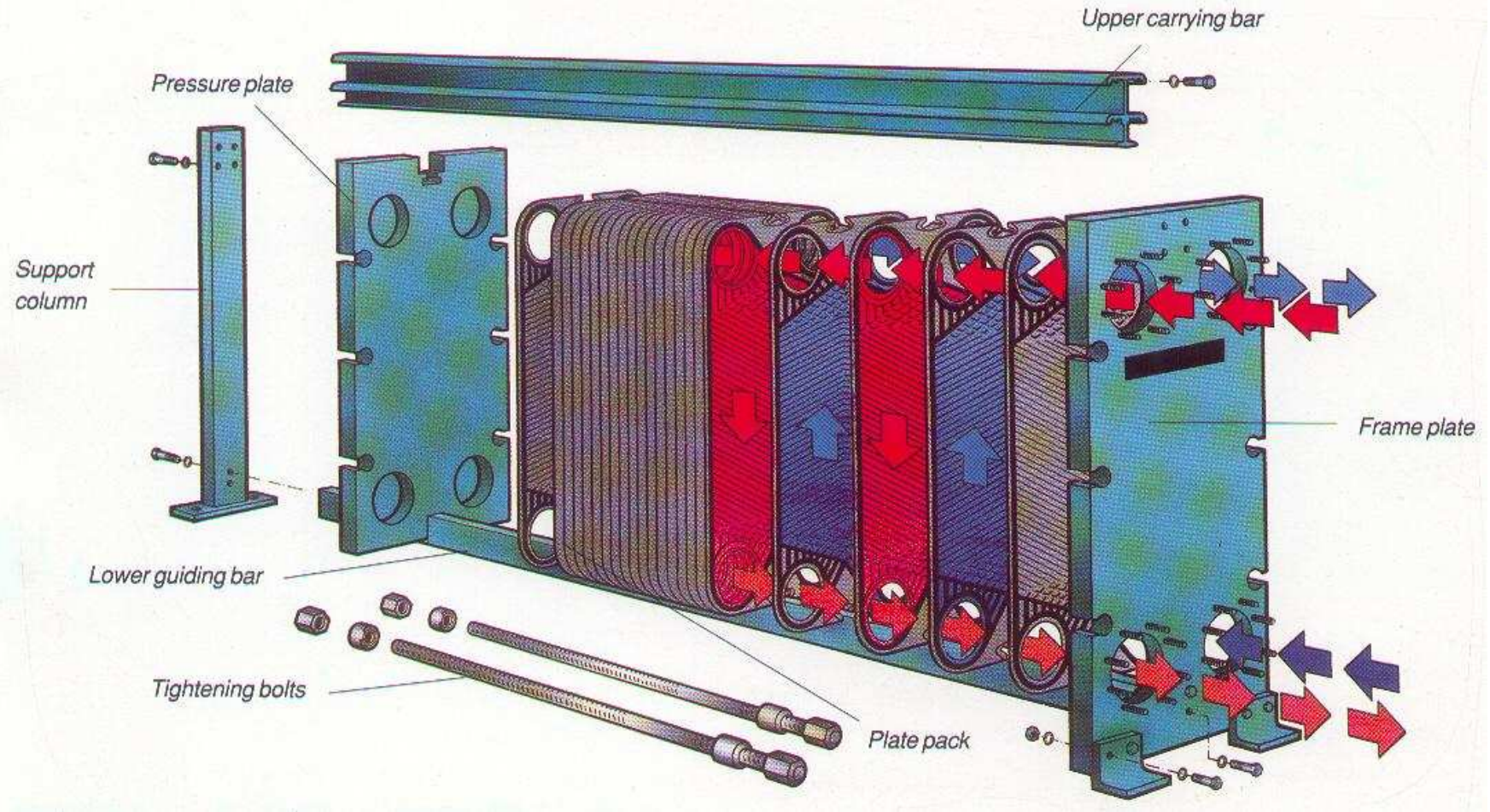
- **Conventional copper tubes with copper fins.**

- **Now** Alternate **stainless steel plates** with water & L.Oil flowing through the passages.

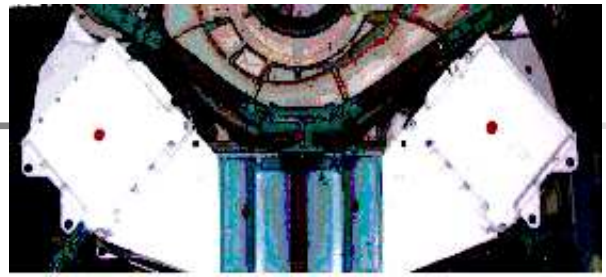
➢**Heat transfer** improved from 190 KW to 295 KW

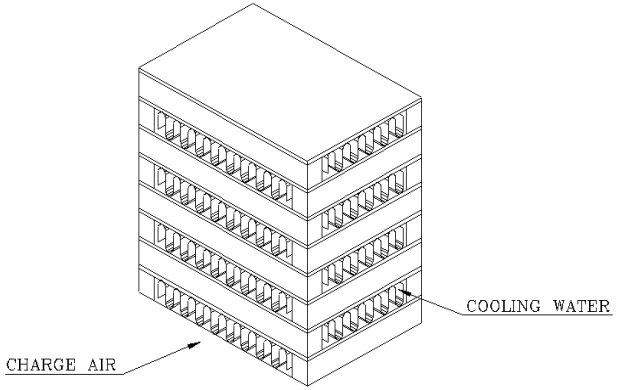
➢Higher reliability

PLATE TYPE L/OIL COOLER



10. Improved After Cooler Design





LARGER AFTER COOLER TWIN AFTER COOLER ALL ALUMINIUM DESIGN

Description	Conventional A/C 10 row	Large A/C 12 row	Large A/C 16 row	Twin A/C	All Aluminium A/C
Effectiveness	50%	70%	80%	95%+	90%
Exhaust gas temperature	>600ºC	550ºC	520ºC	500ºC	500ºC

11.MECHANICALLY BONDED RADIATOR

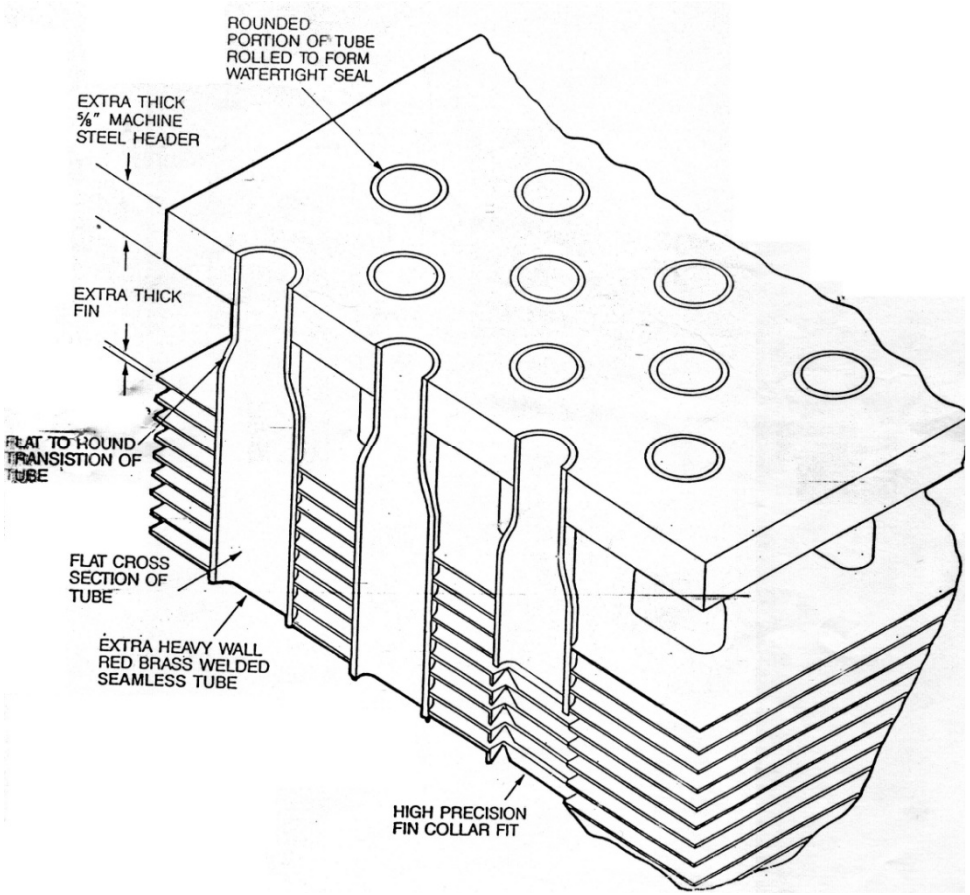
Features:

•Seamless brass tubes having higher bursting pressure and fatigue strength.

•Tubes are joined by expanding them mechanically.

•More reliable as the mechanical joints are much less prone to failure than the soldered joints.

•Header plates ar made of 15 mm thick steel as against 3mm thick brass in conventional radiator.



12. LONG LIFE FILTER

- **Objective** : Extended life & Improved reliability

- **Fuel Primary & 2ndary filter** – Long life filter (80 days)- earlier every trip
- **L.Oil filter** with centrifuge in the circuit- 240 days
- **L.Oil filter** without centrifuge- 120 days
- **Moatti self cleaning filter-** POH to POH
- **Turbo inlet filter** – 90 days life

FILTER contd

- **GD-80 filter** –Disposable paper filter (life enhanced from 15 days to 90 days)
- **inertial air filtration**– Switch over.

* Introducing glass fibre baggy type secondary filters.

  To avoid surging-complete design of air box, connector, holding arrgt.. of bags etc modified.

* AC dust blower motor introduced in place of DC motor earlier.

13. CENTRFUGAL OIL CLEANER

- Reduced engine wear due to highly efficient separation of high density particles.
- Longer oil change intervals.
- Longer paper filter life. (M 8)
  Saves 400 liters of lube oil/loco/yr viz. oil lost in 8 filter changes
- No operating cost ,Being self driven with the inherent pressure of lubricating oil and negligible maintenance.
- TECHNICAL SPECIFICATION

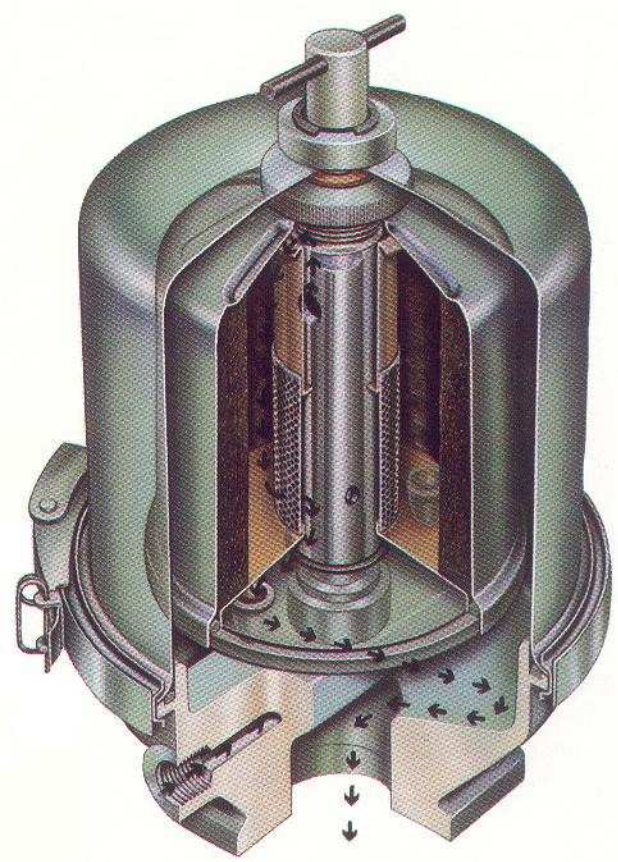
1.Oil flow rate -50 lts/min at 3 bar
- 70 lts/min at 7 bar

2.Operating pressure range- 3 bar to 7 bar

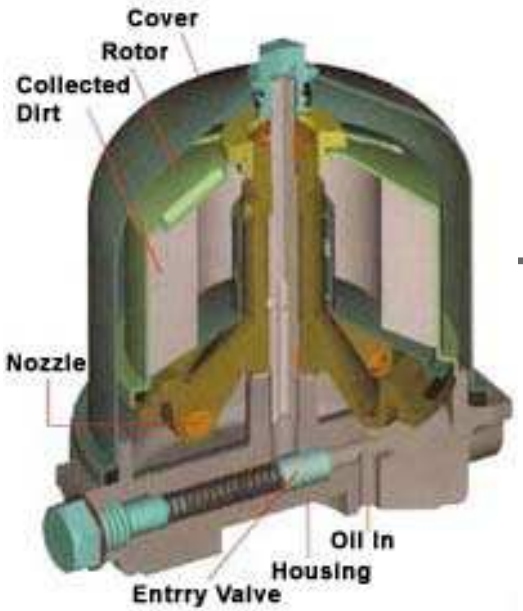
3. Dirt holding capacity - 6.0 lts

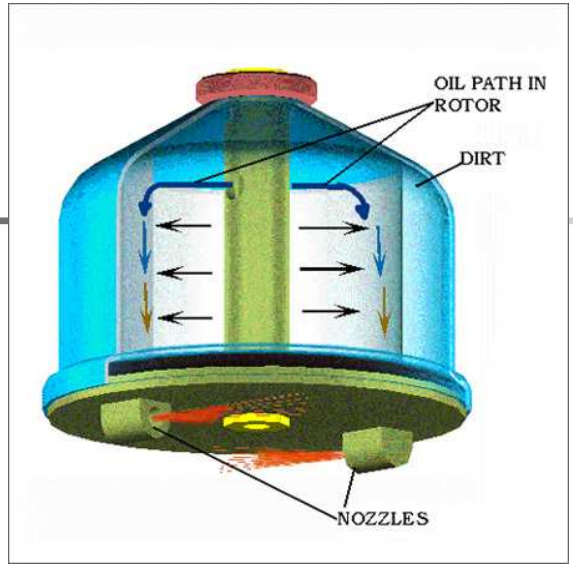
4.Oil capacity - 6.5 lts

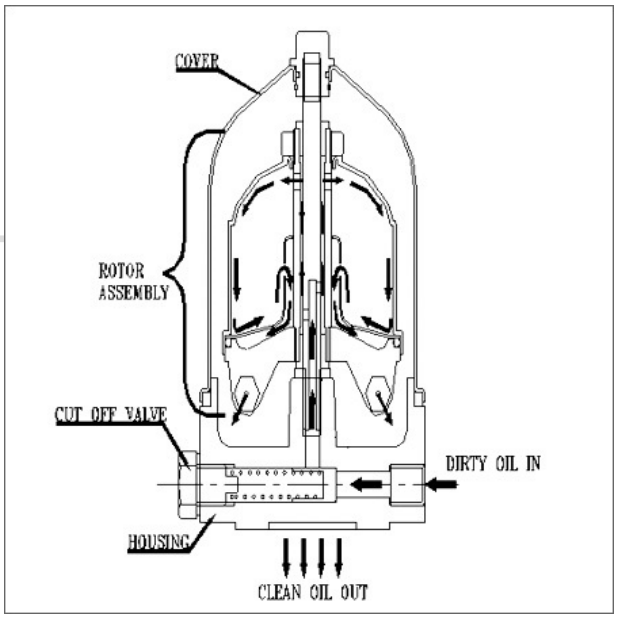
5. periodicity of cleaning – 60/ 120 days



WORKING OF CENTRIFUGAL OIL CLEANER



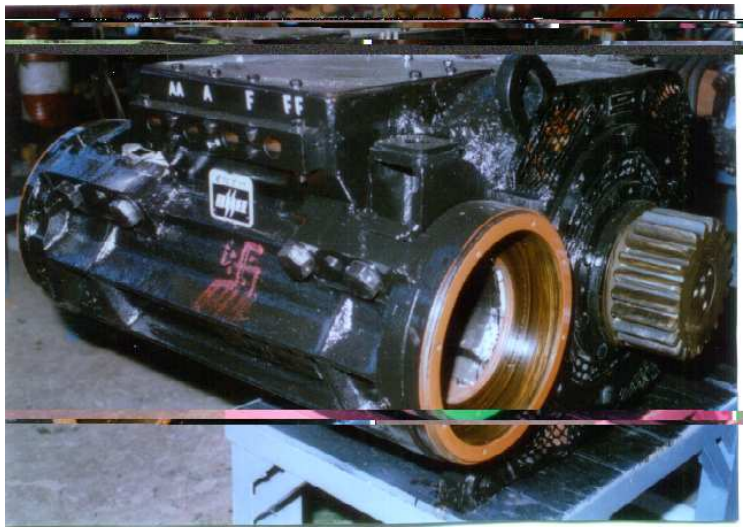




- Separation in a centrifuge is effected purely by centrifugal force acting on dirt particles.
- Oil is admitted to centrifuge rotor under pressure from engine oil gallery.
- After ciculation in rotor, oil is ejected through pair of nozzles at bottom of rotor.
- This gives reaction force to rotor and rotates the rotor with dirty oil inside about a shaft at about 600 rpm.
- Due to rotation, the dirt particles inside rotor experience centrifugal force of 2000 times gravity and are thrown out on rotor wall.
- The particles stick on rotor wall and form a sludge cake which is removed during servicing.

14.ROLLER SUSPENSION BRG.

- Objective – Extended maint schedule & higher reliability.
- Taper roller suspension brg.
- MSU (Motor Suspension Unit) will enable T.M to be removed for repair etc.



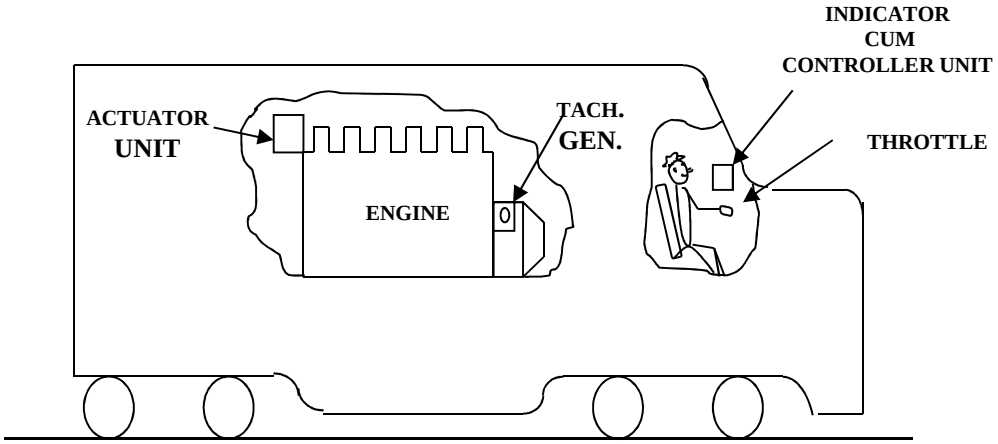
Tapered Roller Suspension Bearing

Advantages:

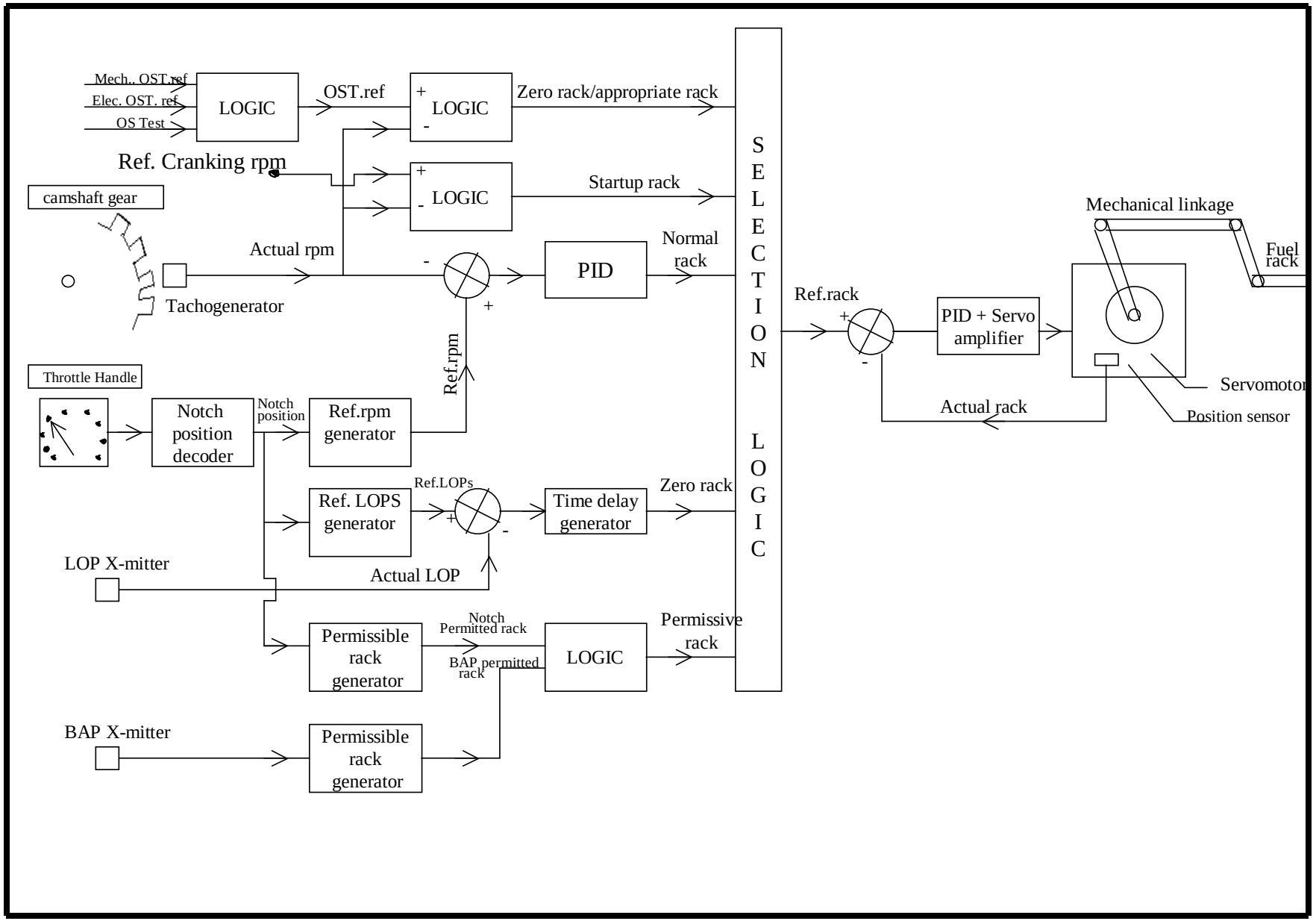
- Significant increase in bearing life with almost ‘NIL’ maintenance.
- Taper roller bearing design permits reduced radial clearances.
- Roller bearing MSU can be separated improving the flexibility during maintenance.

15.MICROCONTROLLER BASED GOVERNOR

- Flexibility in adjustment
- Easier troubleshooting & repairs
- Display of parameters
- No maintenance reqd for 6 years.



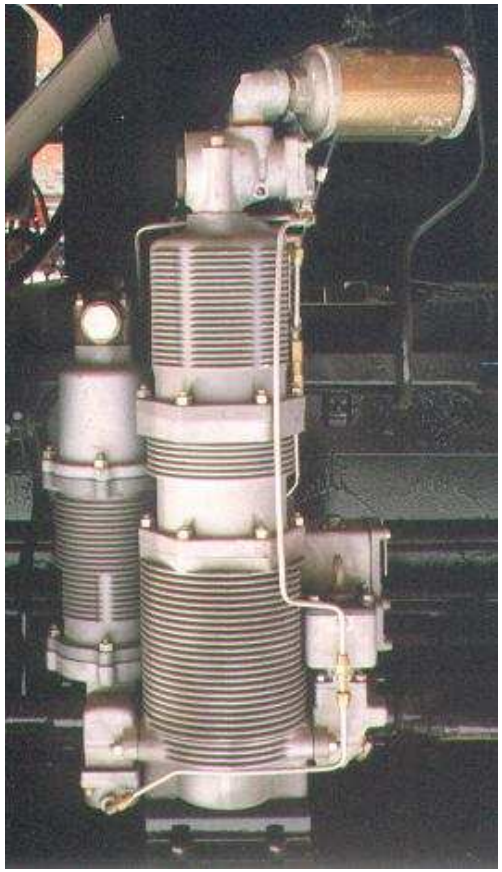
Principle of operation (Schematic)

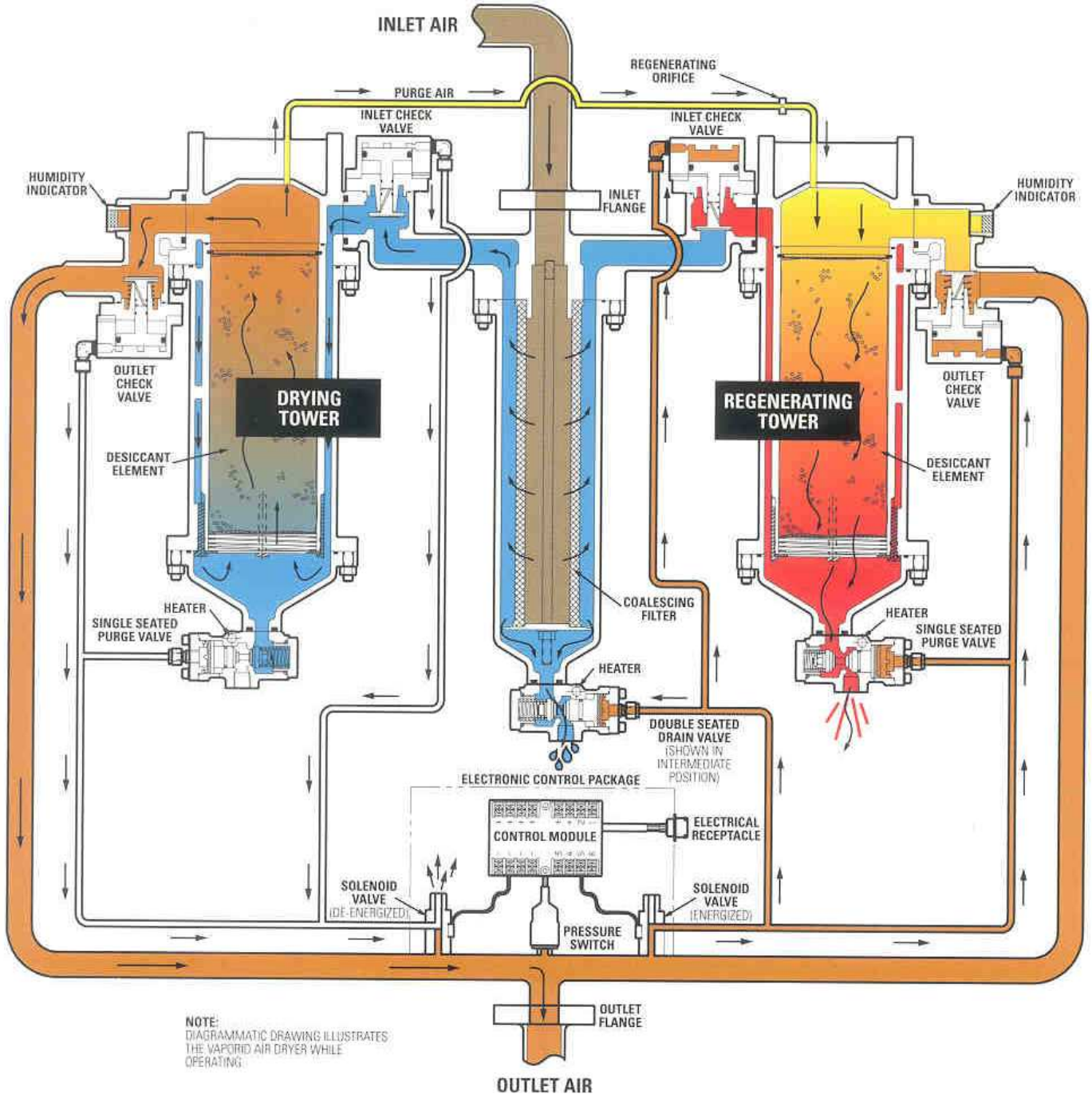


16. AIR DRYER

- **Objective** –To improve reliability of brake valves & electro-pneumatic equipment

→ Twin tower, heat less, regenerative type which contains desiccant to absorb moisture.




INLET AIR
REGENERATING ORIFICE
PURGE AIR
INLET CHECK VALVE
INLET CHECK VALVE
HUMIDITY INDICATOR
INLET FLANGE
HUMIDITY INDICATOR
OUTLET CHECK VALVE
DRYING TOWER
REGENERATING TOWER
OUTLET CHECK VALVE
DESICCANT ELEMENT
DESICCANT ELEMENT
HEATER
SINGLE SEATED PURGE VALVE
COALESCING FILTER
HEATER
SINGLE SEATED PURGE VALVE
HEATER
DOUBLE SEATED DRAIN VALVE
(SHOWN IN INTERMEDIATE POSITION)
ELECTRONIC CONTROL PACKAGE
CONTROL MODULE
ELECTRICAL RECEPTACLE
SOLENOID VALVE
(DE-ENERGIZED)
SOLENOID VALVE
(ENERGIZED)
PRESSURE SWITCH
OUTLET FLANGE
NOTE:
DIAGRAMMATIC DRAWING ILLUSTRATES THE VAPORID AIR DRYER WHILE OPERATING
OUTLET AIR

17. PANEL MOUNTED BRAKE SYSTEM

- **Objective** – To reduce leakage, To improve trouble shooting and maintenance.
- **Initially** – rack mounted
- **Now** – panel mounted – (less pipe joints)
- **Status** – Provided in all pure air brake locos. Now being developed for dual air brake.

System Improvement

- Microprocessor Control

➢ E-Type Locomotive Control System utilizes complex analog circuits based on transistor, magnetic amplifier & electromagnetic / electronic devices – Problem of reliability.

➢ Use of Microprocessor System reduces hardware, eases maintenance, facilitates better (Step less smooth) controls & enhances reliability.

Benefits Of Microprocessor Control Systems

- **Better management of parasitical loads .Higher input to traction as unused auxiliary power is added - upto 100 hp.**
- **Higher adhesion – 5-8% more over the existing value.**
- **Smooth and continuous /stepless excitation .Reduced electrical stresses & enhanced life of electrics. Improved Wheel Slip Slide Control & enhanced wheel life.**
- **Thermal protection of traction machine leading to longer life.**
- **Easy trouble shooting due to fault logging, retrieval and self diagnostics.**

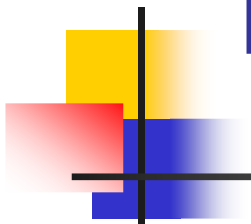
Contd…

Benefits Of Microprocessor Control Systems

contd..

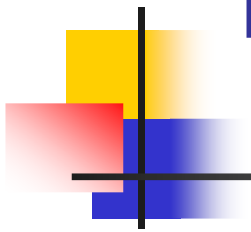
- **Lesser number of electrical interlocks of relays/contactors, increasing reliability.**
- **Improved performance due to elimination of flash over in power contactors.**
- **Flexibility in operation and maintenance due to user settable parameters.**
- **Flexibility for incorporation of new features like auto flasher, event recording, vigilance control device , interface to MCBG , pre lube pump , TE Limitation etc.**

FEATURES OF µp CONTROL



- **Pre Lube:** Pre lube for 60 secs prior to Engine starting. For lubrication of Eng components/ Main Brg. Serially implemented from WDG3A 13267 &WDM3D 11126
- **Post Lubrication**: Continues for 5 mins after Eng shut down to lubricate Engine & Turbo. Serially implemented from WDG3A 13406 &WDM3D 11241
- **Self Load:** Load heat dissipates through Braking Grids (Roof Mounted DBR). Serially implemented from WDG3A 13199 &WDM3D 11062
- **Multi Setting VCD**: µp controlled logging of VCD application with warning message and brake application. Serially implemented from WDG3A 13214 & WDM3D 11106.

FEATURES OF µp CONTROL



- **TE Limit:** Limits the TE upto 30.5 T by limiting max current upto 3000A on weak bridges. µp controls TE current. Serially implemented from WDG3A 13267 onwards.
- **Event Recorder**: Log 20 parameters related to safe operation e.g. BP, VCD cycle etc. Serially implemented from WDG3A 13204 &WDM3D 11125
- **Auto Flasher:** Auto Flasher logic implied through µp. Applied in WDG3A (13024 onwards) & WDM3D 11125 onwards.
- **Auto Emergency Brake**: µp automatically applies AEB when Loco exceeds pre determined speed, specially in ghat section. Applied in all Siemens & Medha µp controlled Locos (need based)

REVISED MAINTENANCE SCHEDULE

- **MODIFIED SCHEDULE**

  - Trip Schedule: 20/ 40 days (T1/T2)
  - Monthly Schedule: 60 days (M-2)
  - (M-3) Quarterly Schedule: 4 months (M-4)
  - (M-9) half yly schedule: 12 months (M-12)
  - (M-18) Schedule : 24 months (M-24) with 100% replacement of cylinder liner & piston rings
  - (M-36) schedule: 48 months (M-48) * certain critical items of M-36 viz. ABB TSC, EXPR, BRAKES & FTTMB has been reduced to M-24.
  - (M-72): same as M-24
  - POH to 8 Years (m-96)

ENGINE UPGRADATION

- FIRST PHASE: 2600 TO 3100 HP

  WDM_{2C}, WDG_2, WDP_2
- SECOND PHASE: 3300 HP

  WDM_{3C}
- THIRD PHASE: 3600 HP
- WDM3D

3100 HP LOCO

- APPLICATION OF FE KIT

  - 17 mm FIP WITH MOD. FP SUPPORT

  - STEEL CAP PISTON

  - MOD CAM SHAFT WITH 140°VALVE OVERLAP

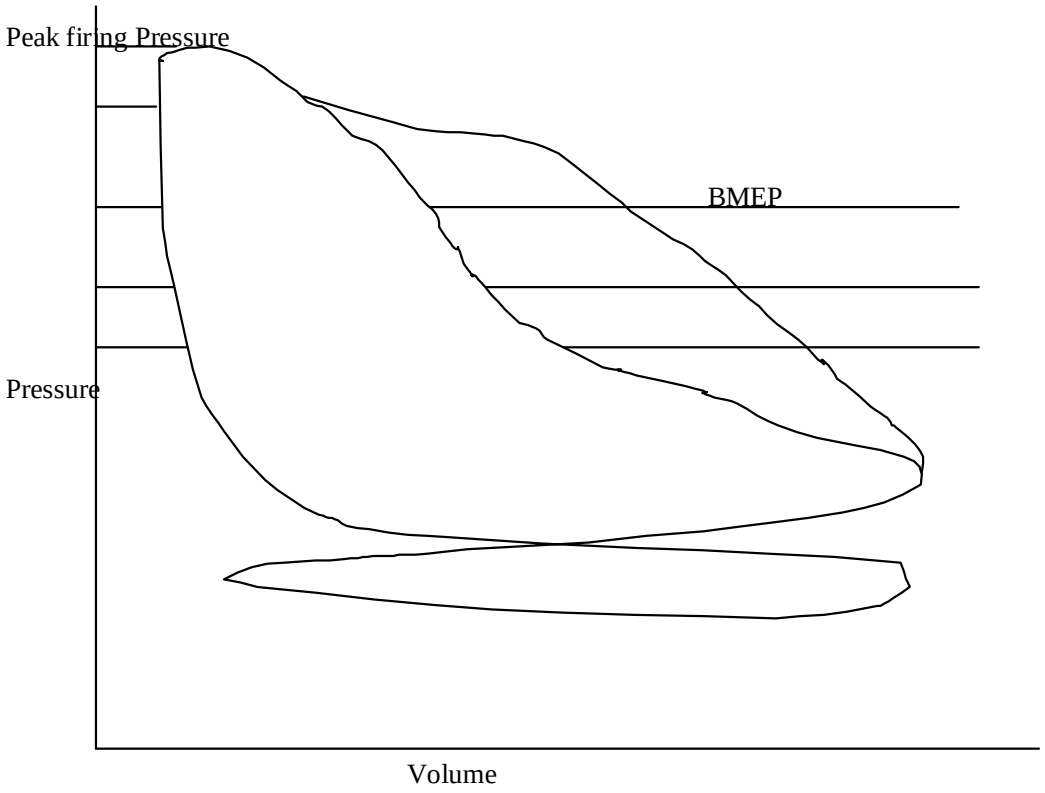
  - HIGH EFFICIENCY AND HIGH CAPACITY TSC WITH LARGER A/ COOLER and MODIFIED WATER CONNECTION

  SFC improved from 166.7 to 156 gms/ BHP hr

3300 HP LOCO

- CONSTRAINT FOR UPGRADATION
  - REACHING LIMIT OF PEAK FIRING PRESSURE
- MODIFIED INDICATOR DIAGRAM WITH THE CHANGE IN CONFIGURATION
- MODIFIED ENG. SUPPORT SYSTEM

INDICATOR DIAGRAM



3300 HP LOCO CONTD

- Configuration:
  - Stiffer Unit Cam Shaft with retarded injection (22^0 BTDC start of injection)
  - GE7S176 turbocharger (22.5 sq. inch nozzle) twin discharge
  - 11.75 C.R. super bowl steel cap piston
  - 251 plus cyl. Head
  - H.P fuel tube for 1200 bar pressure rating

3300 HP LOCO CONTD

- Engine support system
  - **Mechanically bonded, louvered fin radiator for 1700 kw heat load**
  - **Twin/single after cooler for 400 kw heat load & >90% effectiveness**
  - **Plate type lube oil cooler for 290-300 kw heat load**
  - **10” impeller water pump**
  - **Stream lined lube oil and water piping network**
  - **Insulated exhaust manifold**

3600 HP CONFIGURATION

COMPARISON

CONFIGURATION	3300 HP	3600 HP
GE 7S 1716 Turbocharger	22.5 Sq. In. Nozzle	26 Sq. In. Nozzle & Twin Aftercooler
GE Super Bowl Pistons	11.75Compr. ratio	11.75 Compression Ratio
Stiffer Unit Camshaft	Profiled for Sharper Injection	Profiled for Sharper Injection
17 mm FIP	Start of Injection 22^0 BTDC	Start of Injection 22^0 BTDC
New Injector Nozzles	0.35 mm, 157^0 Spray Angle	0.40 mm, 160^0 Spray Angle
251 Plus Cylinder Head	Strengthened Double Deck	Strengthened Double Deck

COMPARISON OF PARAMETERS

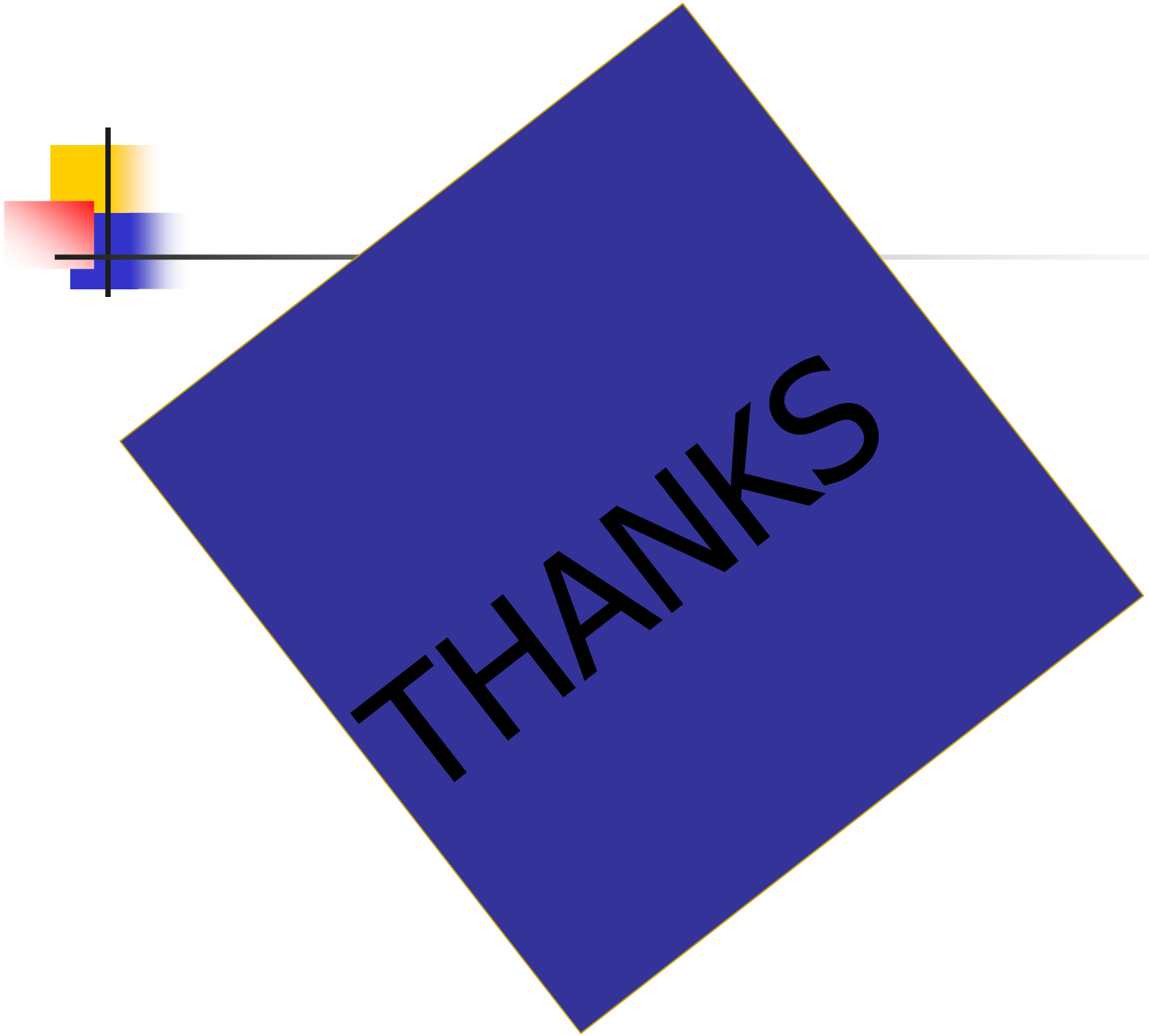
ENGINE OPERATING PARAMETERS	3600 HP	3300 HP	EXISTING 3100 HP
• Peak Firing Pressure	1870 PSI	1850 PSI	1950 PSI
• Exhaust Gas Temp.	525^0C	509^0C	500^0C
• Boost Pressure	1.95 BAR	1.9 BAR	1.9 BAR
• SFC 8^{th} Notch	153 gm/bhp-hr.	152 gm/bhp-hr.	154 gm/bhp-hr.
• BMEP	17.5 BAR	15.7 BAR	14.7 BAR
• Fuel Injection Pressure	1150 BAR	1150 BAR	950 BAR

COMPARISON

PARAMETER	2600 HP	3100 HP	3300 HP	3600 HP
CR	12.5	12.5/ 11.75	11.75	11.75
Peak firing pressure **(max. allowed 1950)**	1600-1800 psi	1950 psi	1850 psi	1870 psi
BMEP	13.3 bar	14.7 bars	15.7 bars	17.2 bars
Fuel injection pressure	750 bars	950 bars	1150 bar	1150-1200 bars
Injection timing	25 degree btdc	25 degree btdc	22 degree btdc	22 degree btdc
Turbo charger	Conv/ Nap/ABB	ABB/NAP	GE 7S1716 (22.5 sq. inch nozzle)	GE 7S1716 (26 sq. inch nozzle)
Lube oil cooler	190 KW shell & Tube type	250 kw	Plate type, 290-300 kw load	Plate type 500 kw load

CONCLUSION

Parameters	Before 1990	Year 2000 onwards
SFC (Gm/BHP Hr)	166	154
SFC Litres/1000 GTKM Passenger Service	5.17(95-96)	4.74(2000-2001)
SFC Litres/1000 GTKM Goods Service	3.18 (95-96)	2.74(2000-2001)
HP/Cyl.	160	210/225
Exhaust Gas Temp(degree C)	600	500
Maintenance Schedule	7 days	15/21/30
Equipment Failure (No. /100 loco)	27.3 (95-96)	15.7(99-2000)


THANKS